HIAS Moodle+ resource

Precise Learning

Planning and teaching science so that all students understand what is essential to make good progress

The document describes why teaching so that every student keeps up is a key challenge for teachers today. It offers a model of planning and teaching that seeks to address this challenge.

At the end of the document there are several examples of lessons where teachers describe how they have tried to apply this model.

The Precise Learning model has been developed and trialled by the Hampshire Leading Science Group for three years.

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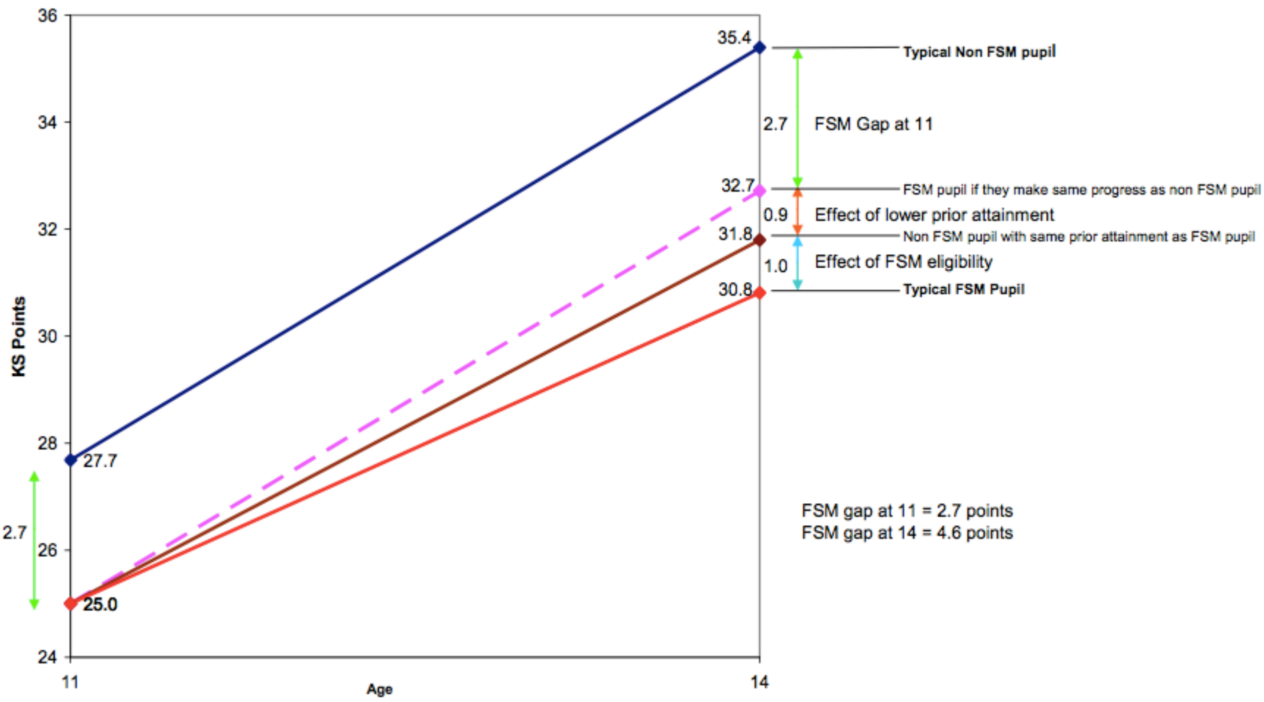
The importance of keeping up

Students from backgrounds of relative poverty on average attain significantly less than other students. At every key stage they fall further and further behind, and as they do so the problems they experience due to relative depravation are increasingly compounded by increasing gaps in their knowledge and understanding.

The graphs below show that students entitled to free school meals enter secondary school with significantly lower attainment than other students, i.e. they have less curriculum knowledge and what they do have is less secure. Even if they were to make the same rate of progress as other students they would still have significant gaps in their knowledge and understanding by the end of Key Stage 3. This would inevitably make further learning difficult because ideas learned at KS4 build upon those learned at KS3. Unfortunately these students make less progress than others partly due to gaps in prior knowledge and partly due to the impact of relative deprivation.

Figure 4-15: Relative impact of FSM eligibility and prior attainment on progress made between Key Stage 2 and Key Stage 3



The consequences of this evidence are profound. Tackling the attainment gap by aiming for free school meals students to make the same progress as others will fail, it will perpetuate the problem caused by gaps in knowledge making further learning difficult. If the gap in attainment is to be closed pupils entitled to FSM will need to make greater progress than other students, but how will this be achieved?

A common model for intervention involves analysing periodic assessment, identifying gaps in knowledge and understanding and then seeking to address these through extra teaching. If the periodic assessment highlights common problems across a whole class planning to address these is relatively straightforward but usually different students have different gaps. Even after seven or eight weeks of teaching the class profile of what students do and don't understand is inevitably complex and as a result it is extremely difficult for teachers to help every student catch up. It is also too late to wait six or seven weeks before intervening, especially for children who already have weak prior knowledge. Knowledge and skills are progressive, they build upon each other and failure to understand the first idea makes it unlikely the one that builds upon it will be understood. For all students, but particularly those that come to us with poor prior knowledge, identifying what they struggle to understand needs to be identified ***as they are learning*** and before it makes further learning problematic. Hence the phrase ***keep up not catch up***

"Precise Learning" is a model of planning and teaching developed to enable all students to understand enough to access the next stage in learning, whether that be the next 10 minutes of a lesson, the next lesson, topic, year or key stage. It is a model for keeping up so that catch up is less necessary.

Although the model was originally developed to address the needs of students with poor prior attainment it has been found to be equally effective at ensuring higher attaining students achieve more.

The model draws upon the work of John Hattie as described in his book Visible Learning. Hattie found there to be a strong correlation between a student's prior and future attainment. This will come as no surprise, but he found that many things that teachers do are **more** influential in determining future attainment than a student's prior attainment. The key highly effective aspects of teaching that lead to high attainment are:

1. **Effective feedback.**
   The feedback students receive that helps them understand what they have done well and what they need to improve is very helpful, but even more important is the feedback teachers seek **from** students in trying to identify how they are learning what is being taught.
2. **Teacher Clarity**
   Students who understand what they are learning and why they are learning it learn more quickly and deeply. A teacher who is absolutely clear in their own mind precisely what they need all students to learn and what the building blocks to achieving this learning are more likely to share this journey effectively with students.
3. **Deep understanding requires surface learning**
   Deep understanding or mastery involves the confident use of ideas in a range of contexts. However sophisticated ideas are constructed and built from other ideas many of which may be very simple (what he calls surface understanding). A failure to ensure these simpler ideas are well understood will make understanding and therefore confident application of more complex ideas unlikely. Hattie explains the importance of teachers understanding the relationship between ideas and skills (progression) and ensuring all students don't have gaps in these foundation ideas before expecting them to understand more complex ideas.

The Precise Learning model is an application of these three key findings to the planning and teaching of science.

It is called the ***Precise*** Learning model because defining what must be learned precisely and unambiguously is at its heart. When teachers are absolutely clear what they want students to understand they are less likely to accept vague responses that disguise a lack of understanding that if left unchecked leads to students falling behind. The problem of imprecision is deep rooted and challenging to overcome, even the National Curriculum is imprecise. At KS3 every statement begins with "Pupils should be taught about". One person's "about" is very different from another's, which raises problems when planning for progression across a department, and can lead to teachers accepting inadequate responses so long as they are "about" the subject matter. For example the KS3 national curriculum states:

"Pupils should be taught about:

- *Exothermic and endothermic chemical reactions (qualitative)."*

What does this mean every student must understand? Is it enough for them to be able to label reactions that get hot as exothermic or do they need to know that this happens as a result of energy transfers from the system or do they even need to know this happens as a result of bonds being made, or even further do they need to understand that the total strength of bonds in the products exceeds that of the reactants? All of these are "about" exothermic reactions but represent significantly different degrees of understanding and teachers could easily accept any of these responses and still be teaching the National Curriculum. It is critical that departments and teachers decide and define with precision exactly what students must understand over the key stage, in a topic and in a lesson.

The same problem can be seen in the following example. In a year 10 GCSE lesson the following learning objectives were shared with students:

"Pupils should know:

- *What type 1 and type 2 diabetes are.*
- *How they are treated.*
- *What lifestyle factors make them more likely"*

These are appropriate learning objectives but unless we are clear what students need to understand when answering these questions we are likely to accept poor quality responses. In this lesson a student wrote: *"Diabetes is the second biggest killer disease in the UK and a million people don't even know they have it. It is caused by a lack of insulin"*. The teacher ticked the answer because they knew what the learning objectives were but had not thought what precisely they wanted pupils to understand from the lesson.

> Defining precisely the knowledge and understanding all students must attain is an essential aspect of *Precise Learning.*

Teaching students to be scientific

As science teachers we don't just want students to understand ideas for the sake of it or simply because they might one day be tested upon them, we want them to use the knowledge and skills we teach them to be scientific. Science is about trying to work out how the universe works, ideas are used to suggest why things might have happened and make predictions about what might happen. Other knowledge, skills and attributes are needed to test these ideas and look for patterns of behaviour of materials, living things and physical phenomena. Precise learning lessons lead to students using the important knowledge and skills to engage in some meaningful and engaging science, but science that can only be tackled through the application of the new knowledge and skills taught.

> Giving students an immediate purpose for learning new knowledge and skills is an essential aspect of *Precise Learning.*

We need to deconstruct the problems we set students to identify the knowledge and skills essential for tackling them. We then need to check students have these knowledge and skills and teach them those they don't before expecting them to successfully tackle the problem. This process of deconstructing can be quite challenging. Here are some examples of scientific problems deconstructed to identify the knowledge essential to tackle them.

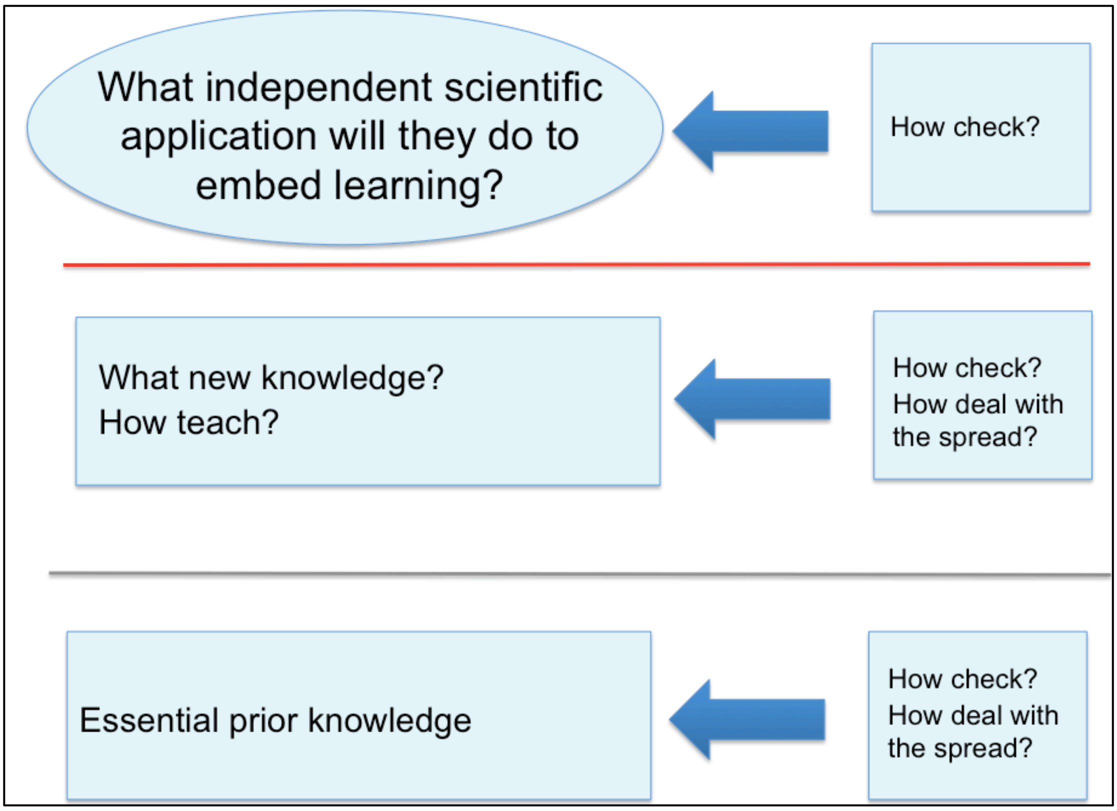
<table>
<tr><th>Engaging and meaningful science</th><th>Knowledge and skills that must be understood to engage in the science</th></tr>
<tr><td>Why did the lid fly off when the empty tin was heated but not when the tin was filled with concrete and heated?</td><td>In solids particles are bonded and vibrating. The particles vibrate faster when heated.
In gases particles are moving very fast and are far apart. The particles move faster when heated
All particles have mass.
When particles collide with something energy is transferred.
Faster moving particles have more energy
Energy is always transferred from particles with a lot to particles with a little.</td></tr>
<tr><td>Finding absolute zero temperature through measuring the volume of a fixed mass of gas at different temps, plotting V against T and extrapolating back until the line crosses V=0.</td><td>In solids particles are bonded and vibrating. The particles vibrate faster when heated.
All particles have mass
All particles have a volume
Line graphs can be extended beyond the data collected to predict results that have not been measured.
The further a line is extrapolated the greater the likely error when interpolating.</td></tr>
<tr><td>Predict the skeleton and position of muscles of different organisms from what they look like and observations of how they move.</td><td>Bones are connected via moveable joints
Muscles are connected to bones through tendons
Muscles move bones by contracting and pulling
Muscles usually work as antagonistic pairs, as one muscle contracts the other relaxes allowing the joint to move in both directions.
Larger muscles exert larger forces.
Larger muscles are attached to stronger bones.
Vertebrates have internal skeletons that provide protection for vital organs and support the animal.</td></tr>
</table>

Deconstructing scientific problems to identify what students must be taught to tackle problems is an essential aspect of *Precise Learning.*

Some of these essential ideas may be prior learning and some might be new and require teaching, identifying which are which is important. Teachers need to check that all students have the essential prior knowledge and support those that don’t. New ideas need to be taught and the teacher needs to check that every student understands them before students are set free to tackle the problem.

Visualising the *Precise Learning* model

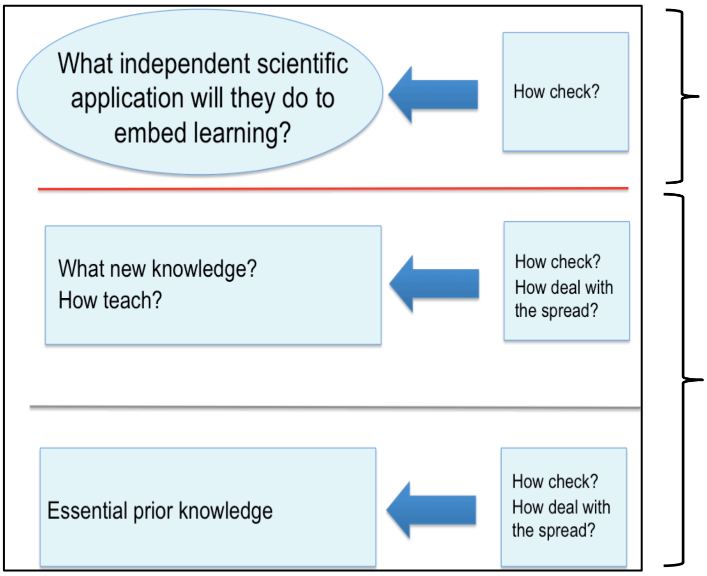
This approach is summarised in the model below:



It summarises the key questions teachers need to consider when planning a Precise Learning lesson

> Checking then ensuring pupils have the essential prior and new learning is an essential aspect of *Precise Learning.*

Every stage in planning lessons this way can be challenging, it requires an investment of time and takes practice. It is important to remember the key driver for the model: ***to plan and teach so that we have done everything we can to prevent any student from falling behind***, but at the same time challenging students with meaningful scientific problems where they have to apply their learning. I.e. we need to stretch students who are ready but develop secure understanding for all. We can see hoe the model supports both these aims.



This is an opportunity for students to apply their knowledge independently of the teacher. Students able to do this are demonstrating a more secure understanding of knowledge and skills. It also provides an opportunity for teachers to focus on students who had not reached the “red line” and ensure they keep up.

This represents the knowledge and skills that all pupils must understand to progress. It is the foundation of further learning. Students that fail to understand this new learning will fall behind.

The red line represents what every student must attain

Checking that every student understands at key points in the lesson and intervening where appropriate to ensure all keep up is challenging, but unless it is planned for and done well students will fall behind. However, we need to be absolutely clear what precisely it is we need to check. The Precise Learning model makes it easier to identify exactly what must be checked.

Checking how well all students are learning at a key point in a lesson is always going to be difficult and the evidence gathered will always have a degree of inaccuracy. All we can do is try our best to find out. Sometimes checking is a simple matter of looking over students shoulders at diagrams e.g. can they draw force arrows correctly or do they know the direction of electrical messages during a nervous stimulus and response. Other times more careful assessment is required that may involve talking and listening to a student explain something; in these cases we may only have time to have discussions with three students, in which case we will make inferences about others based upon these discussions. In these cases we need to select the students we talk with carefully…our indicator species perhaps.

There are many ways in which we can check if students are learning, we need to select the most efficient way to get the information we need to enable us to make judgements about what to do next to ensure that all students keep up.

Examples of lessons planned using the Precise Learning model

Teachers use a variety of scaffolds to help them plan using this model, but in each case they plan to answer the key questions posed above. A proforma to support teachers in beginning to use this approach is shown below.

<table>
<tr><td colspan="2">Prior learning

New Learning</td></tr>
<tr><td colspan="2">Scientific problem to be tackled</td></tr>
<tr><td>Time line</td><td>Checking learning of all</td></tr>
<tr><td colspan="2">Final check of learning</td></tr>
</table>

Example 1: A lesson to teach students how the fractionating column separates alkanes.

There are many ways in which this knowledge can be taught; using the precise model we need to think of how the knowledge learned can be used to engage in meaningful and challenging scientific problem solving. In this case the teacher has decided that students will work out for themselves how the fractionating column works.

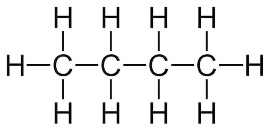
The next job is to work out precisely what a student must understand to be able to tackle this problem; these ideas should include knowledge defined by the GCSE specification or the schools KS3 scheme of work. To identify the essential knowledge it helps to consider carefully what response would be appropriate. This might resemble:

- Crude oil is a mixture of alkanes. Alkanes are chains of hydrocarbons of varying length.
- The crude oil is heated so that all of the alkanes are vapourised.
- The vapour enters the bottom of the fractionating column where it rises.
- As it rises it cools

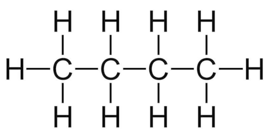
- Different alkanes have different boiling temperatures and as each alkane cools to its boiling temperature it condenses.
- Larger alkanes have higher boiling temperatures because their intermolecular attractions are greater. As the mixture of gases rise up the fractionating column they cool; the larger alkanes condense lower in the column where it is warmest. At these temperatures it is too hot for the smaller alkanes to condense.
- As the vapour mixture rises smaller and smaller alkanes condense as the temperature drops.
- Alkanes condense at the height in the fractionating column that matches their boiling temperature.

We now need to consider what a student would need to understand to be able to work an answer like this out. There is no fixed answer to this; it depends on what the teacher would like students to work out for themselves or what they would prefer to teach them directly. It is important to try and define the ideas that students need precisely; not to say things like “they must understand about the structure or alkanes” or they must understand “how boiling points of alkanes vary”.

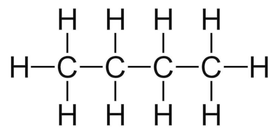
In this case the teacher defined what must be understood as:

Crude oil is a mixture of alkanes.
C and H have valences of 4 and 1 respectively
Alkanes have the general formula C_nH_{2n+2}.
Alkanes have the structure 
All molecules attract each other.
Bigger molecules have stronger intermolecular attractions than smaller ones.
Materials lose energy and cool as they move further from a heat source.
The boiling temperature is the temperature at which a liquid boils to become a gas, which is the same temperature at which the gas condenses to a liquid.

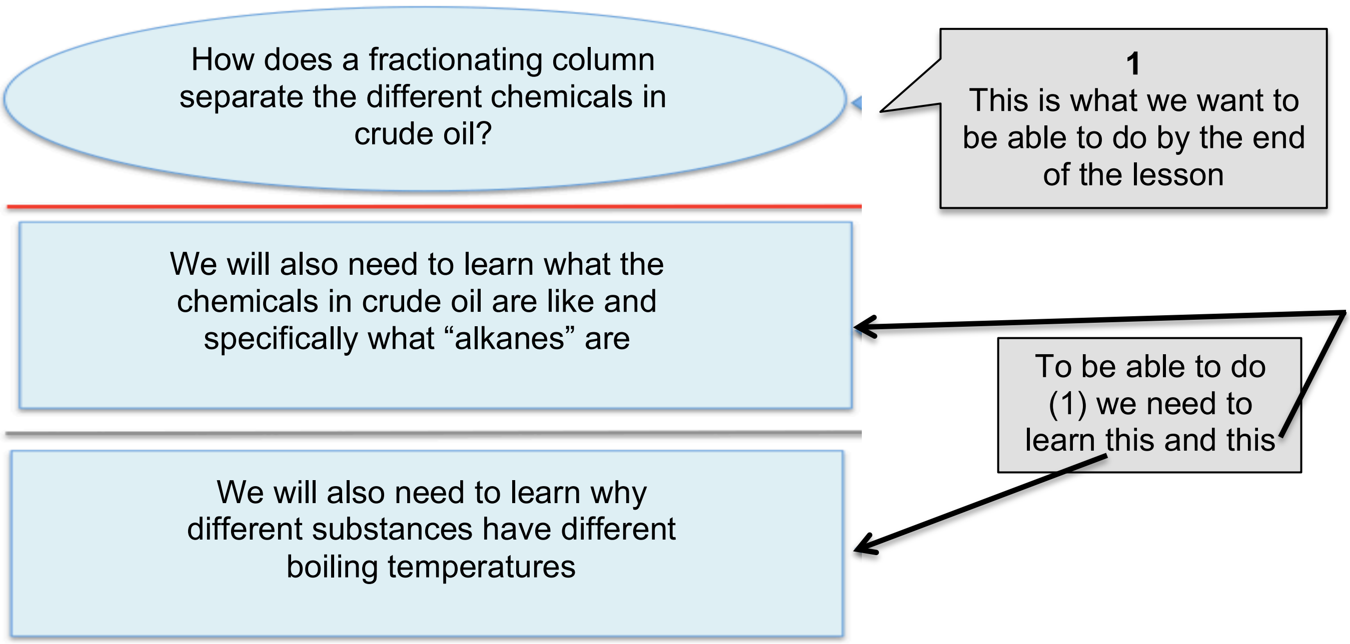
The teacher then divides this knowledge into what should be prior learning and what will be new learning. Again there is no fixed answer to this, it will depend upon where this lesson fits within a topic and where the topic fits in the long term plan. It also depends greatly upon what was taught in KS3. So the teacher has to make judgements

Crude oil is a mixture of alkanes.	New
C and H have valences of 4 and 1 respectively	Prior KS3
Alkanes have the general formula C_nH_{2n+2}.	New
Alkanes have the structure 	New
All molecules attract each other.	Prior KS3
Bigger molecules have stronger intermolecular attractions than smaller ones.	New
Materials lose energy and cool as they move further from a heat source.	Prior KS3
The boiling temperature is the temperature at which a liquid boils to become a gas, which is the same temperature at which the gas condenses to a liquid.	Prior KS3

These ideas seem to fall into two categories: those that help us explain variation in boiling temperatures and those that help us describe what alkanes are

Ideas to help describe what alkanes are	Crude oil is a mixture of alkanes.	New
	C and H have valences of 4 and 1 respectively	Prior KS3
	Alkanes have the general formula C_nH_{2n+2}.	New
	Alkanes have the structure 	New
Ideas to help explain variation in boiling temperatures	All molecules attract each other.	Prior KS3
	Bigger molecules have stronger intermolecular attractions than smaller ones.	New
	Materials lose energy and cool as they move further from a heat source.	Prior KS3
	The boiling temperature is the temperature at which a liquid boils to become a gas, which is the same temperature at which the gas condenses to a liquid.	Prior KS3

We now have a rough structure for a lesson that could also be shared with students



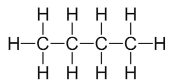
The task now is to consider how these ideas will be taught and how learning will be checked. The teacher's lesson plan using the proforma above is shown below.

Prior learning

All molecules attract each other.
Materials lose energy and cool as they move further from a heat source.
The boiling temperature is the temperature at which a liquid boils to become a gas, which is the same temperature at which the gas condenses to a liquid.
C and H have valences of 4 and 1 respectively

New Learning

Crude oil is a mixture of alkanes.
Alkanes have the general formula C_nH_{2n+2}.
Alkanes have the structure



Bigger molecules have stronger intermolecular attractions than smaller ones

Scientific problem to be tackled

To explain how the fractionating column separates alkanes

Time line

Describe LO through PP and explain what needs to be understood first. Make some 'crude oil by mixing up some different fractions to show that it is a solution.

Remind of terms inter and intra-molecular bonds and teach that the former are weaker and break upon boiling (e.g. of H_2O). (Teacher lead)

Give b.p. of halogens and ask them to think about why the bp increases down the group (insist on using inter / intra terminology). (Group work, teacher draw out examples of ideas, establish idea that larger molecules have larger intermolecular attractions, analogy of surface area and Velcro, and therefore higher bp)

State that the components are called ***alkanes***, made from C and H only. Remind them of valences of C and H and ask them to construct molecules that have 2, 4 and 5 C atoms. (Group work, correcting where errors made and noting if anyone thinks of double bonds or cyclic alkanes, make point that alkanes are the simples hydrocarbon etc)

Give out a formulae, structure and name sheet and insist they use the names correctly from now on. Ask them how many Hs would be on a molecule with 50 C atoms, quickly establish the C_nH_{2n+2} rule.

Remind of the LO, show real Frac Column and then the simple one and let them tackle the puzzle* (Group work, offer clue cards and provide bespoke support)

All pupils write either a long answer or label a diagram of Frac Column describing and explaining how alkanes are separated from crude oil. Exam conditions and 10 min.

Hwk: Give out diagram of frac column with more details, inc bubble caps and trays and names of fractions. They learn how the caps and trays work and find two uses of each fraction and be ready for quick test next lesson.

Checking learning of all

Now we know exactly what we need all students to understand, what is new learning and what is prior and what problem they will tackle with this knowledge. We now need to identify the ***key moments*** in the lesson where all students must keep up, decide how we are going to check and what we will do with the spread that is found.

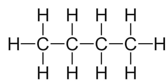
Final check of learning

Prior learning

All molecules attract each other.
Materials lose energy and cool as they move further from a heat source.
The boiling temperature is the temperature at which a liquid boils to become a gas, which is the same temperature at which the gas condenses to a liquid.
C and H have valences of 4 and 1 respectively

New Learning

Crude oil is a mixture of alkanes.
Alkanes have the general formula C_nH_{2n+2}.
Alkanes have the structure



Bigger molecules have stronger intermolecular attractions than smaller ones

Learning Objective

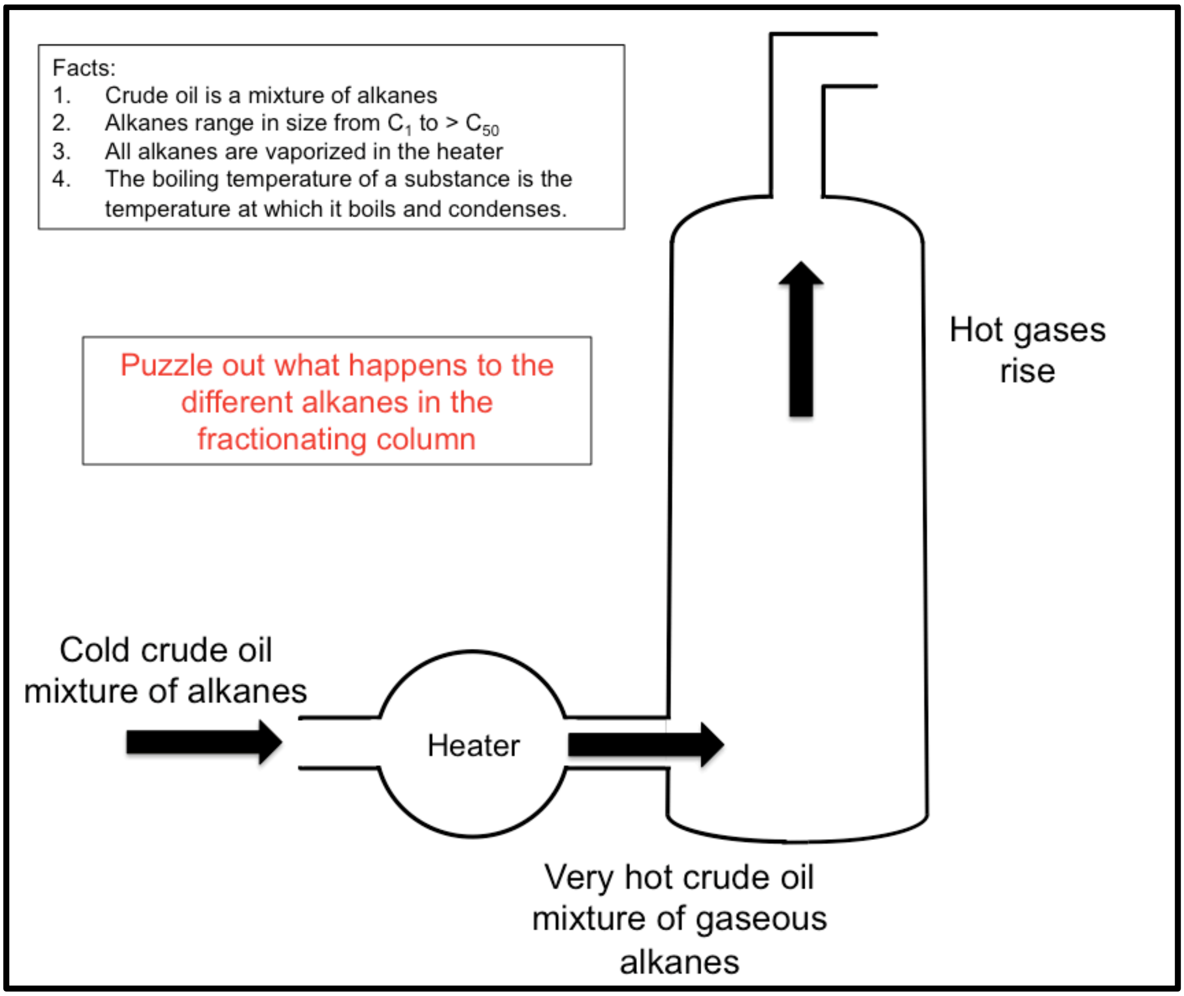
To explain how the fractionating column separates alkanes

Time line	Checking learning of all
Describe LO through PP and explain what needs to be understood first. Make some 'crude oil by mixing up some different fractions to show that it is a solution.	Q: do you all know what need to be able to do by end? Ask if anyone unsure
Remind of terms inter and intra-molecular bonds and teach that the former are weaker and break upon boiling (e.g. of H_2O). (Teacher lead)	
Give b.p. of halogens and ask them to think about why the b.p. increases down the group (insist on using inter / intra terminology). (Group work, teacher draw out examples of ideas, establish idea that larger molecules have larger intermolecular attractions, analogy of surface area and Velcro, and therefore higher bp)	Quick PP showing similar particles, inc molecules of different sizes. Use white boards to put bp in right order
State that the components are called ***alkanes***, made from C and H only. Remind them of valences of C and H and ask them to construct molecules that have 2, 4 and 5 C atoms. (Group work, correcting where errors made and noting if anyone thinks of double bonds or cyclic alkanes, make point that alkanes are the simples hydrocarbon etc)	Circulate looking at pictures
Give out a formulae, structure and name sheet and insist they use the names correctly from now on. Ask them how many Hs would be on a molecule with 50 C atoms, quickly establish the C_nH_{2n+2} rule.	White boards. Find someone with diff answer and explain how you got it. Re-do white boards.
Remind of the LO, show real Frac Column and then the simple one and let them tackle the puzzle on big bit of paper with Frac Col (Group work, offer clue cards and provide bespoke support)	Focus time on those that struggled with previous ideas.
All pupils write either a long answer or label a diagram of Frac Column describing and explaining how alkanes are separated from crude oil. Exam conditions and 10 min.	Marking of work
Hwk: Give out diagram of frac column with more details, inc bubble caps and trays and names of fractions. They learn how the caps and trays work and find two uses of each fraction and be ready for quick test next lesson.	

Final check of learning

- **Class work marking**
- **Quiz outcomes at beginning of next lesson**

* The "puzzle" students are given to tackle will be given to tackle



General comments on the lesson:

- In this case the prior learning was checked and gaps acted upon ***in*** the lesson. How and when to check essential prior learning is an important decision. If the teacher judges that gaps in prior learning can be addressed quickly without holding back the rest of the class then checking at the beginning of the lesson is fine. If on the other hand the essential prior learning gaps are likely to be more complex then a more careful checking needs to take place and intervention needs to be planned so that other students are not held back. In these cases it is sensible to check essential prior learning before the lesson starts. This could be done at the end of a previous lesson or through the use of homework.
- Five learning checks were identified within the lesson. Two of these involved circulating in order to listen and watch. It is important that wherever possible checking learning should be done through observing how students are managing the activities rather than stopping the class to do a separate activity. This ensures a better pace of learning and better differentiation. A lesson containing five learning checks each requiring the whole class to stop and undertake a white board activity for example would likely over run and become very disjointed for students.
- In this lesson the teacher has judged the best way to assess their ability to apply the ideas independently in solving the problem is to mark their written work. Not every piece of work can be marked in this detail and so it is important that teachers reserve this time for important pieces of student's writing. In this case the teacher decided not to mark the homework but check it through a simple quiz at the beginning of the next lesson.

Example 2: A lesson teaching students to understand the carbon cycle Steve Smith, Thornden School.

Context:

This lesson was taught to a set 2 Year 10 class following the AQA Core Science and Additional Science specification. Most pupils in the class are working at a C grade. There are several weak, but hard working pupils as well as some very lazy pupils who are underachieving. The lesson is about the carbon cycle. In previous lessons in this topic they had covered decay and at the start of the year they had covered basic cell structures and processes.

The planning (see annotated lesson plan):

I really wanted pupils to understand the carbon cycle rather than to just be able to label a diagram and name some of the processes involved. By really thinking about what pupils needed to have in their heads to understand the carbon cycle I decided that pupils had to have a firm grasp of the chemistry involved. The fundamentals were:

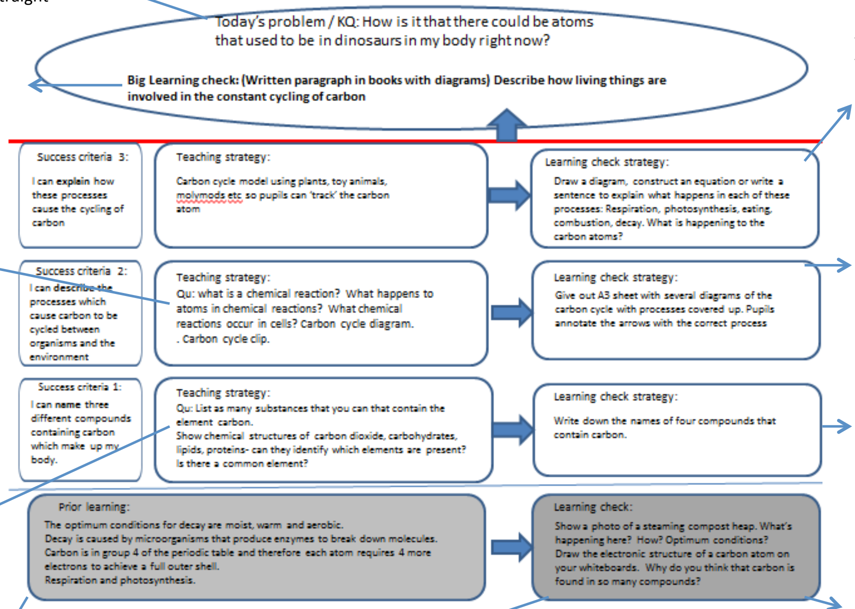
- In a chemical reaction the atoms of the reactants become rearranged to form new products
- Chemical reactions occur in cells

I wanted pupils to be able to visualise the cycling of carbon at a molecular level in the cells of organisms so decided to start with the structure of a carbon atom and the reason why it is found in so many different substances. I then built this up to looking at carbon in molecules and how the molecules make up cells. Only once this was understood I thought that pupils would have an understanding of how the processes that occur in living things allow the carbon to be cycled. I planned to check the learning at specific points of the lesson using ‘small’ learning checks that would enable me to identify pupils that didn’t quite get it and to adapt the teaching for them. To assess the deep learning I planned to use a ‘big’ learning check which I would then take in to identify what I would need to do differently in the following lesson.

The planning process

The 'hook' question to get pupils engaged in the learning straight away.

The big learning check is the key assessment that I planned to take in and mark.



I really wanted to 'see' what's in the pupils' heads and so encourage the use of diagrams

Pupils need to understand that atoms are rearranged in a chemical reaction to really understand how the carbon is cycled.

The aim was to check pupils could identify the processes in different carbon cycle diagrams.

A very quick and simple learning check as all I want them to do is to be able to recall this.

This builds on thinking of carbon at the atomic level to the molecular level

By really thinking about the prior learning it made me approach the lesson at a deeper level of thinking than I had before.

The purpose of the steaming compost heap was to recap the previous lesson about decay, but to see if pupils could relate the process of respiration to heat being released by the microbes.

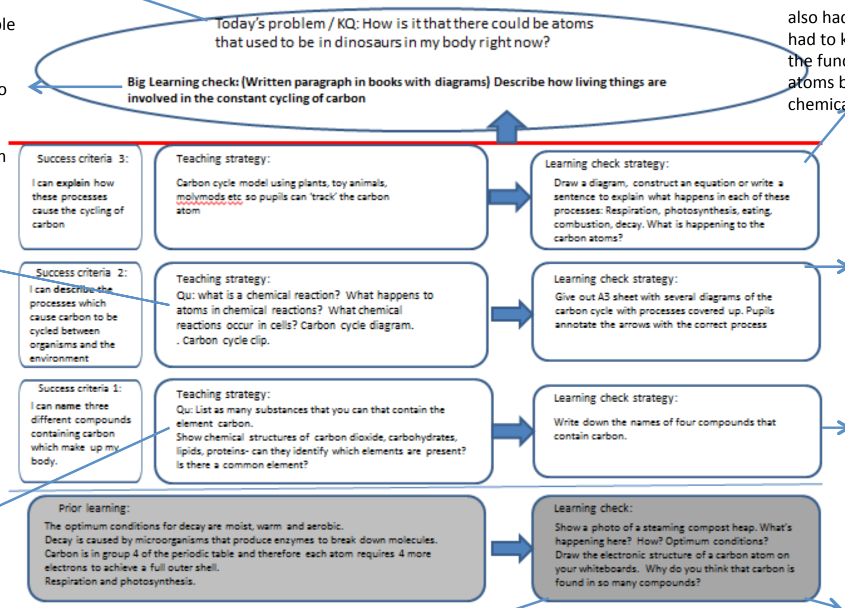
The aim of getting pupils to draw the electronic structure of carbon was to revisit how to use the periodic table, but to get pupils to focus on carbon at the atomic level and then build up to molecules and then cells. If they could grasp this then they would be able to 'visually' track the cycling of carbon within different compounds between the atmosphere and living things.

The teaching process

This question together with a picture of a dinosaur really did engage pupils as they entered and there was a general disbelief that this was possible.

This was really useful and I had to teach what exactly happens during eating because digestion hadn't been taught yet. Combustion also had to be taught again. I had to keep relating back to the fundamental concept that atoms become rearranged in chemical reactions.

Most pupils were able to describe the carbon cycle, but pupils didn't seem to refer to how the carbon atoms were being cycled through each of the processes..



Most pupils were able to do this quite quickly. Some pupils were confused when the carbon cycle was presented in a different format. I was able to circulate and intervene where necessary.

I really had to make it clear that cells are made up of the molecules that contain carbon..

Pupils had heard of these compounds before so it was just a case of ensuring that they had learnt that they all contain carbon.

Pupils could only come up with carbon dioxide.

Pupils had varying ideas about what the steam was, but by focused questioning they were able to make the link between respiration and heat.

Pupils were able to draw the electronic structure of carbon and tell me that carbon required 4 more electrons to achieve a full outer shell but they were a bit vague about how. I decided to go over definitions of element and compound and to briefly recap how atoms bond as I really wanted them to focus on the chemistry of the carbon cycle.

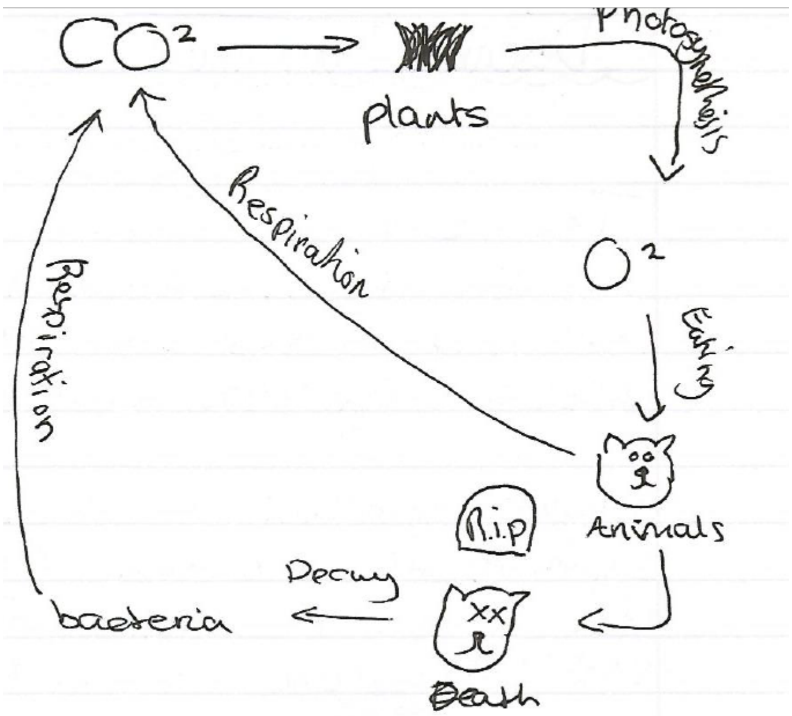
The teaching (see annotated lesson plan and examples of pupils' work):

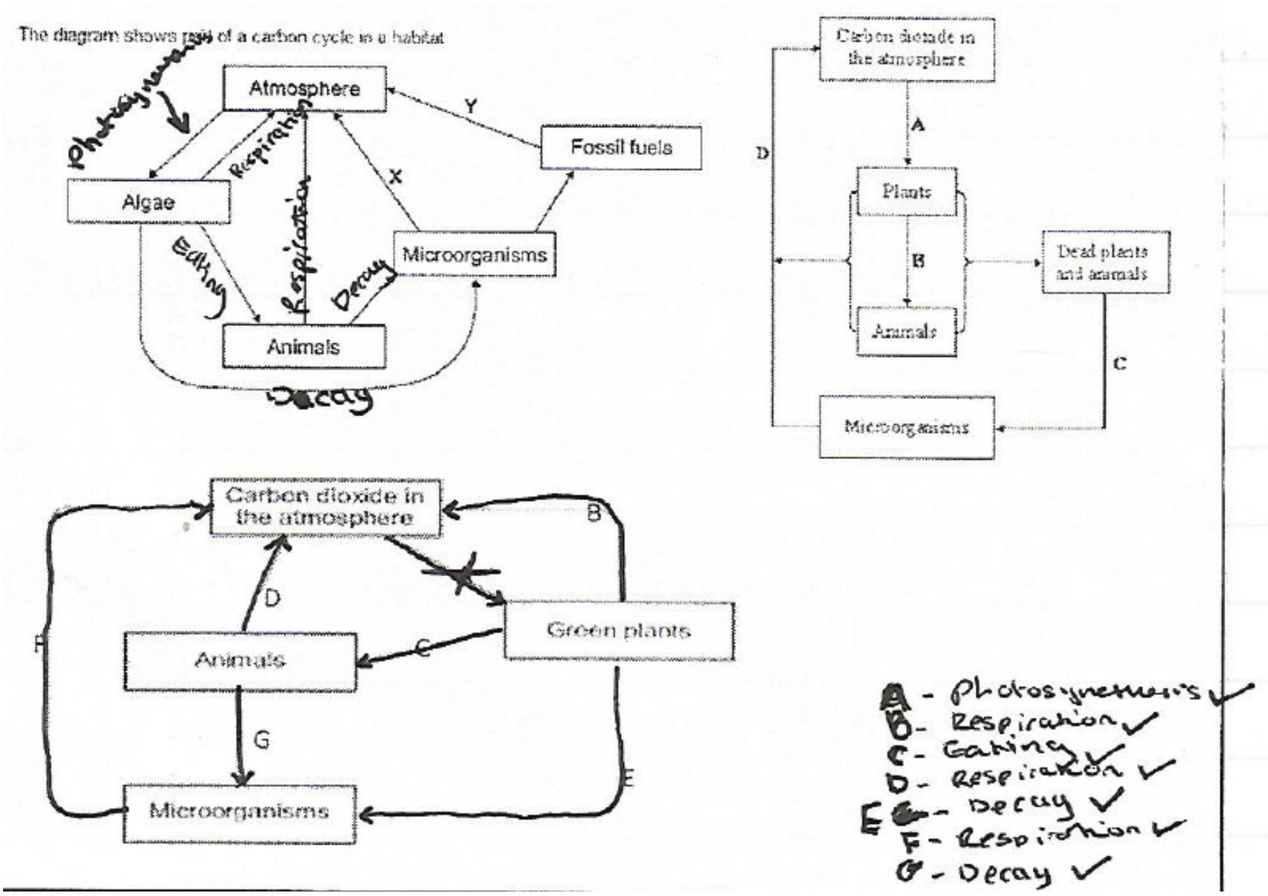
The main 'small' learning check involved pupils annotating the arrows on several carbon cycle diagrams. This was very effective as I was able to circulate and quickly see which pupils had got it. By then pulling this all together by doing a similar task on the board together as a class it was clear that pupils were confident with this. What I found most difficult to assess in the lesson was their true understanding of the key processes such as respiration and photosynthesis. They were asked to draw diagrams, construct equations, or write a sentence about each process. It seemed that most pupils understood each process as they were constructing the word and in some cases the symbol equations. However, it wasn't until i set them the 'big' learning check that it was evident that for some pupils they only had a surface learning understanding of some of these. E.g

- *'With carbon dioxide in the air it produces photosynthesis to the green plants'*
- *'carbon is photosynthesised into plants and trees'*
- *'when an animal dies it decays into the atmosphere which causes respiration'*

By marking the 'big' learning check ('describe how living things are involved in the cycling of carbon') it was clear that pupils could state some of the processes involved in the carbon cycle but were much more vague when it came to describing how the carbon was found in each organism e.g as carbohydrate in a plant. Some pupils the structure of pupils' responses also varied greatly. Several pupils had found it difficult to start their written response.

Small learning checks:





Big learning check pupil A:

Living things are involved in the cycle of carbon because carbon is photosynthised into plants and trees etc which are eaten by animals so they gained by animals in their systems and when an animals dies it decays into the atmosphere which causes respiration which goes back to plants etc. Microorganisms are added to this because they decompose the animals and take the nutrience from animals

How I responded in the next lesson:
To address these issues I started the next lesson by asking the pupils to complete the table below so that they linked the process to the organism and then to the compound that contained carbon. I also showed them how this could be used as a writing frame to structure their answers.

Organism involved in carbon cycle	Process	Compounds containing carbon

living things / organism	Process	compound containing carbon
Animals Green plants microorganism	Eating Respiration * + Respiration + Decay	Carbon dioxide (CO_2 Protein, fat, carbohydrate

* Photosynethis

Improved responses:

Pupil A:

firstly green plants use carbon dioxide from the atmosphere in photosynthesis to make glucose. Then animals eat the green plants which gives them carbon and they store it as fat. Fineally when animals die the microorganisms come and feed of the bodies causing decay. The microrginisms then respire which sends the carbon back into the atmosphere

Pupil B:

firstly green plants use carbon dioxide from the atmosphere in photosynthesis to make glucose. Then the animals eat the plants and get the carbon and store it as proteins or fats. From the animals to the microorganisms the process is decay and the same from plants ~~to~~ to microorganisms. The Microorganisms then release ~~do respiration~~ ~~to~~ carbon dioxide into the atmosphere when they respire.

Example 3: A lesson teaching students about osmosis. Nigel Brown, Warblington School

Context:

The class: Year 10 Triple Science (33 students), all achieving B+, a few very high achievers, a few who often don't 'get it' straight away.

The Lesson: Osmosis. B4d of OCR Gateway. I was doing this lesson at the start of the B4 unit as I wanted students to understand osmosis so that they could apply it in their explanations during the rest of the unit (leaf adaptations for photosynthesis, transpiration, food preservation).

Planning:

In the previous lesson we had recapped 'diffusion' and set up pieces of potato in different concentrations of sugar solution.

I wanted to:

1. 'amend' the concept of diffusion to just think about water when a partially permeable membrane is involved;
2. check that the students could work out the direction of net water movement when given the concentrations (addressing the problem that when we talk about a "concentrated solution" we are referring to the solute not the solvent);
3. check understanding by seeing if students could apply the concept of osmosis to explain the change in mass of the potato pieces;
4. check understanding by seeing if students could explain that if there was no change in mass then the concentration of the sugar solution 'matched' the concentration of the potato pieces;
5. get students to apply 3 & 4 to suggest what would happen to plant cells in 'extreme' concentrations & whether this would be the same for animal cells;
6. draw together thoughts on 5 and then use Q&A with the powerpoint to consider the effects on cells and introduce the new terminology.

I planned for the students to work as independent groups through 3 – 4. The key definitions and cell diagrams were on a white-board for reference.

<u>Teaching</u> – see 'lesson plan – teaching' & 'student work'.

Date Tu 24/3/15	Lesson: B4	Group: **10Q1 Triple Science** Subject / Topic / Focus B4d Osmosis

What are student learning today?

B4d How are living cells affected by the concentration of the solutions they are in?

Prior learning:

Particles move from an area of high concentration to an area of low concentration due to the random movement of individual particles. This is *diffusion.*

All cells are enclosed by a partially-permeable membrane; plant cells also have a rigid cell wall.

New learning:

Osmosis is the diffusion of water across a partially-permeable membrane from an area of high water concentration (ie dilute solution) to an area of low water concentration (ie concentrated solution).

When water moves into plant cells it causes a build-up of pressure. The cells are said to be *turgid*.

When water moves out of plant cells the pressure drops and they become 'floppy'; *flaccid*.

When a lot of water moves out of plant cells it causes the insides to contract. The cells are said

to be *plasmolysed*.
Animal cells don't have a rigid cell wall to maintain their shape so ……
When water moves into animal cells they swell and eventually burst. This is *lysis*.
When water moves out of animal cells they shrivel up. They become *crenated*.

Q&A check understanding of diffusion from previous lesson

Starter activity to introduce the above:
"What do we mean by diffusion?" Remind students by reshowing the animation.
Show the visking tube demo. "The water level in the glass tube has risen. What must have happened?" "Why would water move into the visking tube?"

Core activities/ lesson sequence.	Checking learning of all.	Differentiation, specific reference to individuals and key groups.
Show animation of water movement across partially permeable membrane. Define osmosis. Explain movement of water into visking tube.		
Quick ques. Visking tube containing 50g/dm^3 sugar is put into …….. g/dm^3 Does water move in or out.	Eyes closed; point in or out to show direction of water movement.	**Can quickly see who gets it; speak to those don't as class starts tasks 1-6**
Compare Visking tube to cells; remind of cell structure. Display tasks 1-6 on board; students work through them (in groups): 1. Weigh potato samples set up yesterday in variety of sugar solutions. Calculate % change in mass (*numeracy*). 2. Describe results. 3. Explain results (*literacy*). 4. <u>Estimate</u> the concentration of the contents of the potato cells. (don't need to graph) 5. What has happened to the cells? Look at onion cells in water & in concentrated sugar solution. 6. Extension: Would the same thing happen with animal cells? Why?	Question & discuss with individuals during activities. **If students can describe that when 0% change (which could find accurately using a graph) then no net water movement so sugar conc = cell conc then they get it.** **If not, then can discuss it there & then as students are working through tasks independently.**	Display the key prior knowledge on the white board for reference. Ensure 1:1 Billy, Rosie, Tom C, Rebecca, Claudia, Henry. Challenge: Ques to promote application of K&U & explanation.
Show animation of cells in high & low concentrations. Ask for direction of water movement. Discuss the effect on plant & animal cells. Introduce terms: turgid, plasmolysed, flaccid, crenation, lysis. H/W Students write definitions of these terms.	<u>Next lesson</u>: reshow animation, students use correct term to describe what is happening.	**Quick quiz to check 'understanding'. Pick up problems as class start independent**

Next lesson students will learn
How are leaves adapted to carry out photosynthesis efficiently?

B4

23rd March 2015.

It's a green world

Diffusion;

L.O: What do we mean by diffusion.

Diffusion → The random movement of particles from an area of high concentration (lots of them) to an area of low concentration (less of them) until the concentrations are equal.

The rate of diffusion is increased by:
1) Shorter distance.
2) Bigger concentration gradient.
3) Bigger surface area.

	Sugar Solution g/dm³	Mass of Potato at start (g)	Mass of Potato at end (g)	Change in mass of potato (+/-g)	% Change in mass (+/-)
1	0	3.5	4.1	+0.6	17.1% +
2	72	3.0	3.1	+0.1	3.3% +
3	144	3.5	3.0	-0.5	-14.3%
4	216	1.5	1.1	-0.4	-26.7%
5	360	1.5	1.0	-0.5	-33.3%

24/3/15 The higher the concentraition of the sugar solution, the lighter the potato got. This is because when the potato got heavier, it had let water in, therefore the concentraition of water in the potato must of been smaller than the concentraition of water in the sugar solution. As the concentraition of sugar increased in the sugar solution, the concentraition of water in the sugar solution decreased. The potato got lighter because the water from the

sp

24th March 2015

Water movement.

L.O: How are living cells affected by the concentration of the solutions they are in?

Osmosis → Diffusion of water particles across a partially permeable membrane from an area of high water concentration (dilute solution) to an area of low water concentration. (concentrated solution)

- Carry on - potato went into the ~~con~~ sugar solution as ~~it~~ the solution has a lower consentraition of water than the potato due to the increase of sugar concentration.

To work out the original concentraition of water in the potato, we'd have to find a concentraition of sugar solution that wouldn't affect the weight of the potato.

Turgid - Water moves in, stands up right.
Flaccid - Water moves out, plant wilts
Plasmolysis - loose alot of water, cell contents contract + becomes detached from membrane.
Lysis - Animal cell, water enters = cells swel
Crenated - Water leaves animal cells and it shrivels up.

When the slug had salt put on it, crenation take place because the water leaves the slug as it as a higher concentraition of water than the salt. Salt absorbs the water.

Water Movement 24th march

L/O: How are living cells affected by the concentration of the solutions they are in?

The diffusion of water particles across a partially permeable membrane from an area of high water concentration (dilute solution) to an area of low water concentration.

What has happened?

3) When the solution had lower concentration of water and more of the concentration of sugar the mass of the potatoe started to go down because on our results it shows that when the solution had low concentration of sugar it gained mass however as it went up in sugar concentration it didn't gain as much. ~~This is because~~

Explain

4) This is because inside the potatoe there is more water so that the water goes from inside to out which makes it start to loss mass where as when it gained mass there was an higher amount of water concentration outside so the water ~~bl~~ absorbed into the potatoe's cells, thus meaning that it gained mass.