Science Mysteries

Using unexplained events to explore science enquiry

A TY Science Module

Teacher Hand-out

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Introduction:

This module draft has been written and researched by Mr Patrick Dunne, a biological science with chemistry undergraduate from the University of Limerick, under the direction of Dr Peter E. Childs. We would appreciate your comments and corrections on this draft so later versions can be improved.

The focus of this research is that of mysteries or discrepant events. It is part of a European project TEMI (Teaching Enquiry with Mysteries Incorporated), of which UL is a partner. The idea is to use mysteries or discrepant events to arouse student interest, motivate students to inquire and find out scientific explanations. A discrepant event is defined as an event that surprises, startles and puzzles, or astonishes the observer and may often appear to contradict the basic principles of science. These events stimulate an observer's natural curiosity and after observing a discrepant event, an observer will want to know "why!" Discrepant events engage the observer in the learning process and are rooted in inquiry-based learning.

Disclaimer:

The authors take no responsibility for accidents or injuries that may result during the activities listed in this module. It is the teacher's sole responsibility to ensure the safety of pupils.

The teacher should carry out experiments, investigations and activities prior to the class, in order to ensure that they understand what is happening and that they are prepared for whatever eventualities that may occur.

Pupils must be provided with personal protection equipment for all investigations and the safety notes accompanying each activity should be explained clearly and enforced.

TY Science:

This module is one of a series of modules being prepared for TY students to provide a bridge between Junior Science and LC Sciences. The modules aim to:

- Build on Junior Science
- Relate Science to the real world
- Develop laboratory skills
- Encourage a scientific approach to issues
- Develop IT and presentation skills

It is hoped that by making Science interesting and relevant that more students will be attracted to study Science further, particularly Physics and Chemistry. For details of other modules that are available contact: peter.childs@ul.ie

This is a first draft of this module and we are aware it may contain errors and some things may not work in some schools. Please let us know any problems, errors, suggestions for improvement, so that we can correct things in the next version.

Pupil's Safety

- Personal protection must be worn at all times i.e. white lab coat, goggles and gloves.
- All long hair must be tied back.
- There is strictly no eating or drinking allowed in the laboratory.
- Report accidents (however small) and breakages immediately to the teacher.
- Clean up spills immediately
- Wash hands before leaving the laboratory
- Follow all safety instructions in the units.

Symbols

The following are symbols that you must be familiar with in order to carry out each experiment carefully.

 Corrosive	 Flammable
 Harmful/Irritant	 Toxic
 Oxidising	 Explosive

Brief Overview of the module and units:

Unit	*Description*	*Skills and Concepts*
Unit 1: Light it up!	This unit looks at the properties of light and how they can be used to produce some spectacular optical illusions that will trick both the eye and the mind.	In this unit students will: • Be introduced to the properties and behaviour of light which include *reflection* and *refraction.* • Be encouraged to make predictions as scientists, and test their predictions to show prove. • Be encouraged to develop and analyse their own experimental methods.
Unit 2: Crazy reactions!	This unit focuses on surprising colour changes brought about by chemical reactions. The core activities of this unit see students experimenting with both acid-base and redox reactions. However the unit also provides scope for further investigations into other areas.	In this unit students will: • Be introduced to the concepts of acid – base and redox reactions. • Be encouraged to develop their own experimental and inquiry skills through student driven activities. • Develop communication and problem solving skills.
Unit 3: Some things float! Some things don't!	This unit uses discrepant event demonstrations to get pupils thinking about *"why some objects float and others* don't*"*. It then expands on this idea and examines how some things can both sink and float e.g. submarine.	In this unit students will: • Examine the definitions of density and the role it plays in buoyancy. • Be encouraged to make predictions and then design their own experiments to test them • Develop their research and group work skills. • Be able to design their own submarine and give rationale for their design
Unit 4: Air Power	This unit focuses on the invisible but remarkable, gas that fills the space all around us. In the unit pupils will investigate how air power not engine power is largely responsible for putting planes in the sky.	In this unit students will: • Be introduced to the principles of the Bernoulli Effect. • Examine how air pressure is central to the concept of lift. • Develop investigative, speculative and interpretive skills.

Unit 5: Tricky Senses	This unit focuses on the limitations of the human sensory system. In this unit students will be surprised to learn that we are not as advanced as we think we are.	In this unit students will: • Be introduced to the limitations of the human eye. • Carry-out investigations into why pupil taste things differently and why your skin is more sensitive in certain areas of the body. • Gain an appreciation for the diversity and complexity of animals in the world.
Unit 6: Osmosis Magic!	This unit focuses on the principles of diffusion and osmosis. In the unit student will learn of the above concepts by investigating their surprising affects.	In this unit students will: • Be introduced to the topics by the magic of "Insta-snow". • Carry-out investigations into the physical effects of osmosis. • Become aware of the personal and social importance of reverse osmosis.
Unit 7: Sticky Static	This unit focuses on the topic of static electricity. In the unit students will be amazed by the multiple effects that occur as a result of static electricity.	In this unit students will: • Be introduced to static electricity using the "bending water" discrepant event. • Students will carry out investigations into why static occurs.
Unit 8: A lot of hot air!	This unit focuses on the physical and chemical properties of gases and in particular their behaviour when heated.	In this unit students will: • Predict and evaluate a series of discrepant events that occur from the heating of gases. • Will gain a better understanding of the physical and chemical properties of gases by carrying out investigations of their own.

Contents:

Each unit consists of an introductory single lesson, a double lesson, which involves some practical activity, and an optional single lesson. What you can do depends on the time allocation for Science in your TY programme. If you have only 3 periods (1 single and a double) you can leave out the extra single class or some of it can be used for homework. Although the module is designed as a complete mini-course you can choose to do just one or more units, or take out individual lesson. The units to a large extent are stand alone.

The Student Hand-out is designed to so it can be photocopied. Each student should have his or her own copy of the material. You can either give out the material for each lesson in turn or you can copy the whole Student Handbook yourself so that students can have their own copies. The students should keep the various units in a folder or ring binder, if they do not have their own copy of the whole Student hand-out.

Unit 1:

Light it up!

Lesson 1 (single lesson) – 35 minutes

Haunted mirror!

This lesson is designed for a single lesson and is appropriate to be carried out in both a classroom and a designated science laboratory. It focuses mainly on the characteristics of reflective and transparent materials. The introductory section of the lesson makes use of a discrepant event to grab the student's attention right from the beginning. The remainder of the lesson then sees the pupils using their own prior knowledge and inquiry skills to investigate the event.

Introduction:

The initial part of this lesson uses a discrepant event demonstration which will attempt to stimulate pupil's interest and curiosity of the topic. The demonstration uses the principles of a two way mirror to trick pupils into thinking that you have a so called *haunted mirror!*

Materials required:

- Pane of Perspex/glass
- Reflective film (window tint)
- Ruler
- Candles (x2)
- Matches

Safety Considerations:

This is a relatively low risk demonstration; however care must be taken when using matches.

Preparation/Set-up:

The majority of the set-up for this demonstration involves the construction of a two-way mirror. Such a mirror can be made using a pane of Perspex (glass may also be used however Perspex is the cheaper and safer option) and a sheet of reflective film. By sticking the reflective film to one side of the Perspex you will produce a mirror that allows roughly 20% of light through and reflects the remaining 80%.

Procedure/Commentary:

- To present this discrepant event I would begin by setting up the mirror so its reflective side is facing the pupils. Then light both the candles placing one candle in front of the mirror and the other behind the mirror at the same distance (use a ruler to insure the distances are equal).
- Once this set-up is complete the teacher should turn down the lights in the room and ask the pupils to comment on what they see and whether they think the second candle they see is the image of the first candle in front of the mirror or the candle behind the mirror.
- The pupils will more than likely give the correct answer and say that it is the candle in front because the mirror is reflecting the light.
- Then the teacher should ask the pupils to predict what would happen to the image if the candle in front of the mirror was quenched.
- Once again pupils will more than likely say that the image will quench also.
- The teacher will then blow out the candle in front only to reveal a fainter image of the candle still remains in the mirror.

Explanation:

Due to the partially reflective and partially transparent nature of the mirror when the candle at the front was blown out the only light present was now coming from the candle behind the mirror. This can be demonstrated further by placing a second and even third candle behind the mirror making the area more visible and turning what previously looked like a mirror into a seemingly transparent pane.

Development:

At this point your students will probably be starting to question the method behind this illusion. Therefore this presents the perfect opportunity for you to allow the pupils to come up with the explanation themselves. Here they can work in pairs to give possible explanations to how it works, even make sketches of the apparatus used and record any observations. You may also ask them to come up with examples of practical applications of this concept e.g. two-way mirror in interview rooms, window tint in cars etc.

Once you are satisfied that your students have given an accurate scientific explanation to the illusion you can start to introduce additional concepts related to light to further develop their understanding of the topic. Once again it is important that the pupils drive the lesson by constructing their own answer to the material presented. The teacher's role is to act as a facilitator. Therefore the students should carry out the next activity on refraction in pairs. (Procedure included in student worksheet).

- The activity sees your pupils explaining the science behind why a pencil appears bent in water.

Conclusion:

To conclude this opening lesson have the class recap on the material they have been presented before instructing them to a problem solving question to be attempted before the next lesson. Have the pupils use the concepts they have just seen to provide a scientific reasoning to why we can see reflections in rivers and lakes even though we know that water is transparent. Here you should a picture along the lines of a mountains reflection in a lake as a visual aid.

Lesson 2 (double lesson) – 80 minutes

Now you see me, now you don't!

This lesson is designed for a double lesson and is appropriate to be carried out in a designated science laboratory. The aim of this lesson is to recap on the material covered in the previous lesson while attempting to develop pupil's investigatory and inquiry skills. The lesson should be split into two sections with each taking up one class period.

Introduction:

This lesson will begin with a recap of the ideas and concepts the pupils were introduced to in the last lesson. The next stage of the introduction should see the pupils briefly discussing the questioned posed at the end of the previous lesson.

Development:

Activity 1:

The first half of the lesson should see your pupils testing their ideas to the reasons why we can see reflections in water and the conditions necessary a reflection to occur.
This can be done by asking them to create a reflected image in a container of water using materials that can be sourced within the science laboratory.

Possible materials:

- Large containers
- Black paper/cardboard
- Light source

Activity 2:

The second demonstration involves a similar procedure to that of bent pencil activity in the last lesson. However this time instead of water and a pencil, a glass Pyrex rod should be placed in a beaker of corn/sunflower oil. As both the Pyrex and the oil have the same refractive index the rod appears to be invisible in the oil.

Once again your pupils should be given time before the demonstration to predict what might happen and after to give their opinion on why they think it is happening.

Extra Demonstrations:

In order to further challenge your students understanding the following extra demonstrations can also be carried out.

- By adding a layer of oil to the top of a layer of water it can be shown that the Pyrex rod will appear invisible in the oil layer but reappear in the water layer.
- Secondly by submerging roughly two thirds of a test tube in the oil, your pupils will see that it is visible even though it is also made of Pyrex. However if you proceed to fill the test tube with oil it will disappear.

Conclusion:

After presenting the theory the conclusion of the lesson should see pupils attempting to think about where such concepts could be used in the real world. Here pupils can be shown a video showing how the refractive index of glass can be used in crime scene investigations.

* *The teacher may also present to students the task to be completed in preparation for the optional lesson.*

Lesson 3 (single lesson – optional)

Invisibility cloak!

This lesson is designed as an optional activity to get your pupils to carry out some investigations of their own. The lesson time should be allocated for pupils to present their findings in a format of their choice.

Introduction:

The introduction to this lesson should see the class discussing briefly some of the ideas they came up with for the real life invisibility examples.

Development:

The development of the lesson should see a selected number of pupils presenting their findings to the class.

Here it may be a good idea to get the remaining students to ask questions after the presentation has been made.

It may also be good to get your pupils to think about whether these examples are possible and how they might attempt to try some of them themselves.

Conclusion:

To conclude this lesson you can show a video of how green screens are used to make things seem invisible on television. Encourage pupils to come up with ways that they could produce their own green screen.

Resources:

- Two – way mirror: http://www.ehow.com/way_5378272_do-yourself-way-mirror.html
- Invisible rod: http://www.youtube.com/watch?v=wlELYZJ5JF4,
- Use of refractive index in CSI: http://www.teachertube.com/viewVideo.php?video_id=214724&title=Refractive_index_of_glass.
- Reflection and refraction student notes: http://thephysicsteacher.ie/leavingcertphysicshome.html

Unit 2:

Crazy Reactions!

Lesson 1 (single lesson) – 35 minutes

Miracle water!

This is designed for a single class period and should be carried out in a designated science laboratory. This lesson uses the chemistry of acid/base neutralisation to introduce to your students the topic of chemical reactions, and how they can create some remarkable colour changes in solutions.

Introduction:

To begin this lesson you should carry out the following discrepant event demonstration in order to develop pupils' understanding of the following concepts in a more visual way:

- Acids and bases
- Colour change indicators
- Neutralisation

This event uses such ideas to presumably turn water to wine then back to water and then to milk.

Materials	
<u>4 beakers</u> 1. 20 mL of 0.1 M NaOH solution 2. 20 mL of water and Phenolphtalein Indicator 3. 25 mL of 0.1 M HCl solution 4. 20 mL of $Pb(NO_3)_2$ solution (with water)	Optional: Bromethymol blue Methyl orange Universal indicator Mythol Alcohol

Procedure:

Firstly set-up the four beakers containing the solutions listed above. The teacher should first acknowledge the fact that the four liquids are perfectly clear and that there is no powder in them (initially there was powder to first make the solution, but don't tell the students this). You could just pour the chemicals together, but that would be a little boring and straight to the point, leaving little time for observing and evaluating. Therefore it is more entertaining to make a skit out of it.

For example:

Teacher: “Now, let’s say that you are at a fancy restaurant. OK? Would you like some water sir/mam?”

Student: “Yes please!”

Give the student that first solution

Teacher: “Shall I get you anything else to drink?”

Student: “I would like a glass of red wine.”

Pour the second solution into the first solution

Teacher: “Wait, before you can drink, let’s first see some ID”

Student: “I don’t have any ID.”

Teacher: “Well, then I’m sorry I can only give you water for now”

Pour the third solution into the mixed solutions

Student: ‘Fine. Can I get a glass of milk?”

Teacher: “Certainly!”

Pour the last solution in the mixed solutions.

Explanation:

The chemical that gives us the colour is the phenolphthalein. When the phenolphthalein is in a solution that is neutral or acidic, the solution will remain clear, but if the solution is basic, the solution will turn red. Since we started off with the phenolphthalein in the water, it will indicate that it is neutral. Now, we add the sodium hydroxide, and suddenly the solution turns basic, and now the solution is red. So, how do we change it back? We need to neutralize the base. We start pouring the hydrochloric acid in. Even though there is now acid in the solution, the acid will mix with the base, and so each will neutralize, but there is a lot of basic solution. We need to keep pouring in acid. Once the entire base has been neutralized, the solution will go from basic, to neutral, so the solution will be clear again, and if we still add some acid, the solution will be acidic and the solution will remain clear. So now, we have an abundance of acid, we then add that mixture to the lead nitrate solution. The two chemicals will then combine and form a white precipitate in the final beaker.

Development:

The second part of this lesson should see your pupils attempting to solve the mystery of the water to wine trick that you have just demonstrated. Here it may be effective to ask your students if they can remember any aspects of the Junior Certificate syllabus which showed similar colour changes in solution. They should then use this prior knowledge to try and produce an explanation for this surprising event.

Students may also carry out some small tests of their own in order to help them with their explanation. For example, if they predict that it may be as a result of an acid – base reaction. You can ask them how they could test this. Therefore you can then supply them with litmus paper or any other indicators to test samples of the original solutions used.

A second activity to develop understanding could be to allow your students to perform the trick themselves. In addition you can supply them with other examples of indicators and challenge them to create their own magic trick.

Conclusion:

To conclude this lesson you can present pupils with the method required to make their own acid – base indicator at home using red cabbage. You can also ask them to investigate other coloured vegetables to determine their indicator ability.

Lesson 2 (double lesson) – 70 minutes.

Let's shake things up!

This lesson is designed to be carried out during a double class period in a designated science laboratory. The aim of this lesson is to build on the idea of surprising colour changes in solutions to introduce a different type of chemical reaction. The lesson also aims to further develop your students' inquiry and experimental skills.

Introduction:

The introductory section of this lesson uses the 'blue bottle' experiment in the form of a discrepant event demonstration to introduce to your students concepts such as redox reactions, rate of reactions, kinetics etc.

Materials
Glucose, 8 g Flask, 500-mL, with cap or stopper to fit Methylene blue solution,1% aqueous Graduated cylinder, 500-mL Sodium hydroxide, 8 g Weighing dishes, 2 Water, distilled or deionized

Safety Precautions:

Potassium hydroxide is a corrosive solid; it is especially dangerous to eyes and may blister and burn skin. Avoid contact with eyes and skin and clean up all spills immediately. Methylene blue solution is slightly toxic by ingestion. Wear chemical splash goggles and chemical-resistant gloves and apron. Wash hands thoroughly with soap and water before leaving the laboratory.

Preparation: To prepare the "blue bottle" solution:

- Add 8 g of potassium hydroxide to 300 mL of water in a 500-mL flask.
- Stir until the solid is dissolved.
- Add 10 g of dextrose and a few drops of methylene blue indicator solution.
- Fill to the 500-mL mark, stopper or cap the flask, and mix thoroughly.

Procedure/Commentary:

1. Allow the "blue bottle" solution to stand undisturbed in the stoppered flask until the solution is colourless.
2. Ask your pupils to tell you what colour the liquid in the flask. *Answer: Colourless/Clear.*
3. Ask is this their final answer before gently shaking the flask to obtain a blue colour.
4. Wait patiently as the solution turns colourless again.

Development:

For the second part of this lesson you should use the demonstration to start a discussion, on what is causing the colour change. Student's suggestions can be tried out as far as practicable.

For example:

- To show that the air in the bottle might be causing the reaction, you could fill the flask to the top with water. The solution will initially turn blue due the oxygen present in the tap water but once clear it will not change when shaken.
- Therefore to confirm oxygen is responsible for the colour change, carbon dioxide/nitrogen can be bubbled through the solution for a couple of minutes to displace air from the solution and the flask. If the stopper is now replaced and the bottle shaken, no colour change will occur.

Letting your students carry out the experiment themselves may be helpful to their understanding of the chemistry behind this trick.

Once your students are aware of the chemistry behind the reaction, you can ask them to discuss factors that might affect the time needed for the blue colour to fade. Here pupils can design experiments to test the effect of factors such as temperature, concentration and even how long the bottle is shaken.

Conclusion:

To conclude this lesson the teacher should recap on the concepts that have been introduced in the previous two lessons. You may then ask your students to participate in a brief discussion on everyday examples of chemical reactions. This can form the basis of the optional lesson to follow where pupils will carry out research and present on the role of chemical reactions in different areas of life.

Lesson 3 (single lesson – optional) 35 minutes.

Reactions that make up the world!

This lesson is designed to be used as an optional activity to develop your pupils' inquiry and project skills. The lesson is intended to be carried out during a single period in a designated science laboratory however pupils will also be required to do work outside of class time.

Introduction:

The introduction to this lesson should see the class discussing briefly some of the ideas they came up with for everyday examples of chemical reactions. Before conducting this lesson your students should be divided into groups an given a specific area to research. Examples may include chemical reactions in..................

- medicine
- the human body
- technology
- transport
- food
- energy, etc.

Development:

The development of the lesson should see a selected number of pupils presenting their findings to the class. This can be done in the form of a poster which can then be kept in the classroom for future reference.

Here it may also be a good idea to get the remaining students to ask questions after the presentation has been made.

Conclusion:

To conclude this lesson the teacher can do a quick recap on the reactions that were carried during this unit, before mentioning further reactions that the pupils may research themselves.

Resources:

- Blue – bottle experiment: http://www.flinnsci.com/teacher-resources/

Unit 3:

Some things float!

Some things don't!

Lesson 1 (single lesson) – 35 minutes.

Sink or swim?

This lesson is designed for a single class period and can be carried out in both a classroom and a designated science laboratory. The aim of this lesson is to use a discrepant event to demonstrate to your pupils the science behind why some things float and some things sink. The lesson also aims to develop pupil's observational and inquiry skills.

Introduction:

The introduction to this lesson uses a discrepant event demonstration to introduce pupils to the topic of density.

Materials
Large container of tap water Large container of saturated salt water. Regular coke can (full) Diet coke can (full).

Safety Precautions:

This demonstration is believed to be non-hazardous however normal laboratory safety precautions should be followed.

Procedure/Commentary:

1. Begin by asking your students to predict what will happen to the regular coke when it is placed in the container of tap water i.e. will it sink or float?
2. Then proceed to place the can in the water and ask your students to observe what they see (can should sink to bottom).
3. Then repeat this procedure for the diet coke (can should float).
4. Finally repeat steps 1-3 but this time use the container of saturated salt water (both cans should float).

Explanation:

Despite having the same volume the diet coke can is in fact less dense than the regular coke can, this is due to the higher sugar content in regular coke giving it a greater mass. In saturated salt water however, both cans will float because by adding the salt you are creating a denser solution.

Development:

The second part of this lesson should see your pupils attempting to explain the science behind the event they have just witnessed in the introductory section. Here you should use pupil's prior knowledge of density to allow them to develop the explanation themselves. Emphasis should be placed on the fact that the density of an object is based on both mass and volume. Once you are happy that your pupils have established that the difference in density is due to the higher percentage of sugar present in the regular, they can be challenged to design an method of determining the sugar percentage in each using their relative densities. This can initially be done in groups before deciding as a class on the most effective method. Pupils will then be given time in second lesson to try the method they think is best.

Conclusion:

To conclude this lesson you should present to your students with the second activity they will undertake in the next lesson, which sees them making their own 'Cartesian diver'. Here you can show them an example of the finished product and challenge them to explain the science behind it. A method for making the 'Cartesian diver' apparatus can be found in the student hand-out.

Lesson 2 (double lesson) – 70 minutes.

Sugar sugar!

This lesson is designed to be conducted during a double class period in a designated science laboratory. The aim of the lesson is to build on the material presented in the previous lesson, by giving the students an opportunity to carry out some investigations of their own using hands on activities.

Introduction:

The opening section of this lesson should see your students recapping on the material they covered in the previous lesson. In particular the experiment they designed themselves to test the sugar percentage in diet and regular coke. Therefore this section should also see your students gathering the materials and equipment they will need to carry out their investigations.

Development:

The second part of this lesson should see your students carrying out the method they have agreed from the opening lesson to be the most effective. Shown below is a proposed method that could be used.

<u>Proposed Method:</u>

Hypothesis:
Regular coke is much sweeter in taste than diet coke; therefore regular coke has a higher sugar concentration than diet coke.

Materials:
Sample drinks (coke and diet coke)
Electric balance
Beaker (100ml)
Cups (clear plastic), 8 labelled 0%, 5%, 10%, 15%, 20%, coke and diet coke.
Paper towels
Volumetric Pipette.

Safety Precautions:
Although the materials in this activity are considered non-hazardous, follow all normal laboratory safety guidelines. Any food-grade items that have been brought into the lab are considered laboratory chemicals and are for lab use only. Do not taste or ingest any materials in the laboratory, and do not remove any food items from the lab after use. Wear safety glasses or chemical splash goggles whenever working with chemicals, heat or glassware in the lab. Wash hands thoroughly with soap and water before leaving the lab.
Method:

1. Place a small beaker (100ml) on the electric balance and zero it, by hitting the 'tare' or 're-zero' button.
2. Using the pipette draw up precisely 10.00ml of 0% sugar solution, then empty it into the beaker. Since the beaker was already zeroed out the mass is that of the liquid alone.
3. Record the mass in the data table below.
4. Push the 'tare' button to re-zero the scale for the next reading.
5. Repeat the steps 1-4 with each of the remaining sugar solutions (5% - 20%) and with both samples of regular and diet coke.
6. Use the data in the table to plot a calibration curve putting density (g/ml) on the y-axis and the percentage sugar on the x-axis.
7. Use the graph to estimate the sugar percentage for both the regular and diet coke.

Results:

Per cent sugar/ Drink Sample	0%	5%	10%	15%	20%	Regular Coke	Diet Coke
Mass (g)							
Density (g/ml)							

Preparation:
In empty 1-L or 2-L bottles, place the following:

- 0% = 1000 g of water
- 5% = 950 g of water, 50 g of sugar, two drops yellow food colouring
- 10% = 900 g of water, 100 g of sugar, one drop blue, one drop yellow
- 15% = 850 g of water, 150 g of sugar, two blue drops
- 20% = 800 g of water, 200 g of sugar, one drop blue, one drop red

The sugar concentrations are mass per cent.
Then cap and shake well until sugar is all dissolved and solutions are homogeneous. This makes up close to 1000 mL of each solution, more than enough for 5 sections of 24 students each, working in pairs.
Carbonated drinks should be "flattened" first. This should be done by pouring them back and forth several times between two large beakers. If this is not done, the carbonation can produce bubbles during pipetting and throw off the results.

Once the experiment is completed you can tell your students to complete their own experimental write-up which will have to be presented in the next class.

For the second half of this section you should allow your pupils to develop their understanding of the 'Cartesian diver' as presented in the previous lesson. Here pupils should be given time to construct their own 'Cartesian diver' apparatus.

Conclusion:

To conclude this lesson you can ask pupils to discuss practical applications of the concepts that have seen e.g. how submarines stay underwater. This will then form the basis of the optional lesson for this unit where pupils can be challenged to design and construct their own functioning submarine model.

Lesson 3 (single lesson -optional) 35 minutes.

Yellow submarine!

This lesson is designed to be used as an optional activity to develop your pupil's inquiry and project skills. The lesson is intended to be carried out during a single period in a designated science laboratory however pupils will also be required to do work outside of class time.

Introduction:

This activity should be introduced to your pupils at the end of the previous lesson where they can be split into their groups and given some time to put together a plan of how they will go about the project. They will then be required to carry out their own research on how the model should be constructed and the materials that they would require, before attempting to construct a working example.
Therefore the introductory section of the single lesson should include a recap of the brief the students had been given.

Development:

The next section of this lesson should see each group constructing a working example before presenting it to the class, while also attempting to give a demonstration of the submarine in action (this may require some extra planning on behave of the teacher in order to create an appropriate environment for testing the models).
This should lead to an open class discussion on which design is the most effective.

Conclusion:

To conclude this lesson your pupils should discuss any errors in their designs and how they may go about correcting these errors. The teacher may also take the time to recap on the scientific concepts that have been introduced in this unit.

Resources:

- Density of coke cans: http://www.flinnsci.com/teacher-resources/teacher-resource-videos/best-practices-for-teaching-chemistry/density/

- Target density lab: http://www.flinnsci.com/teacher-resources/teacher-resource-videos/best-practices-for-teaching-chemistry/density/target-density-lab/

- Cartesian Diver: http://www.youtube.com/watch?v=sNOXFiJ4IDU

- Model Submarines: http://science.wonderhowto.com/how-to/make-soda-bottle-submarine-258020/

Unit 4:

Air Power!

Lesson 1 (single lesson) - 35 minutes.
Can you take the pressure?

This is designed for a single class period and can be carried out in a classroom or designated science laboratory. The aim of the lesson is to use a series of quick discrepant event demonstrations to get students thinking about the properties of air.

Introduction:

The introduction to this lesson uses two short demonstrations to show to pupils that air takes up space. In each case you should first attempt to challenge your pupils prior knowledge by getting them to predict what they think will happen and then to evaluate and explain what they observe.

Demo 1: The World's Driest Paper!

1. Stuff the bottom of a small beaker with tissue paper.
2. Ask your students to predict what will happen if the beaker was turned upside down and submerged under the water.
3. Proceed to submerge the beaker for 5-10 seconds and then remove it from the water.
4. Remove the tissue paper and get your pupils to observe whether it is wet or dry.
5. To their surprise the paper is dry. Why is this?

Explanation: When the beaker is submerged it creates a pocket of air between the water and the tissue keeping the paper dry.

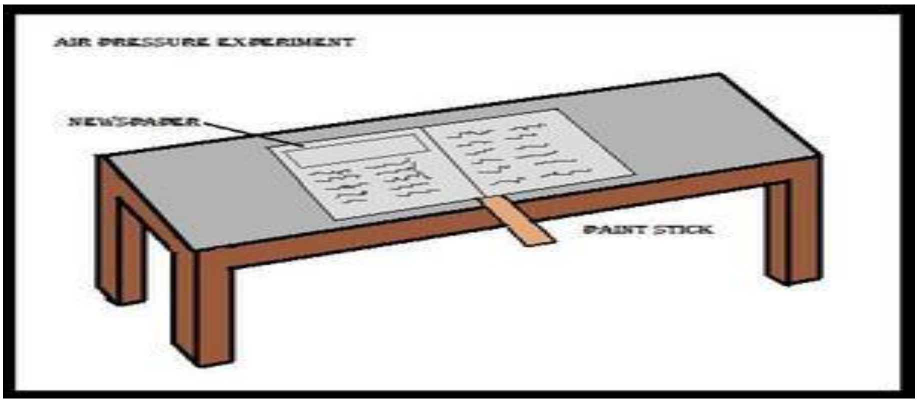
Demo 2: Powerful Paper!

1. Place the piece of wood on a table and let one end hang over the edge about 4 inches. Ask your students, "What will happen if I hit the piece of wood that is hanging over the edge of the table?" Make sure everyone is out of harm's way as you karate-chop the stick. Of course, the stick goes flying end over end just as expected.
2. Return the stick to the table allowing about 4 to 10 inches of the stick to hang over the edge. "Let's use a piece of newspaper to help secure the stick in place." Show a single sheet of newspaper and fold it in half 3 or 4 times. Place the folded newspaper over the end of the stick that is lying on the table. Again, make sure everyone is standing away from the table as you hit the end of the stick that is hanging over the edge of the table. What happened? Did the newspaper help to hold the stick in place? Of course,

the answer is "NO."

3. Finally, show your students a new sheet of newspaper and use it to cover the portion of the stick that is lying on the table. Make sure that the newspaper is flush with the edge of the table. "What do you think will happen now if I hit the stick with the unfolded newspaper covering the stick?" You might anticipate an answer like, "The newspaper will go flying...or the sheet of newspaper will tear apart." Smooth down the newspaper with your hands so that there are no pockets of air under the sheet of paper. Put on your karate-chopping glove to protect your hand. Strike the protruding edge of the stick with your hands with a sudden sharp hit. To everyone's amazement, the stick breaks. Remind the audience that the weight of flat newspaper is exactly the same as the folded newspaper, yet the flat newspaper stayed in place and held the stick in place. That's amazing... but how does it work?

<u>*Explanation:*</u> It is not the weight of the paper that causes the stick to break but the weight of the air pushing down on it. Therefore the unfolded sheet with is larger surface area is heavier than the folded newspaper and so the stick will break.



Development:

The second part of this lesson aims to build on the concepts introduced above using two further demonstrations which get your pupils thinking about the association with air (i.e. Air pressure).

The demonstrations in this section require a level of student participation.

Challenge 1: Stubborn Ping Pong!

1. On the table lie a gas jar on its side with the jar opening at the tables edge.
2. Place a ping pong ball roughly half way down the inside of the jar.
3. Ask one of your students to try and blow the ping pong ball to the back of the jar and ask the rest of the class to predict what will happen.
4. To their surprise the ball will not go to the back of the jar but will in fact shoot back in the direction of the person blowing.

Explanation: When you blow into the jar you are blowing into a compressed space with nowhere for the air to escape therefore the pressure inside the jar is greater than that of the air been blown in and so the ping pong ball flies back out of the jar.

Challenge 2: Lung Buster!

1. Behind the scenes, begin with one plastic drink bottle and the tack. Without showing anyone in your potential audience, press the tack into the plastic to make a small hole in the bottom of the bottle. Widen it so that your hole ends up about 5cm across…if it's a little bigger, that's okay too.

2. Now you'll need a volunteer. Give your volunteer the bottle without a hole, and keep the bottle with the hole for yourself. Now each of you should place a balloon inside the neck of the bottle and stretch the opening of the balloon over the top of the bottle, so that the opening is covered completely.
3. On the count of three, challenge your student to blow up his/her balloon. Get ready for some fun: your balloon should inflate just fine, making an attractive decoration inside the bottle. But the other one will just not inflate!
4. For a little extra fun, invite another volunteer to try, using a different balloon. You can also offer the bottle with the hole in it, but sneakily hold your finger over the hole…if you do that, the other balloon won't inflate either!

Explanation: When we blow up balloons, we move air into a compressed space and inflate the latex. But when the balloon is placed inside the bottle, and there's no way for the bottle's air to escape, the pressure inside the bottle is greater than the pressure that occurs from blowing on the balloon…and the balloon just won't blow up. When there's a hole at the bottom, however, the compressed air can escape, and the balloon can expand.

Conclusion:

To conclude this lesson you should recap on the ideas that have been introduced in the lesson. After the demonstrations your students should believe that we live in an ocean of air and that it is constantly applying pressure all around us. You should then challenge this knowledge by asking......

"Does air pressure hinder or help birds and planes to fly?"

Lesson 2 (double lesson) – 70 minutes.

Up up and away!

This lesson is designed for a double period and is most suited to be carried out in a designated science laboratory. The aim of this lesson is to examine the science behind the question posed to the pupils at the end of the previous lesson which is..................

"Does air pressure hinder or help birds and planes to fly?"

Introduction:

The first part of this lesson aims to use a series of discrepant event demonstrations and student activities to introduce your pupils to the key principles of the Bernoulli Effect.

- Daniel Bernoulli, an 18th century mathematician, discovered that as the speed (velocity) of a fluid (gas/liquid) increases the pressure it exerts is decreased.

For the following demonstrations the teacher should first ask the students to give a prediction of what they think will happen before observing the demonstration and attempting to give an explanation for what they observed (space for this is provided in the student worksheet).

Demo 1:

For this demo you will need:

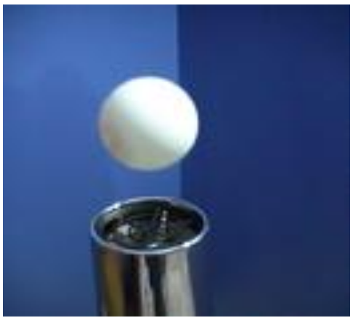
- 2 empty soda cans
- 1 plastic straw

Procedure:

1. Place the two cans beside each other on the table approximately 1- 2cm apart (adjust distance if necessary)
2. Ask your students "what will happen if I blow air using the straw between the two cans?" Most will say that the cans will move away from each other.
3. Proceed to demonstrate and ask your pupils to observe that the two cans are actually attracted to each other.

Explanation: The faster moving air between the two cans creates an area of low pressure and so the cans are pushed together by the higher pressure air surrounding them.

Demo 2:



<u>For this demo you will need:</u>

- Small light balls (e.g. Ping pong ball)
- Hair dryer.

<u>Procedure:</u>

1. Orient the hair dryer so that the outlet is pointing directly upwards. Turn it on.
2. Place a ball carefully in the flow from the hairdryer. It will balance in the air, appearing to levitate!
3. Gently move the hairdryer from side to side – the ball will stay in the air stream, i.e. will also move back and forth. Repeat this process moving the hairdryer up and down.
4. Carefully tilt the hairdryer – the ball will still stay in the airstream, hanging in mid-air with nothing directly underneath it.
5. Try using balls of differing sizes, and challenge your students to see how many they can place in the airstream at once.

<u>Explanation:</u> The airflow from the hair dryer pushes the ping pong ball upwards until its upward force equals the force of gravity pushing down on it. When it reaches this point it gently bounces around, floating where the upward and downward forces are equal. The reason the ping pong ball stays nicely inside the column of air produced by the hair dryer without shifting sideways is due to air pressure. The fast moving air from the hair dryer creates a column of lower air pressure, the surrounding higher air pressure forces the ping pong ball to stay inside this column, making it easy to move the hair dryer around without losing control of the ping pong ball.

<u>Tips for Success:</u> Try to find a hairdryer with a 'cool' setting – it will last longer and allow you to perform the trick for much longer in one sitting, without the hairdryer overheating. Make sure that the balls aren't larger than the output of the hairdryer or it won't work. Tilting the hairdryer to too great an angle will cause the ball to fall out of the airstream.

Development:

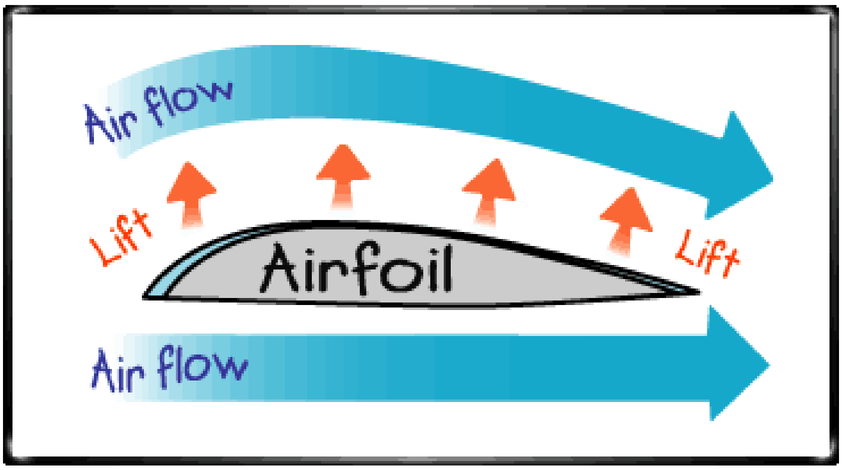
The next section of this lesson should then see your pupils attempting to apply the concepts introduced above to an airplane's wing and how they are able to create lift. Therefore at this stage you can get your pupils to work through the activities outlined in the student worksheet.

These activities require the students to take the knowledge they have just been presented with on the Bernoulli Effect and apply into to the principles of flight.

Activity 1: This activity is designed to both develop and assess your pupils' understanding of the Bernoulli Effect. They are presented with a challenge to move a coin from the edge of a table to a container. However they are not allowed to move the coin or the container with their hands. The only tool they have to use is air. A procedure and challenge rules are provided in the student worksheet. *(It may be effective to allow your students to work in groups of 2-3 when completing this activity).*

Activity 2: After checking your students understanding of the Bernoulli Effect this next activity sees them applying the theory to an air foil (airplane wing). Students are given a procedure of how to construct their own paper air foil and given the opportunity to study the behaviour of an airplane wing when in flight. They will then also be required to complete a diagram illustrating the movement of air over the air foil.

After their investigations are carried out your pupils should be aware that the shape of the air foil means that air is moving faster over the top and slower on the bottom. Air molecules split apart when they reach the leading edge of the wing. Because of the wing's curvature, the air molecule on the top needs to travel faster to meet the molecule, following a straighter, more direct route, on the bottom. The faster moving air on the top has lower air pressure. The greater pressure below then pushes up on the wing. This upward pushing force is called **lift**.



Conclusion:

To conclude this lesson emphasise to students that airplane flight is not the only example of the Bernoulli Effect in action. Ask them to imagine they are in their house with all the windows and doors shut when a tornado hits. The wind outside is moving the air very fast. The air pressure in the house remains the same. The roof is lifted off but by what? The wind speed or something inside the house? Ask your pupils to give an explanation.

Tornados do not tear off roofs. It is the higher air pressure in the house that exerts a force on the roof. The faster the outside air moves, the lower its air pressure and the greater force on the roof from within. Remember 15 psi air pressure equals 180 pounds per square foot of pressure pushing up on the ceiling. As long as the inside and outside air pressures remain the same, it stays up. Lower the outside pressure significantly by high winds of a tornado and the ceiling just lifts up, like a bird's wing. There is no longer an equal pressure holding it down.

For the next lesson (optional) you can ask your students to research other everyday examples of the Bernoulli Effect.

Lesson 3 (single lesson – optional) 35 minutes.

Bernoulli is all around us!

This lesson is designed to be used as an optional activity to develop your pupils' inquiry and project skills. The lesson is intended to be carried out during a single period in a designated science laboratory however pupils will also be required to do work outside of class time.

Introduction:

The introduction to this lesson should see the class discussing briefly some of the ideas they came up with for everyday examples of the Bernoulli Effect or demonstrations of the effect they could show to the class.

Development:

The development of the lesson should see a selected number of pupils presenting their findings to the class.
Here it may be a good idea to get the remaining students to ask questions after the presentation has been made.
If pupils have researched demonstrations they should be given time to present them to the class and given encouragement to include the other students as much as possible.

The class as a whole can then be set the task of complying a file or booklet indicating what they have learned about the Bernoulli Effect and its various examples in everyday life.

Conclusion:

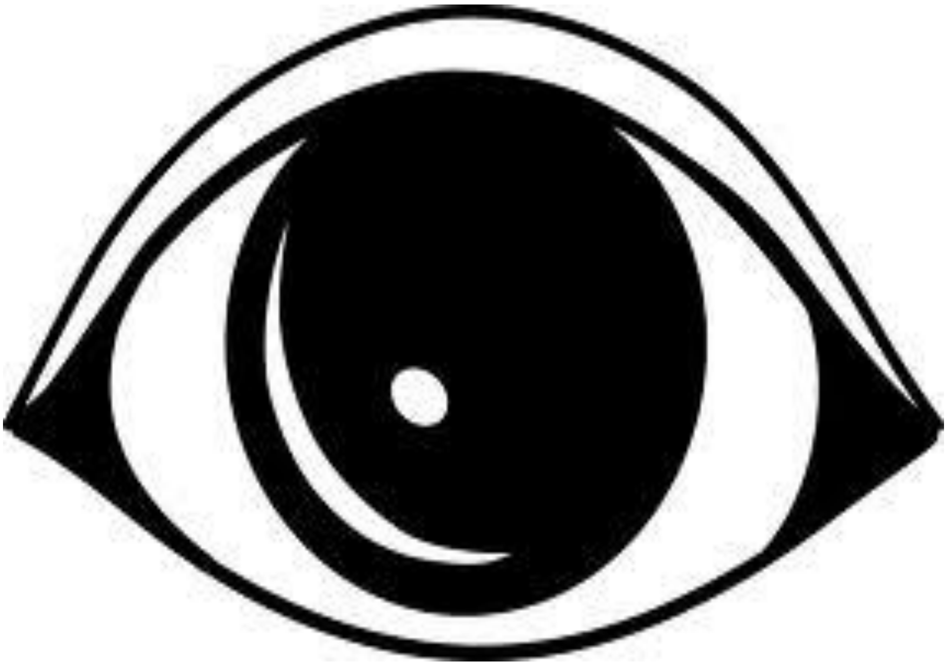
To conclude this lesson you can get your pupils to think about other forces that contribute to flight and encourage them to do some further investigations in order to develop their own knowledge.

Resources:

- Powerful Paper: http://www.stevespanglerscience.com/lab/experiments/heavy-newspaper-air-pressure-science-experiment
- Lung Buster: http://www.education.com/activity/article/balloon_air_pressure_magic/
- Bernoulli Effect: http://www.teachengineering.org/view_subjectarea.php?url=collection/wpi_/subject_areas/wpi_physical_science/physical_science.xml,

Unit 5:

Tricky Senses!



Lesson 1 (single lesson) - 35 minutes.

The blind spot!

This lesson is designed for a single class period and can be carried out in either a classroom or a designated science laboratory. The aim of the lesson is to highlight to students some of the unknown limitations of the human body. Through a series of discrepant event activities and investigations it is hoped that the students will be motivated to learn more about the various sensory organs of the human body.

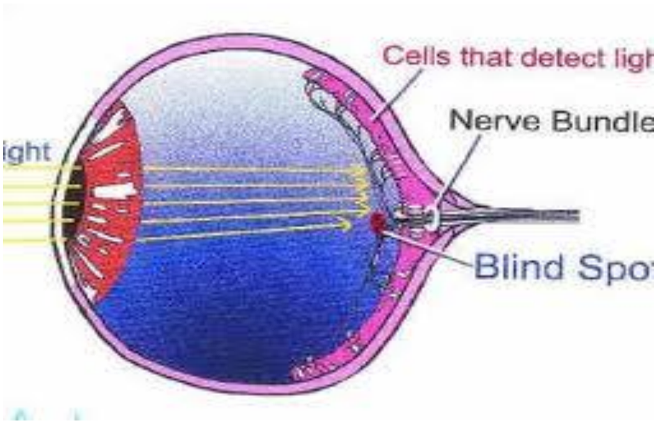
Introduction:

The introduction to this lesson uses a short activity which requires the participation of the entire class group. The activity is designed to demonstrate to pupils a key limitation of the human eye and makes an interesting opener to the unit. Tell your class this will be to see if they can follow directions! “I want to show you that our eyes are not perfect”. Then ask them to follow the instructions given to them in their student worksheet (coy of instructions given below).

Instructions:

1. Take a piece of paper and put a spot in the centre.
2. Then, about 5 cm to the **left** (or 3-finger-widths), make a capital **L**
3. And 5 cm to the **right** make a capital **R**.
4. Now, put your hand over your **left** eye, and stare at the spot with your **right** eye.
5. Move your head closer to the paper (to around 20 cm distant).

Pupils should notice that something disappears. What is missing?" [They should find that the R disappears.] "So, apparently, there's something wrong with your right eye...it's blind in one area. Ask them to now try this with their **left** eye." [The L disappears.] Point out that there are many imperfections in our body...and we'll be looking at some more of them later. At this time, you might ask if anyone knows why we have those blind spots [they correspond to where our optic nerves exit the eyeball]. If nobody knows, you could offer a prize to the first person to find out, write it down, and hand it in, giving the source of his/her information. Here it may be useful to have a diagram of the eye to show to your students.



Development:

The next section of this lesson should see your students carrying out further investigations into their own blind spots. You should therefore begin by asking your students the following questions.........

"Do you think everybody has the same size of a blind spot?"

A couple of minutes should be allowed for pupils to give their opinions on the question posed before presenting pupils with the procedure and equation necessary to measure their own blind spot.

(Procedure and equation included in student worksheet). Pupils can be divided into groups of 2-3 and asked to calculate the diameter of the blind spot for each member in the group.

Once the task has been completed a table containing the results from the entire class can be complied.

Conclusion:

The conclusion of this lesson should aim to provide the students with material to research and investigate in the next lesson. Therefore the teacher should finish this introductory lesson by presenting pupils with the following questions.

- **"Does everyone taste things in the same way?"**
- **"How come some areas of our body are more sensitive than others?"**

Pupils should be tasked with carrying out research of their own into the questions above before attending the next lesson.

Lesson 2 (double lesson) – 70 minutes

Bitter Sweet!

This lesson is designed for a double class period and is most suitable to be carried out in a designated science laboratory. The aim of this lesson is to build on the concepts introduced in the previous lesson by allowing students to design and carry-out investigations.

Introduction:

The introductory part of this lesson should see your pupils discussing the questions given to them to research in the previous lesson.

- **“Does everyone taste things in the same way?”**
- **“How come some areas of our body are more sensitive than others?”**

Therefore you should begin by asking your students to share their findings with the class. The class should then debate the various explanations given before asking them to devise and agree on a hypothesis for each of the questions.

Once this is completed you should task your students with developing a method that could be carried out at home to test their first hypothesis on whether or not everyone tastes things in the same way.

Development:

The second part of this lesson should then see your pupils attempting to test their second hypothesis using the **two point threshold method**. The two-point threshold is the minimum distance by which two rods touching the skin must be separated before the person will report that there are two rods, not one, on 50% of occasions. For this experiment pupils should work in pairs with one person acting as the experimenter and the second acting as the test subject. It must be stressed to your students that it is very important to the experiment that the test subject **be honest** in their reporting.

(a complete step by step procedure and materials list is included in the student worksheet).

Conclusion:

To conclude this lesson you should get your students thinking about the limitations of other animal’s senses. This can then form the basis of the optional lesson for this unit where pupils will be required to carry-out research into the senses of other animals. Students should focus on establishing which specimens have the best sight, taste, hearing or smell, by answering the following question.............

“Are humans the most advanced organisms on the planet?”

Lesson 3 (single lesson - optional) 35 minutes.

Deadly senses!

This lesson is designed for a single class period and can be carried out in either a classroom or a designated science laboratory. The aim of this lesson is to provide students with the opportunity to investigate the various sensory systems in the animal kingdom and to evaluate their effectiveness.

Introduction:

The introduction to this lesson should see your pupils continuing the discussion that began at the end of the previous lesson. The discussion should focus on the question posed to the students......

"Are humans the most advanced organisms on the planet?"

Each student should present to the class their findings on sensory systems from various animals around the world. In each case the student should highlight the difference between the specimen in question and the corresponding human sensory system.

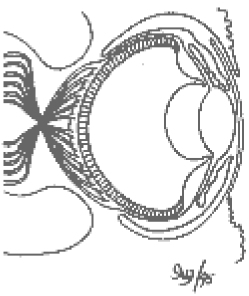
Development:

The next part of this lesson should then see your students building on this initial discussion through group work activities. In groups pupils can be tasked with complying a catalogue of specimens with more advanced sensory systems than humans. This can be presented in the form of posters, power point presentation or even a booklet.

Example:

Did you know?

An octopus does not have a blind spot! The retina of the octopus is constructed more logically than the mammalian retina. The photoreceptors in the octopus retina are located in the inner portion of the eye and the cells that carry information to the brain are located in the outer portion of the retina. Therefore, the octopus optic nerve does not interrupt any space of retina.



Conclusion:

To conclude this lesson you should ask your students to present their work to the class before recapping on the material covered in the unit.

Resources:

- Blind Spot: file:///C:/Users/owner/Documents/College%20Work/4th%20year/FYP/Topic%20ideas/Neuroscience%20for%20Kids%20-%20Vision%20Exp.htm

- Two-point threshold experiment: https://fc.usd497.org/.../Touch%20Sensitivity%20-%20Two%20Point%2

Unit 6:

Osmosis Magic!

Lesson 1 (single lesson) – 35 minutes

Super soakers!

This lesson is designed for a single class period and should be carried out in a designated science laboratory. The aim of this lesson is to introduce pupils to the concepts of diffusion and osmosis, using discrepant event demonstrations and inquiry – based activities.

Introduction:

Introductory section of this lesson uses a magic trick that works using the principles of osmosis. The tick uses a super absorbent polymer to give the illusion of disappearing water.

<u>Materials needed</u>:

- 3 cups
- Superabsorbent polymer (e.g. Instant snow, nappy granules)
- Water

<u>Procedure:</u>

1. Pour out 1 tablespoon of the superabsorbent polymer into one of the cup.
2. Place the three cups on the table in a row.
3. Using a cup add water to the cup with the polymer.
4. Ask your students to keep their eye on the cup with the water before slowly move the cups around.
5. Then ask your students to tell you which cup the water is in.
6. They will be puzzled when you invert each cup but no water will appear.

Explanation: When the water is added to the cup, the superabsorbent polymer soaks it all up to leave a snow like substance. This then sticks to bottom of the cup and will not come out when inverted. Therefore it is important to take your time when switching the cups around, to give time for the polymer to soak up all the water (this might take some practice).

Super absorbent polymers that can be used for this experiment include "Insta-snow". This is derived from the same superabsorbent polymer found in baby diapers. The only difference is that the Insta-snow polymer not only absorbs water but the long chains of molecules swell to an enormous size. The polymer soaks up the water using the process of osmosis (water molecules pass through a barrier from one side to the other). When water comes in contact with the polymer, it moves from outside the polymer to the inside and causes it to swell. The polymer chains have an elastic quality, which allows them to stretch. If you cannot obtain

“Insta-snow” a similar polymer as stated above can be found in disposable nappies or you can also by water absorbent granules in garden centres that can be investigated.

Development:

The next part of this lesson should then see your pupils attempting to explain what they have just witnessed. It is appreciated that students will more than likely have quite a limited knowledge of both diffusion and osmosis. However it is important not to just tell them the answer straight away, let your pupils work in pairs or groups and participate in whole class discussions in an attempt to give an answer for what they observed.

Here you can also ask your students to discuss possible practical applications of such super absorbent polymers. Examples may include:

- Potting soil
- Grow in water toys
- Cleaning up oil spills
- Diapers
- Fire retardant gels

At this stage it may be necessary to present to your students some fundamental knowledge of diffusion and osmosis. This could be known with diagrams in a Power point presentation or any other form of visual aid.

Conclusion:

The conclusion of this lesson should see your students setting up an experiment to be examined and evaluated in the next lesson. This experiment uses eggs to demonstrate the principles of osmosis however this initial preparation sees your students using vinegar to dissolve the hard shell of the egg for use in the experiment. (Procedure and materials list are included in the student worksheet).

Lesson 2 (double lesson) – 70 minutes

Eggmosis!

This lesson is designed for a double period and should be carried out in a designated science laboratory. The aim of this lesson is to allow your students to develop their understanding of the concepts introduced in the previous lesson through inquiry-based activities.

Introduction:

The introductory part of this lesson should see your students' examining the results of the experiment preparation they carried out at the end of the previous lesson. Pupils should be given time to remove, clean, observe and compare their eggs to a fresh egg. The eggs should look very different as the shell will have been removed by the acidity of the vinegar. It should also appear to be much bigger. This is due to osmosis – there is more water in the vinegar than in the egg. Therefore the water diffuses from the area of high water concentration (vinegar), into the area of low water concentration (egg), across the membrane.

Students should then be tasked with explaining what they observed, including what happened to the shell and the increased size of the egg.

Development:

The next part of the lesson should then see the class proceed to carry-out further investigations using the prepared eggs. This next stage of the procedure aims to establish what will happen to the eggs if they are placed in liquids of varying water concentration. The three liquids used are water, vinegar (again) and corn syrup. (Procedure and materials list are included in the student worksheet).

Students should then be tasked with predicting what they think will happen in each case using their knowledge of osmosis to supply a rationale for their prediction. Once again this experiment will have to be left overnight before results can be obtained.

Expected results:

1) The egg in corn syrup will shrink, because corn syrup doesn't have water in it. The water will diffuse from the egg into the syrup.
2) The egg in the vinegar will stay the same size, because it's already been soaking in the

vinegar long enough that it is in equilibrium (same concentration of water in and out of the egg)

3) The egg in the water will get even bigger, since there is a higher concentration of water in the water than in the egg

Conclusion:

To conclude this lesson the you should challenge your students by asking **"if water naturally flows from areas of high concentration to low concentration, what do you think the benefits of reversing the process could be?".**

Therefore the lesson should finish with students setting up a design to move water from an area of low concentration to high concentration. The apparatus must then be observed over a period of time before students can evaluate the results. (Procedure and materials list are included in the student worksheet). After setting up the apparatus students can be asked to make a prediction for the outcome.

Lesson 3 (single lesson –optional) 35 minutes.

All shapes and sizes!

This lesson is designed for a single class period and should be carried out in a designated science laboratory. The aim of this lesson is to give students the opportunity to observe and evaluate the results of their previous experiments. It also aims to raise pupils' awareness of the personal and social importance of such concepts.

Introduction:

The opening section of this lesson should be allocated for students to observe, record and evaluate the results of both the "eggmosis" experiment and the reverse osmosis apparatus. In each case students will compare the results to their predictions and give a scientific explanation for what occurred.

Development:

To develop this idea further asks your students to discuss the statement given below, which aims to introduce pupils to the personal and social effects of this scientific concept.

"How could such concepts be used to solve the problem of unsanitary water in third world countries?"

The teacher should present students with the science behind reverse osmosis which is used as a water purification technique.

Students should participate in a whole class discussion and debate, before being encouraged to do some research of their own, into the topic.

Conclusion: To conclude this lesson the teacher should recap on the material covered and insure that the students are clear on the difference between, diffusion, osmosis and reverse osmosis.

Resources:

- Three cup trick: http://www.metacafe.com/watch/446723/secret_of_water_disappearing_trick_revealed/
- Eggmosis experiment: http://www.desertwind.us/blog/2011/06/eggmosis-osmosis-with-eggs/
- Reverse osmosis info: science.howstuffworks.com/reverse-osmosis.htm.

Unit 7:
Sticky Static!

Lesson 1 (single lesson) –35 minutes

A Love/Hate Relationship!

This lesson is designed for a single lesson and is appropriate to be carried out in both a classroom and a designated science laboratory. The aim of this lesson is to use a variety of simple discrepant event demonstrations to introduce students to the concept of static electricity. For each demonstration presented students will work together to explain what is happening.

Introduction

The introductory part of this lesson uses a simple discrepant event demonstration which sees the teacher bending a stream of water using static electricity with the aim of stimulating pupils' interest in the topic. Students should be allocated time before demonstration to predict what will happen and time after to discuss the explanation.

<u>*Materials:*</u>

- Dry plastic comb
- Tap and sink
- Piece of wool fabric/hair.

<u>*Procedure:*</u>

1. Turn on the tap and slowly turn down the water until you have a VERY thin stream of water flowing.
2. Take the plastic comb and brush it through your hair (or the wool fabric) ten times.
3. Now slowly bring the comb close the flowing water, (<u>without</u> actually touching the water) if all goes well, the stream of water should bend towards the comb! Magic you ask? Not really.

<u>*Explanation:*</u> When you brushed that comb through your hair, tiny parts of the atoms in your hair, called ELECTRONS, collected on the comb. These electrons have a NEGATIVE charge. Now that the comb has a negative charge, it is attracted to things that have a POSITIVE charge. It is similar to the way some magnets are attracted to certain metals. When you bring the negatively charged comb near the tap it is attracted to the POSITIVE force of the water. The attraction is strong enough to actually pull the water towards the comb as it is flowing!

Development:

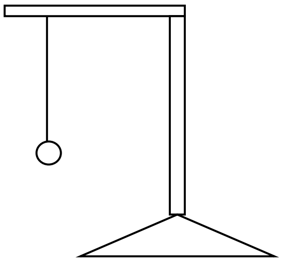
The next section of this lesson should see the teacher presenting a variety of interactive demonstrations, designed to further develop students understanding of static electricity. In each case students will be challenged to give a prediction based on the proposal given and a scientific explanation for what they will observe. Pupils will also be required to complete diagrams in order to cement their understanding.

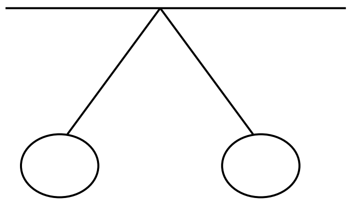
Materials:

- 4 balloons (spares may also be required)
- Matches
- 1 ping pong ball
- Insulated stand
- Plastic Comb
- Confetti
- 2 metres of sewing thread

Safety Concerns: There are really no safety concerns for these events. The only precaution to take is to be careful when using matches in the classroom.

Demonstration 1	
Title:	Balloon/Hair Demonstration
Procedure	1. Ask the class "What happens when you rub a balloon on someone's head and then slowly take it away?" Then ask "Why does this happen?" **Target response:** The hair sticks to the balloon. Static electricity is produced. 2. Get a volunteer with long hair and rub a balloon on their head. Slowly pull the balloon away to show the attraction of the hair and balloon.
Observation	When the balloon was rubbed on the student's hair and then slowly taken away, the hair was attracted to the balloon and stuck to it.
Explanation	Like charges always attract and unlike charges always repel. By rubbing the balloon on the student's hair, the hair becomes positively charged (loses electrons) and the balloon becomes negatively charged (gains electrons). When the balloon is slowly pulled away, some hair sticks to the balloon. This is because there is an attraction between the negatively charged balloon and the positively charged hair.

Demonstration 2	
Title:	Ping Pong Ball Demonstration.
Procedure	1. Set up ping pong ball and insulated stand as seen in figure below. 2. Place the uncharged plastic comb near the uncharged ping pong ball to demonstrate that there is no attraction. 3. Charge the comb by rubbing it with the fur and place it close to the ping pong ball. Have students observe what happens. 4. Touch the charged ebonite rod to the pith ball. Ask the students “What did you see happen?” **Target response:** The ball was attracted to the rod and stuck to it. Then the ball was repelled away from the rod. 5. Ask the students “Why is the ball now repelled by the rod?” **Target response:** They both have the same charge. 
Observation	When the comb was brought close to the ping pong ball, there was an attraction. As the rod was touched to the pith ball, they momentarily stayed together and then the pith ball was repelled.
Explanation	The ping pong ball is neutral and as the negatively charged plastic comb is brought close, the molecules within the ball are reoriented so their electrons will move away from the negatively charged rod (the electrons crowd the far side of the ball. This creates an imbalance of charge on the ball. Even though the ball remains as a neutral object, there is now a net positive charge on the side of the ball closest to the comb and a negative charge on the side farthest from the comb. This causes the ball to be attracted to the comb. Since there has been no contact between the bodies, there has been no actual transfer of electrons. There has only been a temporary rearrangement of the molecules. This is known as electrostatic induction. The charged comb has “induced” a charge on the ball. Once the charged comb is removed, the molecules return to their normal state. The pith ball no longer carries the charge and collapses to its resting position. When the negatively charged comb is touched to the neutral ball, a channel through which electrons flow is established (positive charges do not move, only negatively charged electrons). Electrons from the rod move to the ball giving the ball an excess of negatively charged electrons (a net negative charge). This is known as electrostatic conduction. Now that both the comb and the ball have the same negative charge, they repel each other.

Demonstration 3	
Title:	Balloon and Match Demonstration
Procedure	Steps 1 through 4 will be set up before the class. 1. Pour a small amount of confetti into three balloons. Blow up and tie off each balloon.  2. Take two of the balloons and tie one to each end of the two-meter length of thread. 3. Suspend the two balloons from the ceiling, so that they are hanging with equal lengths of thread. 4. Charge the two hanging balloons by rubbing them with the fur and allow them to come to rest. The set up should appear as in figure above. 5. Charge the one balloon that is not tied up by rubbing it with the fur. Ask the students "What did you notice happen to the confetti?" and get them to explain their answer. **Target response:** The balloon became negatively charged and attracted the positively charged confetti to its inside. 6. Ask the class what they observe about the two suspended balloons and have them explain their answer. **Target response:** The confetti has become attracted to the insides of the balloons. The balloons are repelling one another because they possess the same charge. 7. Take the third balloon, and ask the class what they think will happen if we bring it close to the two balloons hanging from the ceiling. **Target response:** Since they are all the same charges, they should all repel one another. 8. Ask the class "What do you think will happen if a match is struck underneath the balloons?" 9. Make note of the students' predictions. 10. Light the match and hold it about 12 inches below the balloons. 11. Ask the students what they observed. **Target response:** The balloons dropped and came together. 12. Tell the students that the negative charges that existed between the balloons have been neutralized. Demonstrate that the balloons are neither attracted nor repelled by one another. One way this can be done is by bringing the "loose" balloon close to the hanging balloons.
Observation	When the match was lit, the balloons collapsed together to a resting position.
Explanation	At the beginning of the demonstration, all three balloons are negatively charged. Like charges repel each other, so the hanging balloons appear as in the figure shown above. As the third negatively charged balloon is brought close, the hanging balloons separate even further. The striking of the match generates both positive and negative charges. These charges rise up in the heat of the flame. The positive charges generated are opposite from the balloons' net negative charge and are attracted to them. This has the effect of neutralizing the balloons' net charge. Since the net negative charges that existed between the balloons have been neutralized, the balloons no longer repel one another and are free to drop down into a resting state. The negative charges generated by striking the match are repelled from the negatively charged balloons' and dissipate.

Conclusion:

To conclude this lesson the teacher should present students with a task designed to improve their experimental skills and encourage inquiry based learning. In this task students will be asked to investigate any factors that may affect the process of static electricity presented to them in this lesson. This will be done by converting the demonstration of bending water shown above into an experiment. Students will be asked to carrying out the method for bending water using static before and after letting the hot water tap run for a few minutes or after the shower has been used in the bathroom.

Lesson 2 (Double lesson) – 70 minutes.

May the force be with you!

This lesson is designed for a double lesson and is appropriate to be carried out in a designated science laboratory. The aim of this lesson is to recap on the material presented in the previous lesson while also attempting to develop pupil's investigatory and inquiry skills.

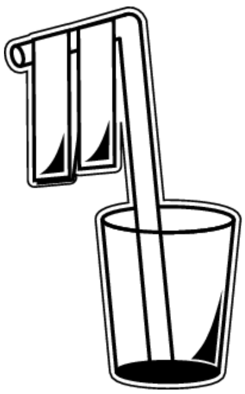
Introduction:

This lesson should begin by recapping on the ideas and concepts introduced in the previous lesson. The next stage of the lesson should then see pupils discussing their findings from the investigations they were asked to complete at home in relation to the factors that affect static electricity with emphasis on the effect of humidity (moisture).

The teacher should then facilitate a class discussion on any other factors that could affect the strength of a static charge. For example students may come to the conclusion that different materials and the amount time spent rubbing materials together may affect the static charge formed.

Development:

After facilitating a discussion on how certain materials and the amount of time they are rubbed together may affect the strength of the static charge the next part of this lesson should see students using an experimental method to test any ideas given. In this section students will not only develop their understanding of static electricity but also learn about an experiment regarding static electricity that can be done using a device made from simple materials called an electroscope. An electroscope is a device that detects electrical charge. There are many types of electroscopes, some complicated models that can be bought from scientific suppliers. However this lesson will outline how to make a simple electroscope using the following materials.



- One small cup (glass, plastic and paper)
- One plastic drinking straw with flexible end
- Tape
- Aluminium foil

*Included in the student handbook for this module is a step by step procedure that can be followed to construct this simple electroscope.

The student handbook also includes the procedure necessary to test a variety of materials to see which material conducts static electricity the best. It may also provide students with the opportunity to investigate the effect of the amount times an object is rubbed on the charge it produces.

Conclusion:

To conclude this lesson the teacher should be set the challenge of using their electroscopes at home to test a wider variety of materials using the same procedure as used during this lesson. The teacher should also set students the task of researching uses for static electricity in everyday life. Here students should be divided into groups of 3-4 and tasked with researching a specific use of static electricity. Students can then be given time to present their findings in the next lesson.

Lesson 3 (Single Lesson – Optional) 35 minutes.

Useful static!

This lesson is designed for a single class period and should be carried out in a designated science laboratory. The aim of this lesson is to give students the opportunity to carry-out some research and investigations outside of the classroom.

Introduction:

The first part of this lesson the teacher should use a short demonstration to show how static electricity can be used to make objects levitate exhibiting a basic use of static electricity.

Static Flyer

Materials:

- Cotton towel
- Plastic produce bag
- Scissors
- Balloon

Demonstration:

1. Use a pair of scissors to cut a strip from the open end of the produce bag. Once the strip is cut, you should have a plastic band or ring.
2. Blow up a balloon to its full size and tie off the end.
3. Rub the cotton towel over the surface of the balloon for 30-45 seconds.
4. Flatten the plastic band on a hard surface and gently rub the towel on the band for 30-45 seconds.
5. Hold the plastic band about one foot over the balloon and release it.

Development:

The next part of this lesson should see students presenting their findings to the research they carried out on a particular use of static electricity.

Here it may be a good idea to get the remaining students to ask questions after each presentation has been made.

Conclusion:

To conclude the lesson the teacher should show a video on a particular use of static. For example how it is used in certain spray painting methods.

Unit 8:

A lot of hot air!

Lesson 1 (Single lesson) – 35 minutes.

Tiny Dancer!

This lesson is designed for a single class period and should be carried out in a designated science laboratory. Matter undergoes phase change when heated or cooled. Phase change therefore is accompanied by energy exchange and transformation. When phase change takes place in a closed container, changes in the physical properties and characteristics also accompany it. The aim of this lesson and unit is to look at these phase changes and the resulting gases behaviour.

Introduction:

The introductory section of this lesson should see the teacher gauging student's prior knowledge of phase changes and their understanding of how gases behave when heated or cooled. This may be done by facilitating an open class discussion where students will be asked to contribute their opinion and understanding to phase changes that they would have experienced in their everyday lives, for example boiling water in a kettle.

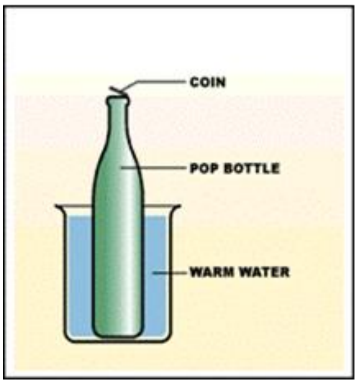
Development:

The next part of the lesson will then see the teacher presenting students with two discrepant event demonstrations designed to get students thinking about the behaviour of gases in a closed container. The demonstrations will also draw on their knowledge of air pressure from an earlier unit in this module.

Demonstration 1

Materials:

- Wet coin (saliva)
- Wine bottle (with small amount of wine in the bottom).
- Container of hot water.



Safety precautions:

- Make sure the water you use is not overly hot. The water does not have to be boiling for this experiment to work. Straight hot water from the tap is all that's required and it is much safer for the students as well.

Procedure:

1. Put some saliva on the back of a coin.
2. Place the coin over the opening of a wine bottle containing a small amount of wine in the bottom.
3. Ask students to predict what will happen when the bottle is placed in a container of hot water.
4. Place the bottle in the container of hot water.
5. Students should observe the coin dancing on top of the wine bottle.
6. Ask pupils to record their observations and give an explanation for why it occurs.

Explanation:

- The hot water heated the air in the bottle and caused the air to expand. Therefore the molecules move faster, pose more energy and collide more frequently and with more energy creating greater pressure on the coin inside the bottle. Because the air was heated it began to expand and leave the bottle. When the air tried to escape it made the coin vibrate because it forces through the seal created by moistening the top of the bottle. If there were no seal the air would simply seep through the top.

<u>Demonstration 2</u>

Materials:

- Egg, hard-boiled
- Paper towel
- Conical flask, to fit egg Tongs
- Lighter or matches
- Wire formed into a hook

Safety Precautions:

- The conical flask will develop a slight vacuum as the hot air inside the flask cools. Use only pyrex flasks with heavy-duty rims and carefully check the flask before use for chips or cracks. Have a source of water nearby to douse the flame if necessary. Wear chemical splash goggles. Wash hands thoroughly with soap and water before leaving the laboratory. Follow all laboratory safety guidelines.

Preparation:

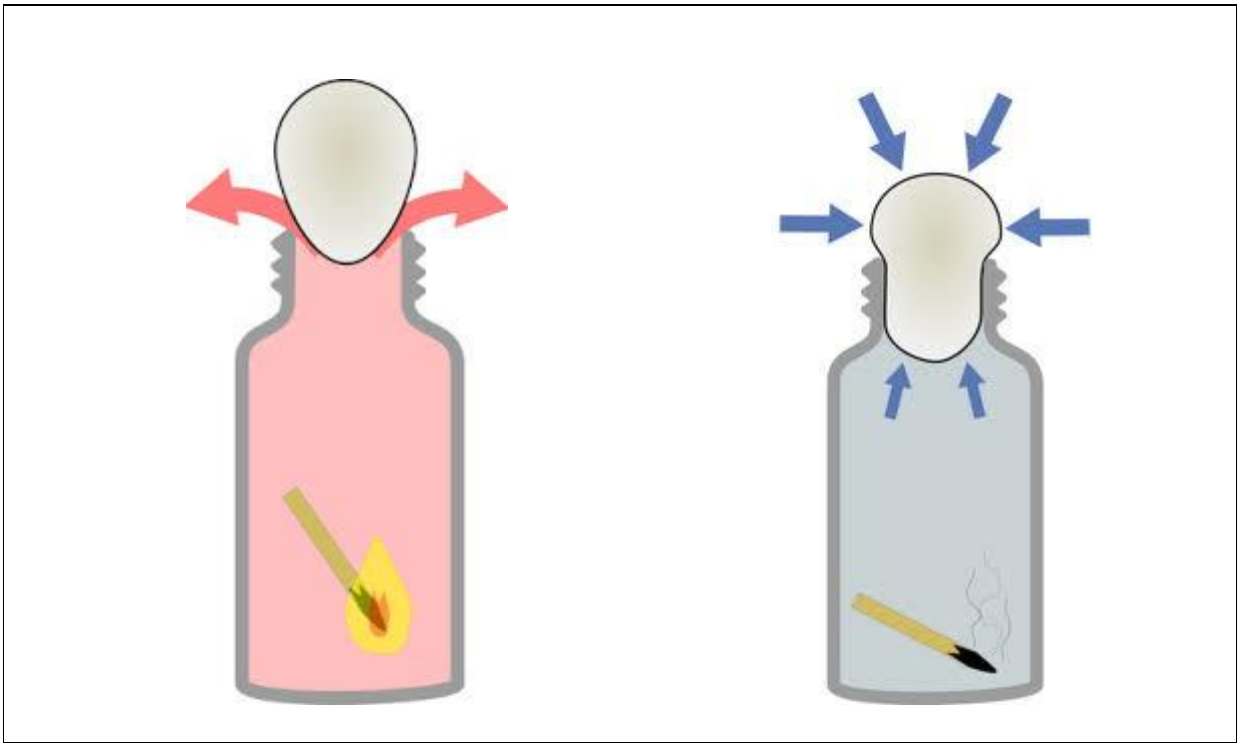
1. Hard boil and peel the egg.
2. Roll the paper towel into a tube shape.

Procedure:

1. Ask students to make a prediction of what they think will happen.
2. Grasp the paper towel with the tongs and light the paper towel.
3. Place the lit paper towel into the conical flask.
4. Place the egg pointed side down onto the lip of the conical flask.
5. After the egg has entered the flask, use a wire hook to remove the burned remains of the paper towel.
6. Challenge students to think of a away of removing the egg from the flask without breaking it.
7. Lift the flask to your lips and press lips tightly and blow hard.
8. Release and catch the egg as it emerges from the bottle.

Explanation:

- Burning the paper heats the air inside the open bottle and causes the gas to expand and some of it to escape from the bottle. When the fire burns out, the remaining air is trapped in the bottle by the egg and subsequently cools down. As the temperature of the air in the bottle decreases, so does the gas pressure inside the bottle relative to that of the surrounding air outside the bottle. The greater pressure (force) of the outside air forces the egg into the flask. It is both the lower temperature and the fewer number of moles of air that cause the egg to be pushed into the bottle. This may be explained using Amontons's law.



Conclusion:

To conclude this lesson the teacher should present students with the following scenarios to discuss in terms of the concepts they have just witnessed.

a.) A balloon is left out in the backyard in the middle of winter.

b.) A half full pail of ice cream is taken out of the freezer and left on the counter with the lid on.

c.) A man's bike is left outside overnight in the cold. The next day, he brings the bike inside and realizes the tires are flatter.

Students should be encouraged to test the scenarios above at home if possible. If the weather is not suitable other means by which to lower the temperature of a gas may be used. (For example placing a balloon in the freezer overnight)

Lesson 2 (Double lesson) – 70 minutes.

Choo Choo Can!

This lesson is designed for a double class period and should be carried out in a designated science laboratory. The aim of the lesson is to build on the concepts introduced in the opening lesson while attempting to develop pupil's investigatory and inquiry skills. This lesson may require students to source some of the materials and therefore they will have to be notified of this prior to carrying out the lesson.

Introduction:

The introductory section of this lesson should see the teacher and the students discussing the results of any experiments carried out at home. Students should be encouraged to share their results with the class.

The teacher should then proceed to another discrepant event demonstration designed to assess students understanding of the concepts they encountered in the previous lesson.

Demonstration

Materials:

- Empty soda cans
- Hot plate
- Tongs
- Large beaker
- Cold water

Safety Precautions:

- Be careful of the hot can and the steam created by heating the water in the can. Wear goggles and protective gloves during the demonstration.

Procedure:

1. Start by rinsing out the soda cans to remove any leftover residue.
2. Fill the bowl with cold water (the colder the better).
3. Add one generous tablespoon of water to the empty soda can (just enough to cover the bottom of the can).
4. Place the can on the burner of the hot plate. Soon you'll hear the bubbling sound of the water boiling and you'll see the water vapour rising from the can. Continue heating the can for one more minute.
5. It's important to think through this next part before you do it. Here's what's going to happen: you're going to use the tongs to lift the can off of the burner, turn it upside down, and plunge the mouth of the can down into the bowl of water.
6. Get your students to predict what will happen
7. Using one swift motion, lift the can off the hot plate, turn it upside down, and plunge it into the cold water.
8. The can should immediately collapse in on itself. How does that work?

Explanation:

- The tremendous pressure required to “crush” the can comes from the differential in pressure that exists between the outside of the can (normal air pressure) and the partial vacuum created inside the can by the condensing steam. The pressure differential is caused by the condensation of the steam inside the closed system as the can cools. There is only a little air in the can to take the steam’s place. There is much less gas on the inside of the can so there is less pressure inside. The pressure on the outside of the can remains at atmospheric pressure (14.7 lb/in2) while the pressure inside the can is significantly reduced as the steam condenses.
- Remember that the can is not “sucked in”—it is the greater pressure on the outside of the can that pushes in on the can and “crushes” it. The total pressure exerted on the outside of the can may be calculated by determining the surface area of the outside of the can and multiplying this area by atmospheric pressure per unit area.

**Students could be allowed to try this experiment themselves if time allowed.*

Development:

The next part of the lesson should see students using the concepts they have learned to demonstrate how they can be used to produce kinetic/mechanical energy. Here students will be tasked with constructing their own hero’s engine. Students will also be challenge to come up with ideas to harness the energy this so called engine produces.

This activity demonstrates in a fun and very inexpensive way the conversion of chemical energy in the form of methane and oxygen (or ethanol and oxygen) into the thermal energy of the flame which in turn can be converted into the mechanical energy of the spinning can, thanks to the phase change of water boiling. This, in turn, might be used to do useful work - perhaps some sort of spool placed over the can could coil up a thread as it is spun, which in turn might lift an object off the floor. Or perhaps the spinning engine could be used to turn a generator to convert the mechanical energy into electrical.

Conclusion:

To conclude this lesson the teacher should set students a research task to be completed before the next lesson.

Students should be asked to go home and research devices/machines that use phase changes to produce a form of energy. One example could be how a steam engine works.

Lesson 3 (Single lesson –Optional) 35 minutes.

Steam Power!

This lesson is designed for a single class period and should be carried out in a designated science laboratory. The aim of this lesson is to give students the opportunity to carry-out some research and investigations outside of the classroom.

Introduction:

The first part of this lesson should see students presenting their findings for the research task they were set at the end of the previous.

Here students should present their material to the class in whatever format they have chosen.

Here it may be a good idea to get the remaining students to ask questions after each presentation has been made.

Development:

A possible development activity for this optional is to task students with designing and constructing a functional model of a steam engine. (This may take more than one lesson and could be carried out as a whole class project.) It would also provide scope for possible collaboration with the engineering department in the school.

Conclusion:

To conclude the lesson the teacher may present the students with a video a steam engine model as an aid to their design process.

Teacher should also recap on the material covered throughout the unit.