

An evaluation of retrieval-based learning through active organisational processing techniques

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Introduction

In the evolutionary history of humanity, the cognitive revolution can be argued as the most significant turning point. Bigger brains granted us superior communication, learning, and an overall advantage in adapting to novel situations. In the great experiment of evolution this was an overwhelming success (Harari, 2011). From this evolutionary perspective it can be said that the brain evolved to educate and be educated. Therefore, it should hold a central position within educational interests (Blackmore & Fruth 2005). In this paper, I will discuss the design and implementation of a retrieval-based learning intervention based primarily on combined readings surrounding the field of educational neuroscience and cognitive psychology.

The school this research enquiry was conducted in is an 11- to 16-year-old voluntary-aided comprehensive school in Cardiff that serves a wide catchment area covering almost half the city. Even though they are ranked 19th out of twenty secondary schools in terms of budgeting per pupil, the latest Estyn report indicated that prospects for improvement are good, signifying many strengths, with no important areas of significant improvement. One of the main areas for recommendation in the report was to raise the standards in science at the key stage 4 level (Estyn, 2015). Wales' new curriculum emphasises the importance of teachers setting high expectations for learners (Donaldson, 2015). Expectations at key stage four and five are explicitly set by predicted exam scores. To meet these expectations pupils need effective revisionary tools that facilitate these ends. My inquiry addresses this by focusing on a top set year 10 triple science class in preparation for their GCSE examinations. Through experiences in teaching this class and conversations with my mentor it was clear that this triple class was highly capable and intelligent; however, they lacked confidence and almost uniformly suffered from anxiety when confronted with past paper questions. The high ability of these students often comes with high expectations. With the added stress of the high stakes testing environment, I felt it was important to confront this barrier to learning by developing an effective solution.

As a result, in this paper, I discuss the development and implementation of an intervention that focuses on building efficient schemas of semantic knowledge through implementing strong memory and retrieval learning techniques. I will summarise a small sample of relevant articles within cognitive psychology and applied educational neuroscience. From these articles, I will justify a retrieval-based learning activity that collectively encompasses what I have termed active organisational processing techniques. I will discuss the implementation of these activities in class and through anonymous feedback and questionnaires I will evaluate the effectiveness of my intervention. Furthermore, I will compare the results of pupil's performance on past paper questions to expected GCSE scores. The aim of my investigation is to develop effective teaching practices that will empower my pupils with the tools to retain and retrieve information across various contexts and over longer lasting time frames. This promotes the development of ambitious confident and capable learners who are building up a body of knowledge and have the skills to connect and apply that knowledge in different contexts (ACL2). This intervention also drives at the develop of healthy, confident pupils who face and overcome challenge (HCI9) and in this building their mental and emotional well-being through the development of their confidence and resilience (HCI2).

Literature Review

A pupils' ability to perform on GCSE and A-level examinations directly impacts their future opportunities within further education. It is then critical that pupils are prepared adequately and given the best tools to succeed on these high stake's examinations. Although the exam content is largely known, the exam questions are not and therefore success on these exams is largely dependent on the pupil's ability to retrieve learned information and apply it under various contexts. The general fields of cognitive psychology and educational neuroscience apply a transdisciplinary approach to understanding learning and teaching that can be directly applied to the benefit of students in this regard. In this literature review I have compiled information on a range of revision strategies and categorised them by general effectiveness. I then further justify this evaluation and discuss the characteristics of effective revision using

information pulled from the fields of cognitive psychology and educational neuroscience. Although my area of research lends itself well to cognitivism, I still felt it was important to take a more holistic approach. Where appropriate I aimed to branch out and find opportunities to incorporate other general areas of educational philosophy. This research guides the development of my own research informed intervention and educational philosophy discussed later.

The Growth Mindset

In my own opinion, the public overemphasises the relationship between high academic performance and innate cognitive advantages. While genetic advantage certainly exists; any sufficiently talented individual can be outperformed with sufficient training and resources. At the heart of this argument lies the importance of educators and pupils in embracing a growth mindset. The growth mindset, popularised by Carol S.Dweck is a positive psychology philosophy that embraces the malleability of intelligence (Dweck, 2006). This stands in opposition to a fixed mindset that views intelligence as innate and rigid (Kapasi & Pei, 2021). Contextualised within educational research, evidence strongly supports the contention that pupils with growth mindsets are heavily correlated to positive outcomes regarding neuroplasticity, motivation, and academic performance across all areas of learning (Kapasi, 2021; Tirri, 2016; Kujala, 2010). Part of the growth mindset is characterised by seeing mistakes not as a lack of ability but rather as opportunities to learn and improve. As I will discuss later, creating an environment and opportunity to cultivate this growth mindset was an important factor when designing and delivering my intervention. This philosophy also ties in nicely with Wales' new curriculum. According to Donaldson, an influential figure in Wales new curriculum design: "Teaching should proceed on optimistic assumptions about its ability to make a difference as self-limiting beliefs about fixed potential are difficult to alter and can have a profoundly negative effect on learning" (Donaldson, 2015: p64). The growth mindset abolishes these negative effects of self-limiting beliefs and sets a learning environment that promotes mental resilience while maximising the potential for achievement and wellbeing.

General Revision Strategies

The first stage in my review of the literature was to compile information on a range of revision strategies and categorise them by general effectiveness. Keeping in mind the scope of this project I summarised my findings in table 1 found below. The general effectiveness of revision strategies used within my intervention will be justified further in the following sections.

Revision Technique	Effectiveness	Summary of Technique
Elaborative Interrogation	Moderate ^{1,2,8}	Pupils explore connections within knowledge schemas by asking why, how, and what happens under varying conditions.
Spaced/Distributed Practice	High ^{1,3,8}	Consistently scheduled practice over large periods of time.
Self-Explanation	Moderate ^{1,8}	Explaining the interrelation of information as well as verbalising the steps required in problem solving.
Summarization	Low ^{1,8}	Creating summaries of material.
Highlighting/underlining	Low ^{1,8}	Selecting text deemed important for future retrieval.
Keyword mnemonic	Low ^{1,8}	Chunking keywords with mental imagery.
Imagery for text (Dual Coding)	Low ^{1,8}	Forming images physical or mental of material in text.
Rereading	Low ^{1,8}	Revisiting text following initial reading.
Practice Testing/Quizzing (With Feedback)	High ^{1, 3,8}	Independent testing/re-testing.
Interleaved practice	Moderate ^{1,3,8}	Scheduled practice that combines differing sets of problems and or materials within a single session.
Peer supported Retrieval	Moderate ^{1,2,8}	Pupils work together to recall information and answer questions.
Using Knowledge Organisers	Low-Moderate ^{2,4,6}	Typically, a one-page document that summarises factual knowledge and technical terms alongside visual representations.
Generative effect	Moderate ^{4,5,7}	Where pupils create revision materials such as practice tests (reverse quizzes) or knowledge organisers.

Table 1: Summary and rating of compiled revision techniques. (1) Dunlosky, J. Rawson, K. (2015). (2) Sherrington, T. Caviglioli, O. (2020). (3) Roediger, H. Butler, A. (2011). (4) Bjork, R. Dunlosky, J. Kornell, N. (2013). (5) Rosner, Z. Elman, J. Shimamura, A. (2013). (6) Sherrington, T. Caviglioli, O. (2021). (7) Voss, J. Galvan, A. Gonslaves, B. (2011). (8) Dunlosky, J. et al. (2013).

Cognitivism, Neuroscience & Knowledge Schemas

In cognitive psychology schemas are widely defined as knowledge structures; a cognitive framework involved in the organisation of knowledge (Neisser, 1967). Educational neuroscience defines a schema more specifically as a framework of knowledge within a network of connected neurons. These neurons form memory traces that associate information allowing for increased efficiency in retrieval (Kesteren, 2013). In the following paragraphs I will briefly summarise the process of memory formation in relation to knowledge schemas. Throughout, I will comment on how this information can inform effective revision strategies. This will ultimately inform the justification for the design of my intervention.

Superficially, memories are stored through the strengthening of synaptic connections between neurons. This is established through a process called long term potentiation (Kesteren, 2013). Colloquially this neurobiological process is taught as “what fires, together, wires together” and represents the basis of memory traces. Under this hypothesis it may seem that repetition is key to effective revision, and while repetition is important, successful memory retention is more complex (Tulving & Kroll, 1995). When presented with information memories must first be encoded. The brain region responsible for this (the medial prefrontal cortex) has been shown to serve as a novelty detector (Tulving & Kroll, 1995; Matsumoto et. al., 2007). As such, familiar information is thought to be less well encoded than novel information (Kesteren, 2013). This is termed in the literature as novelty encoding theory. Novelty encoding theory is based on predictive coding theory (Friston, 2005). Predictive coding theory describes deviation or prediction error as the driving force in memory encoding. These predictions are made of pre-existing schemas, if deviations exist between predictions and the schema's output, then encoding occurs (Kesteren, 2013). Therefore, both novelty and feedback serve as an important criterion for effective revision as both aid in driving memory encoding. This understanding can also be used to help explain the general ineffectiveness of revision strategies such as re-reading and highlighting (Dunlosky et al, 2013) as these strategies do not foster novelty, deviation, or feedback. Another closely related theory, the supply-demand model of neuro-plasticity, describes the major driving force of brain adaptation

as a “mismatch between functional supply (ability) and demands (education) (Wenger & Lövdén, 2016). Under this theory if mismatch is too large then the system will not respond, and plasticity does not evolve. In contrast if the system is already capable of responding to the environmental stress and no mismatch occurs then plasticity is not required and therefore adaptation does not occur. In educational practice the supply demand model of plasticity implies the importance of effortful practice that challenges students based on their current ability.

Following memory encoding is memory consolidation. This occurs mostly outside of the classroom, over long ranges of time, concentrated primarily within sleep (Wilson & McNaughton, 1994). Although getting good sleep is a critical step towards effective revision it is for obvious reasons beyond the scope of this intervention. After consolidation comes memory retrieval, a variable that is often discussed in terms of retrieval strength (Sweller, 2016). This is a critical variable to improve and monitor as it is the main end point that is tested in exams. Spaced/distributed practice is a critical variable in fostering greater retrieval strength as it allows the extended time required for the re-encoding and re-consolidation of information (Dunlosky & Rawson, 2015; McKenzie & Eichenbaum, 2011).

Expert Reversal & Guidance Fading effect

One way to approach setting goals for effective revision is to develop the characteristics of pupils' thought processes from novices to experts. An interesting caveat of this process is the expert reversal effect. Not only do differences in knowledge exist between novices and experts but also how their knowledge is organised (Chi, et.al, 1979). This deviation affects how these two groups approach novel problems. Novices, with underdeveloped schemas, approach problem solving by working backwards (i.e., What could the answer be?). Thereby requiring novices to remember individual elements. This requires a greater cognitive load. In contrast experts chunk elements and work forwards (i.e., What is the question asking?). This reduces cognitive load freeing up space for higher order thinking (Chi, et. al, 1982). To approach problems in this way requires a more developed schema. A requirement of this is exposure to re-

encoding and re-consolidation events (i.e. spaced practice). Re-consolidation events require extended periods of time and teaching time allocated to revision within the classroom is limited. As such effective revision should extend beyond the classroom. However, with a shorter timeline for my intervention, I looked to find a way to bridge the gap in the divide between novice and expert thinking. To do this, I aimed to leverage the guidance fading effect. The guidance fading effect is a pedagogical tool that can aid in facilitating the transition from novice to expert (Kennedy, 1995). This requires a gradual reduction in guidance or scaffolded support as pupils develop expertise within a focused area. An example of this fading procedure could include questioning that starts as closed ended questions with support and guidance to a gradual shift to open ended questions where pupils are entirely reliant on their knowledge schemas alone. This will be discussed further in the following section.

Justification of intervention

The primary goal of my intervention was to address the general lack of confidence with past paper questions within a class of year 10 triple award students. To meet these ends I designed and implemented 'active revision booklets. These active revision booklets are a focused retrieval-based learning resource that collectively represents a combination of characteristics I have described as 'active organisational processing techniques. This designation is based on the interventions focus on active retrieval practice that is scaffolded and designed to facilitate the efficient organisation of schemas of semantic knowledge. These newly organised and focused schemas are then directly applied to exam questions.

Each active revision booklet is constructed to holistically cover one unit. Designing the booklets begins with collecting a set of past paper questions from the WJEC test bank. These questions are carefully selected to cover the range of topics presented within the given unit as well as any misconceptions or areas of improvement from previous mock exams results. Next, by leveraging school resources I collect all Bangor revision sheets available on the unit. These sheets serve as pre-made knowledge organisers for all the

specification content within each unit. By using the marking schemes from the selected past paper questions I proceed to verify that the information is presented clearly within the revision sheets and adapt and edit the sheets where required. Once this is complete, I then create a two-page active retrieval map (Lesson 1C, 2B, 3B). The active retrieval map is a targeted question sheet containing various styles of questioning. Once these three sections are completed (retrieval map, revision sheets & past paper questions) I combine them into a completed active revision booklet (Lesson 1C-D, 2B-C, 3B-C).

In this paragraph I will briefly explain how the active revision booklets were implemented within the classroom. During implementation students are given time to complete the map either by retrieving information from their existing schemas or by actively retrieving the information within the adapted revision sheets. Once completed students then move on to completing the past paper questions. At this point pupils are no longer allowed to reference the revision guides. The last stage of the lesson involves feedback on the past paper question answers. These are corrected and graded by the students using designated green pens (Lesson 2E). The active revision guides set up the lesson to be primarily student driven. As the teacher in the room, my primary goal is to foster a positive learning environment by promoting the growth mindset philosophy to students as they make progress.

The design of the active revision booklets has been informed and justified the information presented within the literature review. Seeing as the active retrieval map questions are reverse engineered from both the past paper answer keys and the revision guides, all the information encoded from completing the retrieval map can be applied to the past paper questions. This is done intentionally to leverage the guidance fading effect discussed earlier (Kennedy, 1995). This design is targeted at building pupils' knowledge schemas of the focused material in the first part of the lesson. This then creates a reduced cognitive load when confronted by the past paper questions allowing for a greater amount of cognitive load allocated to higher order thinking. In this case specifically focusing on what the questions are asking and how to use the

information to answer them appropriately rather than worrying about whether they have all the information required. The active retrieval map has also been designed to incorporate a variety of questioning styles that reflect effective revision techniques compiled from table 1. This was done to maximise memory encoding as a variety of questioning styles produces novelty, an important driving factor in predictive coding theory (Kesteren, 2013; Tulving & Kroll, 1995; Matsumoto et. al., 2007). Additionally, the questions span a wide area of knowledge and have been set at a variety of difficulties to help ensure that filling out the revision maps is an active and effortful process helping drive the neuroplasticity described by the supply demand model of neuroplasticity (Wenger & Lövdén, 2016). Lastly, past paper questions were chosen as the endpoint of the intervention as they reflect the exam conditions pupils are preparing for. Furthermore, practice testing was commonly advocated as the most effective revision strategy within the literature.

Regarding the core four purposes this intervention targets elements of ACL, ECC and HCI. The active revision booklets, when framed correctly, are an enjoyable problem-solving activity (ACL1). They provide a challenge where pupils are required to build a body of knowledge that is then applied in different contexts (ACL2). Naturally questions within topics cover elements of numeracy and literacy along the way (ALC6). This presents an opportunity for pupils to both use numbers effectively in different contexts and foster an understanding of how to interpret data and apply mathematical concepts (ACL7). The questioning within the revision maps also links nicely to ECC2 where pupils can think creatively to reframe, and problem solve.

My interventions success is primarily depended on the development of pupil's confidence. This intentionally links towards developing healthy, confident individuals (HCI). This is especially so regarding building mental and emotional well-being through the development of confidence and resilience (HCI2). Lastly, the active revision booklets provide opportunities for pupils to face and overcoming challenge (HCI9). In this they develop the confidence to perform well on their exams (HCI7).

Results & Discussion

Pilot active revision booklet

The topics covered by the year ten class at the start of the intervention were cells, digestion, respiration, and circulation. Being the first topic learned, I produce the pilot active revision booklet on the cell's topic (Lesson 1C-D). To gather feedback on students' current confidence with the material I had them rank the topics from most to least confident anonymously on sticky notes. Following this I had them RAG rate each topic individually (Lesson 1B). The RAG rating system designates red topics unconfident, amber as fairly-confident, and green as confident. Of the 22 responses, cells, digestion, and respiration had an average ranking of 2 while circulation had the lowest average ranking of 3 with 55% of correspondents ranking it as their least confident topic. The data obtained from the RAG rating is visualised in figure one below. The intervention was carried out three times over three lessons meaning the digestion topic was not covered by the intervention and therefore was omitted from the data.

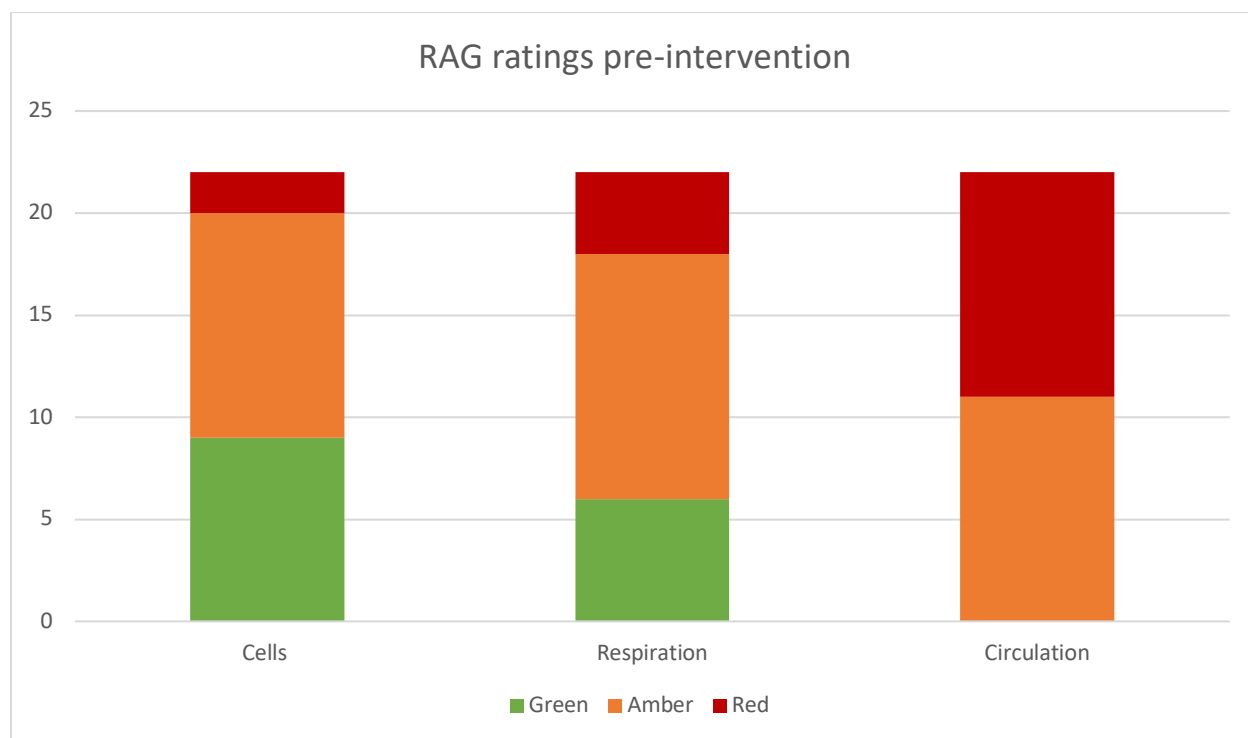


Figure 1: RAG ratings pre-intervention (n=22). Pupils designate colours that represent their confidence with the material. Red represents unconfident, amber is fairly-confident, and green is confident.

Following the lesson, I collected anonymous feedback from the students regarding the active revision booklet in the form of a WWW/EBI (what went well / even better if) exit ticket (Lesson 1G). The following table (table 2) summarises the feedback provided, and action taken in response. From the cell booklet intervention, a random sample of pupil booklets were collected and scanned, any names were omitted from the scanned images to maintain anonymity of pupils (Lesson 1E, 1F). From these scanned books it was clear that pupils would require more time to complete the number of questions originally set out in the booklet. This was also reflected in the feedback provided from students. To address this the next active revision booklets (Lesson 2, 3) were created with fewer questions in order to increase completion rates and feedback time within the lesson.

What went well	Even better if	Notes/Actions taken on EBI
"All the resources/questions were available in one place"	"Please make the text a little bit bigger"	Text was made bigger for the next two booklets produced.
"Useful information to be able to answer questions"	"Too much info on one page"	This was good feedback as the time required to complete the retrieval map was longer than expected as well. The next two booklets addressed this with less questions and a more specific focus to the past paper knowledge required.
"Good to quiz yourself on memory"	"Better picture quality"	This was an issue with the photocopier. I spoke to the technician about the photocopier, the next run of booklets was printed with new toner and more detail.
"Fun engaging/Good material"	"Task is clearer"	A few students thought they were unable to use the revision notes when filling in the retrieval map. Although it was explained to students, I will make sure to have them explain the task back to me before beginning.
"Helps me take in a lot of information at once"	"More tips on how to revise better"	Was unable to address this with the time allocated however providing time or resources on effective revision strategies within the lesson structure is an area for future development.

Table 2: Summary of feedback following pilot run of active revision booklet intervention (Lesson 1G).

Circulatory and Respiratory system active revision booklets

Based on the feedback from the pilot run I made several adjustments to the booklets and delivery of my intervention (see table 2). The next active revision booklets produced covered the circulatory system and the respiratory system (Lesson 2, 3). Following intervention of all three topics I used the RAG rating system to get a general assessment of confidence in the material post-intervention (Lesson 4A).

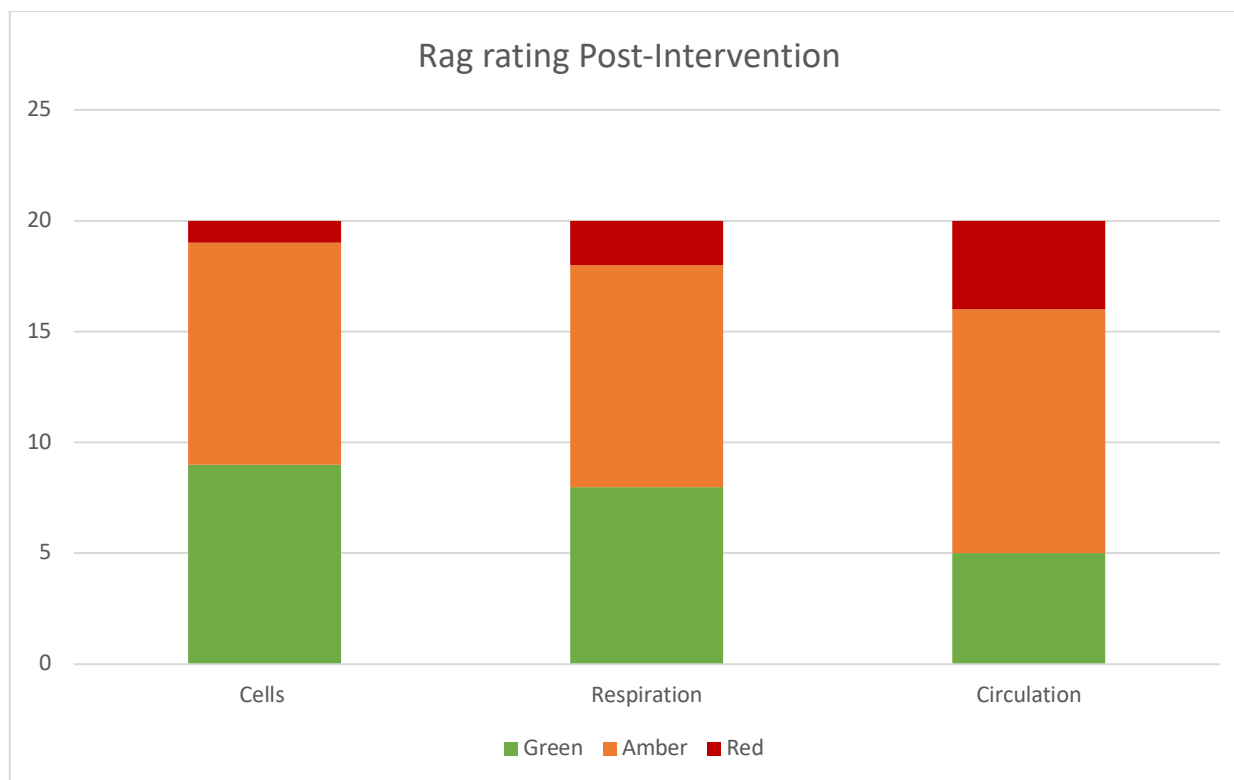


Figure 2: RAG ratings post-intervention (n=20). Pupils designate colours that represent their confidence with the material. Red represents unconfident, amber is fairly-confident, and green is confident.

The difference in sample size between the two RAG assessments makes it difficult to visualise side by side (n=22 versus n=20). To address this, I combined confidence ratings across topics covered and calculated the proportion of pupils rating themselves at each confidence level (figure 3 below). Pupils ranking themselves as unconfident went from 26% pre-intervention to 15% post-intervention. Furthermore, the percentage of pupils ranking themselves as confident went up from 23% pre-intervention to 30% post-intervention. Pupils ranking themselves as fairly-confident remained relatively the same with pre-intervention at 52% and post-intervention at 55%.

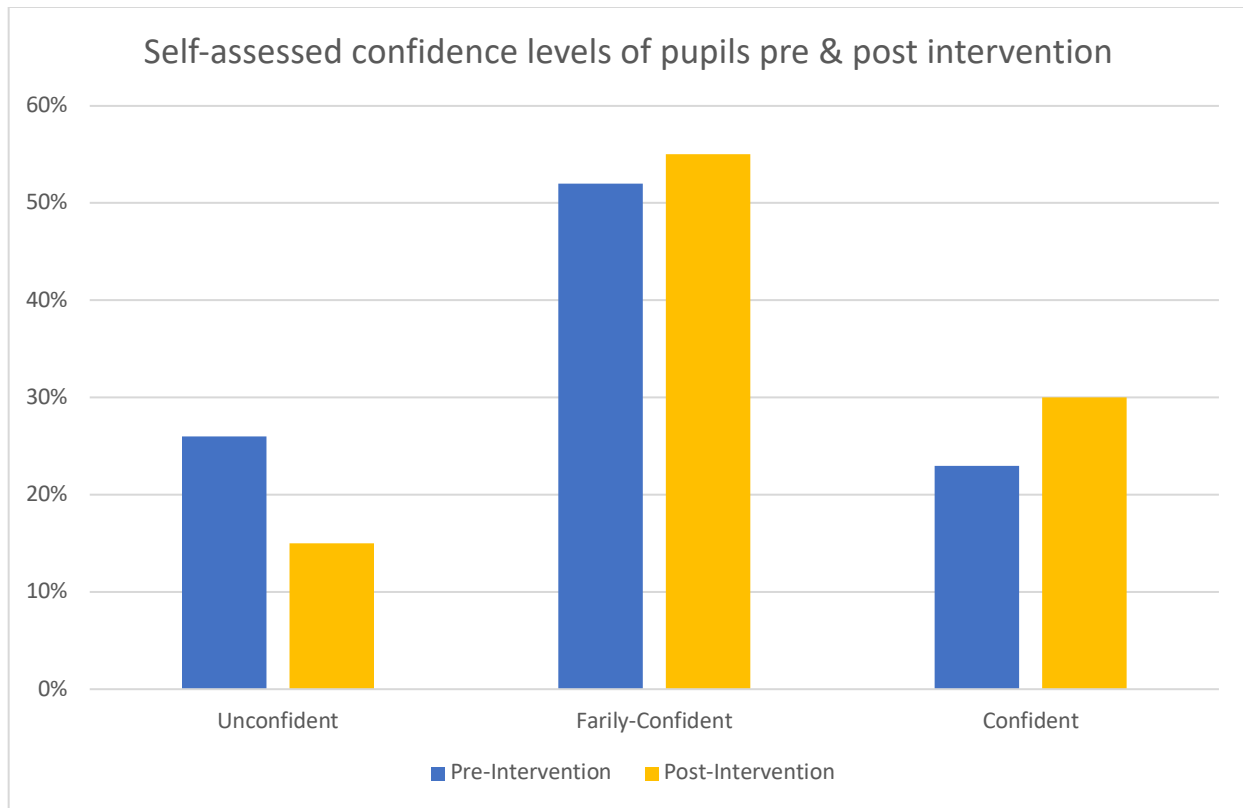


Figure 3: Bar graph depicting the proportion of pupil's confidence in relation to topics covered pre and post intervention.

To corroborate these results an anonymous survey was conducted (Lesson 4A). As seen from the RAG rating results the survey indicated that from the perspective of the class the revision materials made them more confident with both the material and approaching exam questions. In the survey pupils were asked to rank the difficulty of both the active revision maps and past papers question sections. As expected, the difficulty of the active retrieval map was scored lower than the difficulty of the past paper questions. This indicates that the scaffolding of difficulty inspired by the guidance fading effect did occur. Furthermore, pupils on average ranked the active retrieval maps difficulty at 3 out of 5 indicating that effortful practice was occurring, an important factor discussed surrounding the supply demand theory of neuroplasticity. Additionally, this effortful practice was in line with the ability of the pupils providing the most optimal conditions for plasticity to occur. Lastly, 77% of pupils agreed or strongly agreed that they felt more confident with both the material and approaching exam questions while 82% of pupils agreed or strongly agreed that the retrieval maps helped them in

answering the past paper questions. This serves as another indication that the resource diminished barriers for learning and fulfilled its intentions.

As a final end-point assessment a random selection of both the circulatory and respiratory system booklets of six pupils were selected. Random sampling was used to reduce bias and help ensure the sample was representative of the population. Cell booklets were not collected as the pilot run of the intervention did not allow enough time for pupils to complete an adequate amount of past paper questions. Due to workload considerations and variations in completion rates between samples a collection of 4 past paper questions were selected for analysis between the two booklets. The calculated average score in table 3 represents the mean of these four scores for each participant.

Participant	Calculated average score	Predicted Score
N1	88%	A*
N2	88%	A*
N3	88%	A
N4	77%	A
N5	77%	A
N6	96%	A*

Table 3: Averaged score compared to predicted GCSE score. Average scores were calculated from a selection of 4 past paper questions.

From this result we can see that the intervention had limited success in besting the sampled students' predicted scores. We can also see that the random sample ended up being skewed towards higher ability pupils. Being a high ability triple award class, this is still somewhat representative. It is also important to keep in mind that predicted scores are usually inflated from "true scores" as they are set as a high bar for student achievement. Furthermore, GCSE scores are also calculated on a relative scoring system rather than the absolute grades calculated here. To address this limitation, if I were to run this intervention again, I would implement a mock pre-test and post-test condition.

Conclusion

Both successful futures and Wales' new curriculum emphasises the importance of teachers setting high expectations for learners. Expectations at key stage four and five are explicitly set by predicted exam scores. To meet these expectations pupils need effective revision tools that facilitate these ends. Based on the results above the active revision booklets were able to boost perceived confidence in pupils. The active revision booklets provided a scaffolded challenge for pupils that was both novel and effortful. This was intentional by design. The scaffolding of challenge represented efforts to take advantage of the guidance fading effect while the novelty of questions and effort was designed to maximise memory encoding based on both predictive coding theory and the supply-demand model of neuroplasticity. Perceived confidence may also have been boosted through the promotion of the growth mindset, a powerful positive psychology tool in increasing mental resilience and emotional intelligence amongst learners. While pupil scores remained largely unaffected relative to predicted GCSE scores the true effect may be masked by inflated predicted scores.

The primary limitation of this intervention is the time required for re-encoding and re-consolidation of information. This requires consistent spaced practice over time. This intervention could only be implemented and assessed once per week spanning three weeks. Another limitation is time constraints within the lessons. Even following the pilot run I still found it quite difficult to attain high completion rates of the active retrieval map and past paper questions while still having time for feedback. As all three are critical to effective retrieval practice, if I were to continue this intervention, I would chunk it down even further and potentially interleave the activity over multiple lessons. It would be interesting to consider setting up a micro-version of this intervention that still included the cycle of active retrieval, practice testing and feedback. It could then be established as a plenary or starter activity spaced across the school year. This spaced practice would allow for the consolidation periods required to facilitate stronger retrieval.

Summary of Developing Pedological and Educational Philosophy

The process of carrying out and reflecting on this intervention has contributed in many ways to my developing educational and pedagogical philosophy. For background, I fundamentally do not believe that success on an exam represents a “good” science education. I do not believe that exams as endpoints in education are conducive to good pedagogy. However, I am also pragmatic in the sense that these exams are deterministic and therefore teaching to the test in this environment is an essential priority if pupils are to have further academic opportunities. I have seen this represented in practice ubiquitously by fantastic teachers with so much more to offer.

These statements are not intended to undermine my intervention and the principles that inform it. These criticisms are mainly targeted towards a system that places too much emphasis on exam grades and hence motivates the over usage of educational practices that ultimately promotes skills that do not transfer to the world at large. With that said, looking forward, the material and intervention outlined here will still serve a positive benefit for my own future practice. The intervention and principles discussed are great tools in priming students with the semantic knowledge required to address and develop higher order skills such as good scientific inquiry and critical thinking. To play the game of chess you need to first learn and memorise the movement of the pieces. Only once you pass this initial threshold a world of possibility for creative critical thinking and inquiry opens. In future practice I will use the tools developed here to move students beyond this initial hurdle. This will allow more time spent exploring and developing higher ordered and more transferable skills.

While most of this paper covers topics central to cognitivism. I'd like to also touch on the influence of the growth mindset within my developing philosophy. Although difficult to evidence, I have found this principle hugely beneficial in practice. The growth mindset is a great tool in developing mental resilience and emotional intelligence within students as well as myself. When thinking about the ideal education I am confronted with answering what needs to be taught for pupils' future success. This is difficult because it

partly requires me to predict the future, something that not even the brightest and most funded hedge funds can do. Considering the unpredictability of the future, the only thing I can say for certain is that whatever future we try to prepare pupils for is not the future they will encounter. However, I am now more confident that the mental resilience and emotional intelligence that the growth mindset promotes creates well-adjusted individuals and lifelong learners that will be more capable in handling the challenges of the future as it unfolds.

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An evaluation of retrieval-based learning through active organisational processing techniques

Mitchell Shiell

APPENDIX (Evidence)

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Lesson 1

*Cells, Movement
Across Membranes
& Enzymes*

Class	Year 10 Triple
Topic	Series of weekly revision lessons covering various topics
Purpose of the Unit / Topic	Developing embedded knowledge schemas, expertise and confidence in approaching the GCSE examinations
Core purpose	ACL: 1, 2, 3 ECC: 5, 6, 7 HCI: 2, 7, 9

What will you do?	What will the learners be learning / doing?	Resources
Starter: Introductions Hand out posted notes Hand out Bingo sheets Provide bingo clues through text and visuals	Rank topic covered in terms of confidence RAG rate each topic First to line up 5 in a row wins (carry on activity regardless)	Post it notes Bingo Cards
Main: Hand out Active Retrieval Booklets, explain to students the objective Circulate the room, motivate students and promote growth mindset	Students complete the active revision map questions by using the revision guide notes	Active Revision notebook
Plenary: Past paper questions and class feedback Exit ticket - WWW/EBI	Pupils complete past paper question, depending on time we can do a peer assessment or hand in for teacher assessment (allows for evidence of standard) Following this revision lesson students reflect and provide feedback on the active revision booklet resource.	Past paper questions in active revision booklet Post it notes

Evaluation

For full guidance on this section, please [click here](#)

Learning: progress against the learning intentions	Learning: how did you know?	Teaching: what was the impact of what you did?
Students enjoyed the bingo activity and were able to engage with the material enthusiastically The revision maps were filled in and i was able to promote the growth mindset and mental resilience while addressing issues and misconceptions as i circulated the room	Revision guides are collected and briefly assessed following the lesson, during the lesson i actively circulate the room	The low stakes starter activity helped build relationships with the students that helped boost participation and students willingness to ask questions and reach out for help

Priorities for the next lesson (learning)	Priorities for the next lesson (teaching)
Did not have enough time for feedback on past paper questions, this was okay though as the class was engaged with the material, however it needs to become a priority as we move closer to their exams.	There are a few pupils who are currently discouraged especially since just finishing mocks and feeling as though they are "failing", I will try to ensure that i build confidence in these individuals as the revision lessons are an excellent opportunity for weaker pupils to develop confidence.

Evidence Lesson 1A: Lesson plan for pilot run of the active revision booklets. Learning intentions and success criteria are left out as the learning intentions reflect the specifications for the cells unit while the success criteria are all incorporated and achieved through completion of the active revision booklet.



Evidence Lesson 1B: To gather feedback on students' current confidence with the material I had them anonymously rank the topics from most to least confident on sticky notes. Following this I had them RAG rate each topic individually. The RAG rating system designates red topics unconfident, amber as fairly-confident, and green as confident. Of the 22 responses, cells, digestion, and respiration had an average ranking of 2 while circulation had the lowest average ranking of 3 with 55% of correspondents ranking it as their least confident topic.

Biology

Year 10 Triple

Active Revision Booklet:






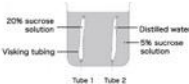

*Cells, Movement Across
Membranes & Enzymes*

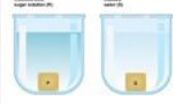
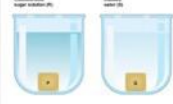
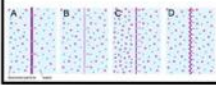
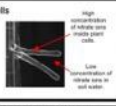


Name:

Class:

Contents

Active Retrieval map.....	4
Cells and Microscopy.....	6
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Describe how a sperm cell is adapted for its function. Function =	
Adaptations =	
Lipase break down lipids to: Protease breaks down proteins to: Carbohydrase breaks down starch to:	
What is the function of mitochondria in a cell?	
The real length of the following cell is 66 micro-meters. What is the magnification of the picture?	
Describe the effects of pH on an enzymes rate of reaction.	
What happens when an enzyme becomes denatured?	
Describe how a root hair cell is adapted for its function. Function =	
Adaptations =	
Label the structures within this bacterium that differ from an animal cell	
Describe what will happen to "Tube 2" in the diagram below.	
Label the structures found inside of this _____ cell	
What are the two most common biological stains and what do they stain for?	

Complete the table describing the differences:	State the advantages and disadvantages of a light microscope.								
<table border="1"> <thead> <tr> <th>Plant Cells</th> <th>Animal Cells</th> </tr> </thead> <tbody> <tr><td> </td><td> </td></tr> <tr><td> </td><td> </td></tr> <tr><td> </td><td> </td></tr> </tbody> </table>	Plant Cells	Animal Cells							
Plant Cells	Animal Cells								
Tissues are:	What is the function of the nucleus?								
Define/Describe the process of diffusion:	Can you predict what will happen to the pieces of potato in each beaker? Why?								
									
	Describe the uptake of nitrate ions by root hair cells.								
Label the structures found inside of this _____ cell									
	How do you calculate magnification?								
	Draw a simple labelled diagram of the lock and key model below								
	An undifferentiated cell is also known as a?								
	When a cell becomes specialised it is called?								
	What is the function of the chloroplasts in a cell?								
									

Evidence Lesson 1C: I produced the pilot active revision booklet on the cell's topic. Pictured above is the title page next to the table of contents and the active retrieval map. The active retrieval map spans two pages and covers all the content of the cell's topic. The answers to these questions can all be found from the revision notes found within the booklet. The information required to answer the retrieval map covers all the content for the past paper questions. This resource is an evidenced based design. For a more in-depth justification for its design refer to the literature review and subsequent justification of intervention found within the paper. Complete active revision booklets can be found on PLP.

Substances Enter and Leave Cells Through the Cell Membrane

Active Transport

When the concentration of a material is lower outside the cell it must be **actively transported** into the cell (sometimes referred to as **active uptake**).

During active transport, salts or ions are pumped from an area of low concentration to an area of higher concentration. This process requires energy released by the cell. This requires oxygen + ATP

Example – Uptake of nitrate ions by root hair cells

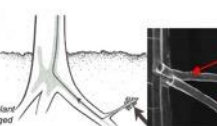


Fig. 1 Diagram of a plant root with enlarged view of a root hair cell.

- Nitrate ions cannot move in by diffusion.
- Nitrate ions must be actively transported from the soil water (an area of low nitrate concentration) to the inside of the plant cells (an area of high nitrate concentration).

Other examples of active transport include:

- Glucose actively transported from the small intestine into the blood.
- Marine algae can use active transport to concentrate iodine in their cells to concentrations a million times greater than surrounding sea water.

Factors affecting active transport

- Active transport needs **energy**.
- Energy is released during **respiration**.

Any factor that affects the rate of respiration will affect the rate of active transport:

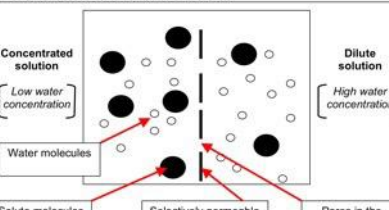
- Glucose concentration** – respiration needs glucose.
- Oxygen** – aerobic respiration needs oxygen.
- Temperature** – affects the enzymes controlling respiration.
- Toxic substances** – e.g. cyanide stops respiration.

Substances Enter and Leave Cells Through the Cell Membrane

Osmosis

Osmosis is the **diffusion of water molecules** from an area of high water concentration to an area of low water concentration through a **selectively permeable membrane**.

The cell membrane is **selectively permeable membrane**; it lets some molecules through but not others.



Concentrated solution (Low water concentration) | **Dilute solution** (High water concentration)

Water molecules | Solute molecules e.g. salts, sugars | Selectively permeable membrane | Pores in the membrane

The pores in the membrane allow small water molecules to pass through. The solutes are too large to pass through the pores in the membrane.

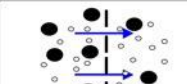


Fig. 1 The movement of water is from an area of high water concentration to an area of low water concentration through a selectively permeable membrane.

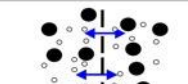


Fig. 2 No net movement of water. The concentration of water on both sides of the membrane is equal. The same numbers of water molecules move in both directions.

Substances Enter and Leave Cells Through the Cell Membrane

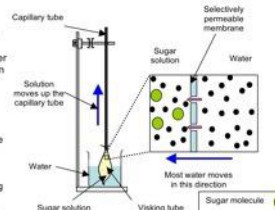
Osmosis Investigations 1 – Modelling Living Material

Visking tubing is very similar to the cell membrane. It is also a **selectively permeable membrane**. It has tiny holes (pores), which allow small molecules through, but stop molecules that are too large to fit through them.

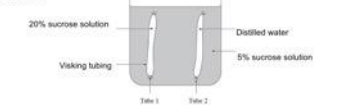
You will also come across visking tubing in experiments to do with the digestive system (See page 29).

Investigation 1

The concentration of water outside the visking tubing is higher than the concentration of water inside the visking tubing. Water moves in through the pores in the selectively permeable membrane by osmosis. This increases the pressure inside the visking tubing causing the solution to move up the capillary tube.



Investigation 2



Tube 1
Gets bigger (becomes turgid). The concentration of water outside the visking tubing is **higher** than the concentration of water inside. Water has moved in through the selectively permeable membrane by osmosis.

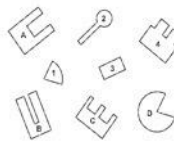
Tube 2
Gets smaller (becomes flaccid). The concentration of water inside the visking tubing is **higher** than the concentration of water outside. Water has moved out through the selectively permeable membrane by osmosis.

3. (a) Use some of the following words to complete the table about enzymes. [2]

fatty acids lipids amino acids glucose glycerol

Enzyme	Substrate	Products
protease	protein	
lipase		and

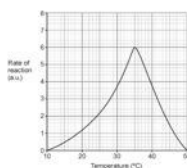
(b) The diagram shows four enzymes A – D and four substrates 1 – 4. [1]



Use your knowledge of the lock and key theory to complete the table below by matching each enzyme to its substrate. [1]

Enzyme	Substrate
A	
B	
C	
D	

(c) The graph shows the effect of temperature on the rate of an enzyme-controlled reaction between 10 °C and 50 °C. [2]




(d) From the graph, describe the effect of temperature on the rate of the reaction between 10 °C and 50 °C. [2]

(e) Most enzymes are denatured by boiling. Use your answer to part (d) to help explain why a denatured enzyme can no longer work. [2]

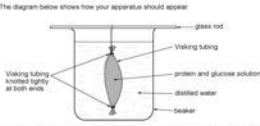
4. (a) State the meaning of the term diffusion. [1]

(b) After a lesson on the properties of cell membranes a year 10 class was asked to investigate some of these properties using Visking tubing. They were given the following instructions:

- Scale a 15 cm length of visking tubing in water to soften it.
- Tie a knot in one end of the tube.
- Fill the tube with a solution made up of protein and glucose dissolved in water.
- Tie a knot in the other end of the tube.
- Wash the tube under a stream of tap water for 15 seconds.
- Using a glass rod support the Visking tubing in a beaker of distilled water.



The diagram below shows how your apparatus should appear:



(c) Why were the students instructed to 'wash the tube under a stream of tap water for 15 seconds'? [1]

Evidence Lesson 1D: Each active revision booklet is constructed to holistically cover one unit. Here is an example of some Bangor revision sheets and some WJEC past paper questions covering the cells unit. The Bangor revision sheets serve as pre-made knowledge organisers for all the specification content within each unit. Past paper questions are selected to cover as much of the unit as possible and to address any misconceptions or areas of weakness relayed by my mentor. Using the marking schemes from the selected past paper questions I verify that the information is presented clearly within the revision sheets and adapt and edit the sheets where required. These sheets can be referenced by students if they are unable to retrieve the information on their own during the active retrieval map activity.

Describe how a sperm cell is adapted for its function.
Function = swims to egg cell
Adaptations = tail.

Lipase break down lipids to fatty acids + glycerol
Protease break down proteins to amino acids
Carbohydrase break down starch to simple sugars (glucose)

What is the function of mitochondria in a cell?
Where respiration happens, provides the energy.

The real length of the following cell is 65 micrometers.
What is the magnification of the picture?
 $\mu = 3.5 \text{ mm}$
 $65 \div 3.5 = 18.8571$
 $= 19$
magnification = 19x (whole number).

Describe the effects of pH on an enzyme rate of reaction.
Living system pH can denature an enzyme, the optimum pH will speed up the rate of reaction.
What happens when an enzyme becomes denatured?
It stops working as its active site has changed shape.

Describe how a root hair cell is adapted for its function.
Function = absorb water.

Label the structures within this bacterium that differ from an animal cell.
cell wall, cell membrane, nucleus, cytoplasm.

Describe what will happen to 'Tube 2' in the diagram below.
If it shrinks, higher water conc^o from solution it's in. Water will move from high water conc^o (Tube 2) to low water conc^o (15% sucrose solution) through partially permeable membrane (in living tubing) via osmosis.

Label the structures found inside of this animal cell.
nucleus, cell membrane, cytoplasm, mitochondria.

What are the two most common biological stains and what do they stain for?
methylene blue - nucleus, stain.

Complete the table describing the differences.

Plant Cells	Animal Cells
Variable	no vacuole
Chloroplasts	no chloroplasts
cell wall	no cell wall.

Tissues are:
groups of similar cells with similar functions.

Define/Describe the process of diffusion:
The movement of particles from an area of high concentration to low concentration, sped up by a steep + maintained concentration gradient, shorter distance to travel, optimum pH/temp and a larger surface area.

Label the structures found inside of this plant cell.
cell wall, cell membrane, cytoplasm, nucleus, chloroplasts.

State the advantages and disadvantages of a light microscope.
adv - allows you to see things in more detail.
disadv - low magnification.

What is the function of the nucleus?
controls the cell, contains DNA.

Can you predict what will happen to the pieces of potato in each beaker?
What? Potatoes in E will shrink, higher water conc^o from solution so water moves out of it. Potatoes in S will expand as it's lower water conc^o than the distilled water so water moves in to it.

Describe the uptake of nitrate ions by root hair cells.
Via active transport, ions go from low conc^o (soil water) to high conc^o (plant) up/against the conc^o gradient.

How do you calculate magnification?
Multiplication of the power of the eyepiece lens by the power of the objective lens.

An undifferentiated cell is also known as?
unspecialised
When a cell becomes specialised it is called?
differentiated.

What is the function of the chloroplasts in a cell?
to absorb sunlight for photosynthesis.

Evidence Lesson 1E: Example of a completed active retrieval map taken from the cell's active retrieval booklet. Boxes in green highlight retrieval map questions that match up with the past paper questions seen below. Relevancy to past paper questions was improved upon following the pilot run.

(a) Use some of the following words to complete the table about enzymes. [3]

fatty acids lipids amino acids glucose glycerol

Enzyme	Substrate	Products
protease	protein	amino acids
lipase	lipids	fatty acids and glycerol

(b) The diagram shows four enzymes A - D and four substrates 1 - 4.

Use your knowledge of the lock and key theory to complete the table below by matching each enzyme to its substrate. [4]

Enzyme	Substrate
A	3
B	2

(c) The graph shows the effect of temperature on the rate of an enzyme controlled reaction between 10°C and 50°C.

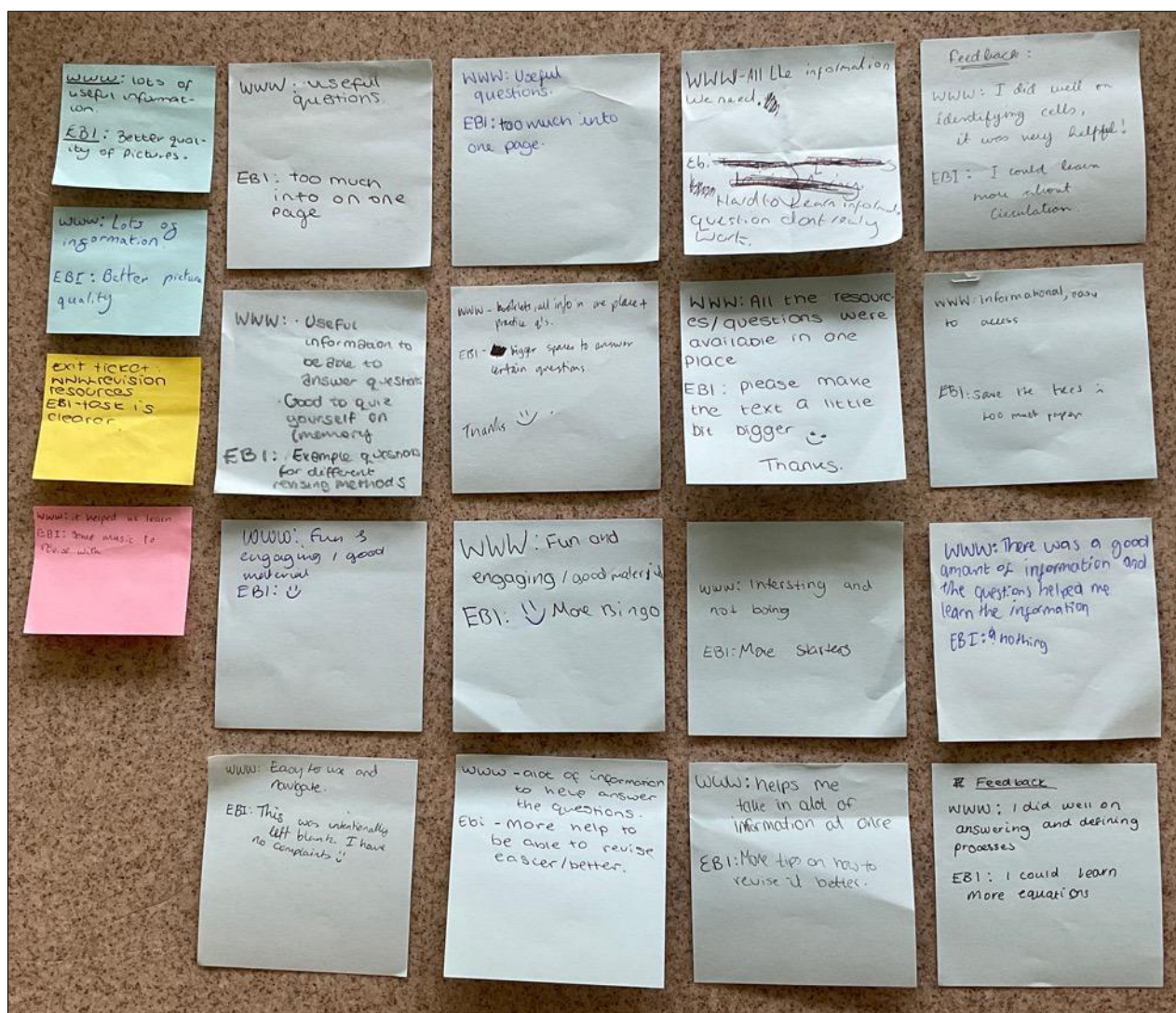
(i) From the graph, describe the effect of temperature on the rate of the reaction between 10°C and 50°C. [3]

As temp increases to 35°C, the rate of reaction increases and reaches its peak. Above 35°C, the enzyme is denatured so the rate of reaction decreases until it can no longer react.

(ii) Most enzymes are denatured by boiling. Use your answer to part (b) to help explain why a denatured enzyme can no longer work. [2]

Heat makes the enzyme expand and change shape. Its active site changes shape so the substrate can't fit.

Evidence Lesson 1F: Example of a completed past paper questions taken from the cell's active retrieval booklet. On this pilot run we did not have time for feedback and marking using green pens.



Evidence Lesson 1G: I collected anonymous feedback from the students regarding the active revision booklet in the form of a WWW/EBI (what went well / even better if) exit ticket. Feedback was collated and summarised in table 2 of the paper. Based on this feedback action was taken which included: bigger text, less questions (retrieval map and past papers), improving picture quality (printing issue) and expanding on clarity in the explanation of the task.



Lesson 2

The Circulatory System

What will you do?	What will the learners be learning / doing?	Resources
Starter: Who wants to be a millionaire	Using whiteboards students will answer 15 multiple choice questions in ascending difficulty If incorrect the student will hand in there white board and be given a class pop The student(s) who can hold on to their whiteboards the longest win	Who wants to be a millionaire ppt
Main: Hand out circulatory active revision booklet Explain the booklet (they should be familiar with it's design however it doesn't hurt to reiterate) Provide a target time of 20 mins to complete, set timer on board and circulate room	Students will use the revision guide to complete the active revision map on pages 4 and 5 of the booklet, these questions are developed to provide practice for future retrieval during the past paper plenary activity.	Circulatory system active revision booklet
Plenary: 20 mins past paper questions, silent activity Peer assessment will be completed at the start of the next revision lesson (spaced practice and delayed feedback)	Students will have 20 mins to complete the past paper questions at the back of the booklet	Circulatory system active revision booklet

Evaluation

[Click here](#) for guidance on this section

Learning: progress against the learning intentions	Learning: how did you know?	Teaching: what was the impact of what you did?
Students were enthusiastic and engaged with the material, they were able to answer most questions on the active retrieval map and we able to get some feedback on the past paper questions within the plenary of the lesson.	Students were able to fill in the active revision map questions and make progress on the past paper questions. These booklets are collected following the lesson for assessment.	Most of the impact of this lesson was within the preparation of the revision guide. This iteration had less questions on the retrieval map which created time for feedback and self assessment using green pens following the lesson.

Priorities for the next lesson (learning)	Priorities for the next lesson (teaching)
Next revision lesson we will focus on respiration and the respiratory system, I believe this was the second lowest in ranking when assessing the RAG rating activity from lesson 1.	Instead of doing a starter game I want to use direct instruction to emphasis the importance of a growth mindset when approaching the active revision booklet activity.

Evidence Lesson 2A: Lesson plan for the circulatory active revision booklet. This lesson was more streamlined in order to provide more time to complete the active revision booklet and provide time for feedback on the past paper questions.

Biology

Year 10 Triple

Active Revision Booklet:

Circulatory System

Name:

Class:

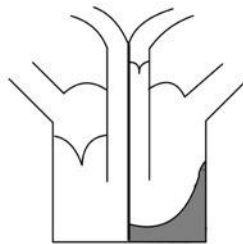
Contents

Active Retrieval map.....	4
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Draw a cross-section of an artery with a brief description.

Draw a cross-section of a vein with a brief description.

The following is an abstract artwork by an accomplished artist who wishes to remain anonymous. Label the diagram making sure to draw in the 2 missing structures. Add arrows and colors indicating the flow of blood (Blue for deoxygenated blood and Red for oxygenated).



Starting from the pulmonary artery describe the flow of blood to the right atrium.

Match the following:

Red blood cells

Plasma

Platelets

White blood cells

Carries dissolved substances

Defends the body against pathogens

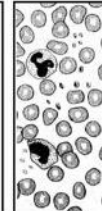
Carries Oxygen

Clotting of Blood

List some of the substances transported within plasma

Describe the function of platelets.

Label the picture to the left.



Draw, label and compare a red and white blood cell.

Complete the following table.

Treatment	Method	Advantages	Disadvantages
	Stopping smoking starting regular exercise eating more healthy food		
	Drugs taken daily		
			Sometimes only a temporary remedy

What is the role of the Coronary artery?

How does an atheroma lead to a heart attack?

Evidence Lesson 2B: Based on the feedback from the pilot run I made several adjustments to the booklets. The next active revision booklet, the circulatory system seen here, was made with less questions on the active retrieval map (and therefore less past paper questions) and bigger text (scaled down to fit this page). A greater variety of question answer styles were used as well. For a more in-depth justification of its design refer to the literature review and subsequent justification of intervention found within the paper. Complete active revision booklets can be found on PLP.

Blood and Circulation

A Historical Perspective

In the early 1600s William Harvey, a physician to King Charles I, suggested that the blood circulated around the body, flowing from the heart through arteries and returning through veins.

Harvey's Approach

Prior to Harvey's discovery, it was thought that the blood was formed in the liver, and was used up as it went around the body.

Harvey used a scientific approach, which included:

- Dissection of humans and other animals.
- A detailed study of the structure of the heart.
- Observation of living hearts in fish.
- Experiments on human circulation.
- Mathematical models.

The Human Circulatory System - A double circulatory system.

The blood must pass through the heart twice before completing one whole circuit of the body.




Fig. 1
William Harvey

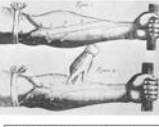


Fig. 2 Harvey's experiment on human circulation.

The Pulmonary circulation

Blood pumped from the heart to the lungs and back to the heart.

Oxygen enters the blood in the lungs.

The Systemic Circulation

Blood pumped from the heart to the body and then back to the heart.

Oxygen enters the blood in the lungs.

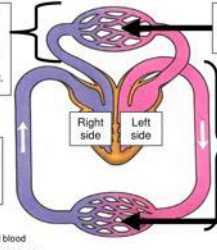


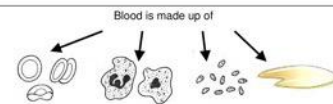
Fig. 3
Diagram showing a double circulatory system.

Oxygenated blood
Deoxygenated blood

Blood and Circulation

Blood

Blood is made up of



Red blood cells
carry oxygen

White blood cells
defend the body against pathogens

Platelets
clotting of blood

Plasma
carries dissolved substances

Fig. 1 - Illustration of the components of blood.

Examining blood smears

(These are diagrams you should be able to label)

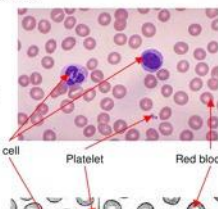


Fig. 2. Micrograph of a blood smear.
The centre of red blood cells appear paler because they have no nucleus and therefore more light from the microscope passes through them.

White blood cell Platelet Red blood cell

Fig. 3 - Illustration of blood smear

Blood and Circulation

The Heart

Structure of the Heart

The function of the heart is to pump blood. The heart is made of a special muscle called cardiac muscle.

There are blood vessels on the outside of the heart - the **coronary arteries**. These supply oxygen and glucose to the heart muscle. Without a steady supply of oxygenated blood the heart muscle couldn't keep contracting and pumping blood.

If a blood clot blocks a coronary artery, the heart muscles won't get enough oxygen and will stop working - this is a heart attack.


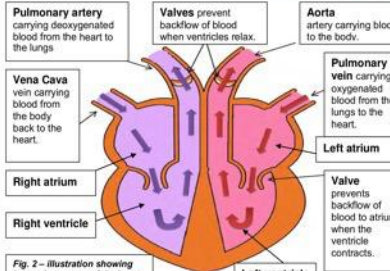


Fig. 1 - Illustration showing the outside of a human heart. The blood vessels shown are the coronary arteries.



Pulmonary artery carrying deoxygenated blood from the heart to the lungs

Valves prevent backflow of blood when ventricles relax.

Aorta artery carrying blood to the body.

Pulmonary vein carrying oxygenated blood from the lungs to the heart.

Left atrium

Valve prevents backflow of blood to atrium when the ventricle contracts.

Left ventricle

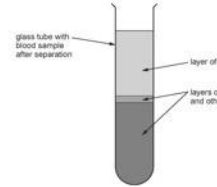
Right atrium

Right ventricle

Vena Cava vein carrying blood from the body back to the heart.

Fig. 2 - Illustration showing internal structure of the heart.

1. A sample of human blood was placed in a test tube and the contents were separated by spinning the tube at high speed in a laboratory centrifuge. The diagram below shows the results.



glass tube with blood sample after separation

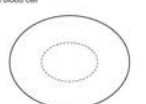
layer of liquid A

layers of blood cells and other parts of blood

(a) (i) The drawing below shows a red blood cell.

In the space, draw another type of cell which would be found in the sample.

State the name of the cell and its function. [2]



Red blood cell

Function - carries oxygen

Name of cell

Function

(ii) Name the liquid in layer A in the sample and state two substances which it transports. [2]

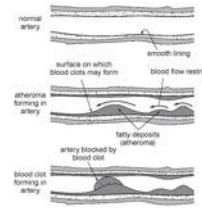
Name of liquid

Substances transported

1.

2.

2. The diagrams show fatty deposits (an atheroma) building up in an artery. One cause of this is high cholesterol. This may eventually cause a blood clot to form.



normal artery

smooth lining

surface on which blood clots may form

atheroma forming in artery

blood flow restricted

fatty deposits (atheroma)

artery blocked by blood clot

blood clot forming in artery

(a) Explain how an unbalanced diet and lack of exercise could lead to an atheroma formation. [2]

(b) Name a group of drugs which reduces the chance of build-up of fatty deposits in arteries. [1]

(c) Explain how an atheroma may lead to a heart attack. [2]

5

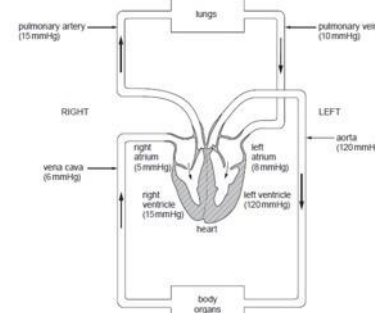
4. In one complete circulation of the body, blood passes through the heart twice. The blood travels:

- from the heart to the lungs and then back to the heart in the pulmonary circulation and then;
- from the heart to the other organs of the body and back to the heart in the systemic circulation.

This double circulation is essential for the functioning of highly active animals such as mammals.

The diagram below represents the double circulation in humans. It shows the direction of blood flow and the pressure of the blood in various blood vessels in a healthy 25-year-old woman at rest.

The pressure of the blood is measured in mmHg (millimetres of mercury).



pulmonary artery (15 mmHg)

lungs

pulmonary vein (10 mmHg)

RIGHT

right atrium (5 mmHg)

right ventricle (15 mmHg)

LEFT

left atrium (5 mmHg)

left ventricle (120 mmHg)

heart

vena cava (5 mmHg)

aorta (120 mmHg)

body organs

Evidence Lesson 2C: Here is an example of some Bangor revision sheets and some WJEC past paper questions covering the circulatory system unit. As with the previous active revision booklet, the Bangor revision sheets serve as pre-made knowledge organisers for all the specification content within each unit. Past paper questions are selected to cover as much of the unit as possible and to address any misconceptions or areas of weakness relayed by my mentor. Using the marking schemes from the selected past paper questions I verify that the information is presented clearly within the revision sheets and adapt and edit the sheets where required. These sheets can be referenced by students if they are unable to retrieve the information on their own during the active retrieval map activity.

Draw a cross-section of an artery with a brief description.

Draw a cross-section of a vein with a brief description.

The following is an abstract artwork by an accomplished artist who wishes to remain anonymous. Label the diagram making sure to draw in the 2 missing structures. Add arrows and colors indicating the flow of blood (Blue for deoxygenated blood and red for oxygenated).

Starting from the pulmonary artery describe the flow of blood to the right atrium.

- carries deoxygenated blood from heart to lungs
- pulmonary vein carries oxygenated blood lungs-heart
- Left atrium
- Aorta carries blood to body
- vena cava carries blood from body to heart.
- Right atrium
- Right ventricle
- pulmonary artery.

Match the following:

Red blood cells	Carries dissolved substances
Plasma	Defends the body against pathogens
Platelets	Carries Oxygen
White blood cells	Clotting of Blood

List some of the substances transported within plasma

- Urea
- Nutrients
- Hormones

Describe the function of platelets.

- platelets help to clot blood and form scabs over open cuts

Label the picture to the left.

Draw, label and compare a red and white blood cell.

Complete the following table.

Treatment	Method	Advantages	Disadvantages
Change to lifestyle	Stopping smoking starting regular exercise eating more healthy food	Reduces risk of CVD	Self-discipline needed
Statins	Drugs taken daily	Orally taken.	- can forget to take them
Angioplasty	Small balloon in artery	Improved blood flow	Sometimes only a temporary remedy

What is the role of the Coronary artery?

To deliver nutrients and oxygen to the heart muscle.

How does an atherosclerosis lead to a heart attack?

Restricts blood flow through the arteries, depriving the heart of oxygen and nutrients.

Evidence Lesson 2D: Example of a completed active retrieval map taken from the circulatory system active retrieval booklet. Boxes in green highlight retrieval map questions that match up with the example past paper questions seen below. Relevancy to past paper questions was improved upon in this iteration.

3. The diagram below shows the double circulation of blood found in humans.

(a) Label blood vessels A and B on the diagram above.

(b) Occasionally a baby is born with a hole in the wall that separates the left and right sides of the heart. In the diagram below this hole is shown in the wall separating the right and left ventricles.

Using the diagram of the double circulation of blood shown opposite and your knowledge of blood circulation, explain the consequences to a person suffering from a hole between the right and left ventricles of the heart.

The contractions of the heart would be effected. Because oxygenated and deoxygenated blood may mix. Causing the baby to have an irregular heart beat. Meaning not enough oxygen will be supplied to cells, tissues and organs.

- Blood flows through left and right ventricles

(b) Occasionally a baby is born with a hole in the wall that separates the left and right sides of the heart. In the diagram below this hole is shown in the wall separating the right and left ventricles.

Using the diagram of the double circulation of blood shown opposite and your knowledge of blood circulation, explain the consequences to a person suffering from a hole between the right and left ventricles of the heart.

The contractions of the heart would be effected. Because oxygenated and deoxygenated blood may mix. Causing the baby to have an irregular heart beat. Meaning not enough oxygen will be supplied to cells, tissues and organs.

- Blood flows through left and right ventricles

Evidence Lesson 2E: Example of a completed past paper question taken from the circulatory system active retrieval booklet. Here you can see self assessed feedback in green pen. The improved timings of the lesson allowed adequate time for whole class feedback.



Lesson 3

Respiration & The Respiratory System

What will you do?	What will the learners be learning / doing?	Resources
Starter: Discuss importance of resilience and the growth mindset when approaching challenges and failures. Hand out respiratory system active revision booklet	Get seated with equipment on desk ready to work	respiratory system active revision booklet
Main: 20 minutes to complete the active retrieval map	Students will use the revision guide to complete the active revision map on pages 4 and 5 of the booklet, these questions are developed to provide practice for future retrieval during the past paper plenary activity.	respiratory system active revision booklet
Plenary: 20 minutes Past paper questions 10 minutes feedback on past papers	Students will have 20 mins to complete as many of the past paper questions at the back of the booklet Using green pens students will correct and assess their work compared to the marking scheme	respiratory system active revision booklet

Evaluation

[Click here](#) for guidance on this section

Learning: progress against the learning intentions	Learning: how did you know?	Teaching: what was the impact of what you did?
Students were on task and working on the booklets for the larger majority of the lesson, they were able to answer more questions on both the retrieval map and past papers.	Books were collected, checked and scanned onto my ipad following the lesson.	Students generally displayed a greater degree of perseverance and were more relaxed and confident when writing answers. Highlighting the growth mindset at the start of the lesson framed the activity nicely as being a low stakes individually developmental activity.

Priorities for the next lesson (learning)	Priorities for the next lesson (teaching)
This was the last of the revision lesson, marking schemes will be posted onto the teams drive for pupils to reference when using the booklets for their revision	Within the next lesson I will conduct an anonymous post intervention survey to gather data and feedback on the intervention.

Evidence Lesson 3A: Lesson plan for the respiratory system active revision booklet. This lesson further improved on the timing and pace of the lesson allowing adequate time for feedback on the past paper questions. It also incorporated the direct instruction of the growth mindset and how it can be used to benefit the students.

Biology

Year 10 Triple

Active Revision Booklet:

*Respiration
& the Respiratory
system in humans*

Name:

Class:

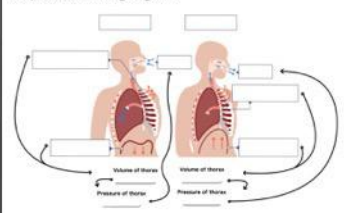
Contents

Active Retrieval map.....	4
Revision Notes.....	6
Past Paper Questions.....	16

Respiration is controlled by a series of _____ therefore the rate of respiration is affected by?

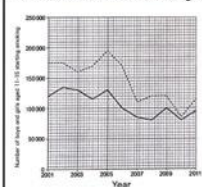
How are alveoli adapted for gas exchange?

Complete the following diagram.



When we lose mass through exercising where does the mass go? Write out the appropriate word equation with your answer.

What two trends are shown in the graph below?



What is an oxygen debt?

Complete the following table.

	Aerobic	Anaerobic
Oxygen consumed (not needed)		
Products		
ATP Produced (more/less)		

What cell produces lactic acid?

What are the functions of cilia and mucus in the cleaning of the lungs?

Complete the following using the word bank below.

Aerobic respiration occurs when _____ is available. Compared to anaerobic respiration aerobic respiration produces more molecules of _____. This is because glucose is _____ broken down. This is an _____ of aerobic respiration.

Anaerobic respiration occurs when the blood _____ to the _____. In anaerobic respiration glucose molecules are _____ broken down. Therefore, anaerobic respiration produces _____ molecules of ATP. This is a _____ of anaerobic respiration. Anaerobic respiration also produces:

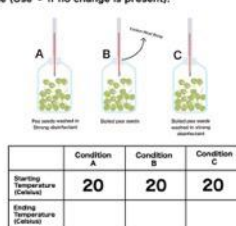
- 1)
- 2)
- 3)

Word Bank:

oxygen fewer advantage cannot supply sufficient disadvantage ATP completely muscle incompletely

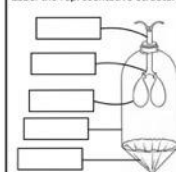
What are the effects of smoking on cilia & mucus?

Have a look at the experiment below. Complete the results table using arrows to indicate the magnitude and direction of change (Use '-' if no change is present).



Why were the peas boiled? Why was disinfectant used?

Label the representative structures.



What structures are missing?

Evidence Lesson 3B: This iteration of the active retrieval booklet carried much of the same design elements as the prior booklet. In this booklet, I continued to ensure a variety question and answer formats were used to maximise the novelty factor. Again, for a more in-depth justification of its design refer to the literature review and subsequent justification of intervention found within the paper. Complete active revision booklets can be found on PLP.

Respiratory System

Breathing

Breathing in (Inspiration)

1. Intercostal muscles contract. Rib cage moves up and out.
2. Diaphragm contracts, moves down and flattens.
3. Volume of thorax increases.
4. Pressure inside thorax decreases.
5. Lungs inflate and draw air into the lungs.

Breathing out (Expiration)

1. Intercostal muscles relax. Rib cage moves down and in.
2. Diaphragm relaxes and moves up.
3. Volume of thorax decreases.
4. Pressure inside thorax **decreases**.
5. Air pushed out of the lungs.

Respiratory System

Gaseous Exchange in the Alveoli

The alveoli are the **respiratory surface** of the lungs. The alveoli are full of air and are covered on the outside by blood capillaries.

Oxygen **diffuses** across the walls of the alveoli from the air into the blood. Carbon dioxide **diffuses** across the walls of the alveoli from the blood into the air in the alveoli.

Fig. 1 Outside view of alveolus.

How are alveoli adapted for gaseous exchange?

1. **Good blood supply**
So that more gases can be exchanged.
Red blood cells (carry oxygen)
2. **Large surface area**
Increases gaseous exchange. (Provided by a large number of alveoli.)
3. **Thin walls**
Gases can pass through by diffusion much easier.
4. **Moist lining**
To dissolve oxygen so that it can diffuse through the alveolus wall.

Fig. 2 View of alveolus cut open.

Respiratory System

Differences between inspired air and expired air

Inspired air is breathed in and expired air is breathed out. The body absorbs oxygen from inspired air and adds carbon dioxide and water vapour to expired air.

- Expired air has less oxygen than inspired air.
- Expired air has more carbon dioxide than inspired air.
- Expired air has more water vapour than inspired air.

	Inspired air	Expired air
Oxygen	21%	16%
Carbon dioxide	0.04%	4%
Water vapour	Varies	Saturated
Nitrogen	79%	79%

Limewater test for carbon dioxide

The limewater turns cloudy.

Keeping the Lungs Clean

The air you breathe contains dust, bacteria and viruses. The alveoli are very delicate, so the air has to be 'cleaned' before it reaches them.

Tracheal cells with cilia
Cilia move the mucus.
Mucus producing cells

The mucus traps any dust and bacteria in the air.

- The cilia move the mucus out of the lungs into the back of your throat in a wave like motion (like a Mexican wave).
- You swallow the mucus and acid in the stomach destroys any bacteria.

This prevents all prevents bacteria/dust/mucus entering the lungs

An investigation compared the composition of inspired and expired air. This is shown in the table below.

Gas	% Concentration of air inspired	% Concentration of air expired
oxygen	20.9	16.0
carbon dioxide	0.04	4.0
water vapour	variable	variable
nitrogen	78.1	78.1

(a) (i) Calculate the difference in the % concentration of oxygen in the expired air and the inspired air. [1]

difference = _____ %

(ii) State the process in cells that uses oxygen and glucose to release energy. [1]

(b) People with a disease called ARDS (Acute Respiratory Distress Syndrome) have difficulty getting enough oxygen. The diagrams show a healthy alveolus and an alveolus from someone with ARDS.

(i) Draw an arrow on the diagram of the healthy alveolus, to show the direction of movement of oxygen through the alveolar lining. [1]

The graph below shows the efficiency of the lungs (how well they work) in three different groups of people: non-smokers, smokers who stopped smoking at the age of 50 and heavy smokers.

(a) What is the difference in percentage efficiency of a 60 year old non-smoker and a 60 year old heavy smoker? [1]

_____ %

(b) (i) Continuing to smoke heavily can damage the lungs and lead to disability. At what age does the graph above show this disability occurring? [1]

(ii) Suggest what the lung damage mentioned in (i) could be. [1]

Explain how the bell jar model shown below can be used to illustrate inspiration (breathing in). In your explanation you must state which organs in the body are represented by the balloons and rubber sheet in the model. [5 QWC]

Evidence Lesson 3C: Here is an example of some Bangor revision sheets and some WJEC past paper questions covering respiration and the respiratory system. As with the previous active revision booklet, the Bangor revision sheets serve as pre-made knowledge organisers for all the specification content within each unit. Past paper questions are selected to cover as much of the unit as possible and to address any misconceptions or areas of weakness relayed by my mentor. Using the marking schemes from the selected past paper questions I verify that the information is presented clearly within the revision sheets and adapt and edit the sheets where required. These sheets can be referenced by students if they are unable to retrieve the information on their own during the active retrieval map activity.

Respiration is controlled by a series of reactions therefore the rate of respiration is affected by?
Enzymes

How are alveoli adapted for gas exchange?

1. Good blood supply
2. Large surface area
3. Thin walls
4. Moist lining.

Complete the following diagram.

When we lose mass through exercising where does the mass go?
Write out the appropriate word equation with your answer.
Water and carbon dioxide are waste products that the body must get rid of.
 $\text{Glucose} + \text{Oxygen} \rightarrow \text{Water} + \text{Carbon dioxide} + \text{Energy}$

What two trends are shown in the graph below?

1. The number of boys and girls aged 11-15 starting smoking are decreasing
2. The difference between the number of boys and girls starting smoking is decreasing

What is an oxygen debt?
Breathing deeply after finishing exercise to get oxygen to the muscle means that lactic acid is broken down.

Complete the following table.

	Aerobic	Anaerobic
Oxygen (needed/not needed)	needed	not needed
Products	ATP Energy	Lactic acid
ATP Produced (more/less)	more	less

What cell produces lactic acid?
muscle

What are the functions of cilia and mucus in the cleaning of the lungs?
Cilia moves the mucus. The mucus traps any dust and bacteria in the air.

What are the effects of smoking on cilia & mucus?
Smoke from tobacco paralyses cilia in the trachea. Mucus becomes clogged and the cilia cannot sweep it away.

Complete the following using the word bank below.

Aerobic respiration occurs when oxygen is available. Compared to anaerobic respiration aerobic respiration produces more molecules of ATP. This is because glucose is completely broken down. This is an advantage of aerobic respiration.

Anaerobic respiration occurs when the blood cannot supply sufficient to the muscle. In anaerobic respiration glucose molecules are incompletely broken down. Therefore, anaerobic respiration produces fewer molecules of ATP. This is a disadvantage of anaerobic respiration. Anaerobic respiration also produces:

1) Lactic acid
2) ATP
3) Carbon dioxide

Word Bank:
oxygen fewer advantage cannot supply sufficient disadvantage ATP completely muscle incompletely

Have a look at the experiment below. Complete the results table using arrows to indicate the magnitude and direction of change (Use '+' if no change is present).

	Condition A	Condition B	Condition C
Starting Temperature (Celsius)	20	20	20
Ending Temperature (Celsius)	32	28	20

Why were the peas boiled? Why was disinfectant used?
As the bacteria would also respire and produce heat.

Label the representative structures.

What structures are missing?
intercostal muscles
alveoli
bronchioles

Evidence Lesson 3D: Example of a completed active retrieval map taken from the respiration and respiratory system active retrieval booklet. Boxes in green highlight retrieval map questions that match up with the example past paper questions seen below.

The following word equations show the two types of cell respiration which occur in humans.

Equation 1

$$\text{Glucose} + \text{Oxygen} \rightarrow \text{Carbon dioxide} + \text{Water} + \text{ATP}$$

Equation 2

$$\text{Glucose} \rightarrow \text{Lactic acid} + \text{ATP}$$

Name each of the types of cell respiration shown above and write an account explaining when each occurs in the human body. Include any advantages or disadvantages of each type of respiration. [6 QER]

Equation one is aerobic respiration. This type of respiration takes place when oxygen is present so it is able to break down more glucose and more energy will be produced. This is an advantage.

Equation 2 is anaerobic respiration and this takes place when there's a low supply of oxygen, so lactic acid will be produced. A disadvantage is that less energy will be produced because there's not enough oxygen for.

4. Explain how the bell jar model shown below can be used to illustrate inspiration (breathing in). In your explanation you must state which organs in the body are represented by the balloons and rubber sheet in the model. [6 QWC]

The bell jar model can illustrate inspiration because the rubber sheet is pulled down, this represents the diaphragm contracting so volume in the thorax increases and pressure decreases. The balloons represent the lungs and they inflate when we breathe in.

Evidence Lesson 3E: Example of a completed past paper question taken from the respiration and respiratory system active retrieval booklet.



Lesson 4

Follow-up Survey

Circle your confidence rating for each of the following topics:

Cells Unconfident fairly-confident confident

Respiratory System Unconfident fairly-confident confident

Circulatory System Unconfident fairly-confident confident

Questions	1 (Strongly Disagree)	2 (Disagree)	3 (Neutral)	4 (Agree)	5 (Strongly Agree)
In general, I feel more confident with the material than before					✓
I am more confident approaching exam questions.				✓	
How difficult would you rate the active retrieval maps? (1=Easy, 5 =Very difficult)			✓		
If you are reading this, please select three/neutral.			✓		
How difficult would you rate the past paper questions? (1 = Easy, 5 = Very difficult)				✓	
The active retrieval map activity helped me to answer the past paper questions.					✓

(Optional Feedback)

The active retrieval map has helped a lot with preparations for exams. ☺

Evidence Lesson 4A: Example of completed anonymous survey. The survey indicated that from the perspective of the class the revision materials made them more confident with both the material and approaching exam questions. In the survey pupils were asked to rank the difficulty of both the active revision maps and past papers question sections. As expected, the difficulty of the active retrieval map was scored lower than the difficulty of the past paper questions. This indicates that the scaffolding of difficulty inspired by the guidance fading effect did occur. Furthermore, pupils on average ranked the active retrieval maps difficulty at 3/5 indicating that effortful practice was occurring, an important factor discussed surrounding the supply demand theory of neuroplasticity. Additionally, this effortful practice was in line with the ability of the pupils providing the most optimal conditions for plasticity to occur. Lastly, pupils generally agreed that the retrieval map questions presented a novel challenge and that the retrieval maps helped them in answering the past paper question. This evidence serves as another indication that the resource fulfilled its intentions.



Supplemental Evidence




Ethics Checklist

The Cardiff School of Education and Social Policy has adopted the British Educational Research Association's Ethical Guidelines for Educational Research, fourth edition (2018). The guidelines can be viewed by going to <https://www.bera.ac.uk/researchers-resources/publications/ethical-guidelines-for-educational-research-2018>.

• I have familiarised myself with the BERA Ethical Guidelines.	✓
I undertake to:	✓
• respect and protect the anonymity of the school, all participants and groups;	✓
• minimise any possible risk or disruption to the on-going life of the school, participants or groups;	✓
• explain the following to participants where relevant e.g. during data collection such as interviews, questionnaires, etc.	✓
• the purpose of the research;	✓
• the use to be made of the data;	✓
• that they have the opportunity to withdraw from the research at any time without prejudice;	✓
• provide evidence in my assignment that ethical considerations have been addressed.	✓
I have discussed the ethical implications of the research with my tutor, senior mentor and mentor.	✓
I have obtained consent to undertake this research from the Senior Mentor/Mentor at my Lead Partnership School.	✓
If photographs or videos have been included, the school has signed a "Written Permission to Use Photos or Videos" document.	✓

Please submit this form to your tutor

Make sure it has been signed and approved by your personal tutor and research champion.

Signed: 	(Student teacher)	Date: May 3, 2022
Approved by:		
	(Personal tutor)	Date: May 3, 2022
	Senior Mentor/Mentor	Date: May 3, 2022

Cardiff Partnership
for Initial Teacher Education

Partneriaeth Caerdydd
ar Gyfer Addysg Ddiwyddol I Athrawon

Supplemental Evidence A: Ethics form signed by my mentor, personal tutor and me.

Partneriaeth Caerdydd ar gyfer Addysg Gychwynnol i Athrawon

Written Permission to Use Photographs or Videos of a Child/Young Person for Academic and Professional Practice (to be issued by the Head Teacher)

Student teachers on ITE programmes at Cardiff Metropolitan University are required to undertake classroom-based research and enquiry and may, where appropriate, benefit from using media as evidence of learning. Student teachers are required to seek permission from their Head Teacher prior to this being undertaken and be fully aware of the pupils whose parents/guardians have not given permission to the school.


In line with the Cardiff Partnership Child Protection Policy and Student Teacher Code of Conduct, written permission is required from schools for the use of photographs or videos for academic and professional practice.

Programme/Subject/Year: PGCE Secondary Biology 2021/2022

Student Teacher: Mitchell Shiell

School: Cardiff Corpus Christi Catholic School

I agree to give permission for photographs or videos to be taken and used in support of student teachers' work whilst on their Initial Teacher Education programme.

Signed (Head Teacher):  Date: 25/4/22

An electronic copy of this form – with signatures – must be housed in the student teacher's Professional Learning Passport.