

Scheme of Work

Cambridge Lower Secondary

Science 0893

Stage 8



This Cambridge Scheme of Work is for use with the Cambridge Lower Secondary Science Curriculum Framework published in September 2020 for first teaching in September 2021.

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# Introduction

This document is a scheme of work created by Cambridge Assessment International Education for Cambridge Lower Secondary Science Stage 8.

It contains:

* suggested units showing how the learning objectives in the curriculum framework can be grouped and ordered
* at least one suggested teaching activity for each learning objective
* a list of subject-specific language that will be useful for your learners
* some possible models and representations that are relevant to the learning objectives
* some possible misconceptions learners may have, or develop
* sample lesson plans.

You do not need to use the ideas in this scheme of work to teach Cambridge Primary Lower Secondary Stage 8. This scheme of work is designed to indicate the types of activities you might use, and the intended depth and breadth of each learning objective. These activities are not designed to fill all of the teaching time for this stage. You should use other activities with a similar level of difficulty, including those from endorsed resources.

The accompanying teacher guide for Cambridge Lower Secondary Science will support you to plan and deliver lessons using effective teaching and learning approaches. You can use this scheme of work as a starting point for your planning, adapting it to suit the requirements of your school and needs of your learners.

## Long-term plan

This long-term plan shows the units in this scheme of work and a suggestion of how long to spend teaching each one. The suggested teaching time is based on 90 total hours of teaching for Science Stage 8 at 3 hours a week. The actual number of teaching hours may vary according to your context.

| Unit and suggested order | Suggested teaching time | Unit and suggested order | Suggested teaching time | Unit and suggested order | Suggested teaching time |
| --- | --- | --- | --- | --- | --- |
| **Unit 8.1**  Gases | 10% (9 hours) | **Unit 8.4**  Light and colour | 10% (9 hours) | **Unit 8.7**  Speed, motion and forces | 10% (9 hours) |
| **Unit 8.2**  Liquids | 11% (10 hours) | **Unit 8.5**  Atomic structure and chemical reactions | 11% (10 hours) | **Unit 8.8**  Earth and the Solar System | 11% (10 hours) |
| **Unit 8.3** Respiration and the respiratory system | 12% (11 hours) | **Unit 8.6**  Health | 12% (11 hours) | **Unit 8.9**  Applications of science | 12% (11 hours) |

## Sample lesson plans

You will find two sample lesson plans at the end of this scheme of work. They are designed to illustrate how the suggested activities in this document can be turned into lessons. They are written in more detail than you would use for your own lesson plans. The Cambridge Lower Secondary Science Teacher Guide has information on creating lesson plans.

## Other support for teaching Cambridge Lower Secondary Science Stage 8

Cambridge Lower Secondary centres receive access to a range of resources when they register. The Cambridge Lower Secondary support site at [**https://lowersecondary.cambridgeinternational.org**](https://lowersecondary.cambridgeinternational.org) is a password-protected website that is the source of the majority of Cambridge-produced resources for the programme. Ask the Cambridge Coordinator or Exams Officer in your school if you do not already have a log-in for this support site.

Included on this support site are:

* the Cambridge Lower Secondary Science Curriculum Framework, which contains the learning objectives that provide a structure for your teaching and learning
* grids showing the progression of learning objectives across stages
* the Cambridge Lower Secondary Science Teacher Guide, which will help you to implement Cambridge Lower Secondary Science in your school
* templates for planning
* worksheets for short teacher training activities that link to the teacher guide
* assessments provided by Cambridge
* a list of endorsed resources, which have been through a detailed quality assurance process to make sure they are suitable for schools teaching Cambridge Lower Secondary Science worldwide
* links to online communities of Cambridge Lower Secondary teachers.

## Resources for the activities in this scheme of work

We have assumed that you will have access to these resources:

* paper, graph paper, pens, pencils, rulers and calculators for learners to use
* clean water
* the internet.

Other suggested resources for individual units and/or activities are described in the rest of this document. You can swap these for other resources that are available in your school.

The Cambridge Lower Secondary Science Equipment List provides a list of recommended scientific equipment that your school should have access to in order to teach all stages of Cambridge Lower Secondary Science. It is available on the support site.

## Websites

There are many excellent online resources suitable for teaching Cambridge Lower Secondary Science. Since these are updated frequently, and many are only available in some countries, we recommend that you and your colleagues identify and share resources that you have found to be effective for your learners.

## Approaches to teaching Cambridge Lower Secondary Science Stage 8

There are three components to the Cambridge Lower Secondary Science Curriculum:

* four content strands (Biology, Chemistry, Physics, and Earth and Space)
* one skills strand (Thinking and Working Scientifically)
* one context strand (Science in Context).

When planning lessons, the three components should work together to enable you to provide deep, and rich, learning experiences for your learners.

We recommend you start your planning with a learning objective from one of the four content strands. This determine the focus of the lesson. Once there is a content learning objective lesson focus you can consider what Thinking and Working Scientifically learning objectives can be integrated into your teaching, so learners are developing their scientific skills alongside their knowledge and understanding of science.

This approach is exemplified in this scheme of work by providing activities that cover the content learning objectives while also developing selected Thinking and Working Scientifically learning objectives. Some Thinking and Working Scientifically learning objectives are covered multiple times over the scheme of work which reflects the need for learners to have several opportunities to develop skills.

The selection, and frequency, of Thinking and Working Scientifically learning objectives in this scheme of work may match the needs of your learners. However, the selection of Thinking and Working Scientifically learning objectives needs suit the requirements of your school and needs of your learners. Any changes to what Thinking and Working Scientifically learning objectives are selected to be developed when teaching the content learning objectives will require activities to be reviewed and edited.

Once you are confident with the combination of content and Thinking and Working Scientifically learning objectives, you then have the option to integrate context into your lessons to show how the learning objectives and/or skills relate to the world the learners know and experience. The Science in Context learning objectives provide guidance on doing this. As including context is dependent on your learners and your context, the scheme of work does not give contextual links to an activity. Possible ways to contextualise units are provided in the unit introductions, aligned to the relevant Science in Context objectives.

Further support about integrating Thinking and Working Scientifically and Science in Context into lessons can be found in the Cambridge Lower Secondary Science Teacher Guide.

Models and representations

Scientists use models and representations to represent objects, systems and processes. They help scientists explain and think about scientific ideas that are not visible or are abstract. Scientists can then use their models and representations to make predictions or to explain observations. Cambridge Lower Secondary Science includes learning objectives about models and representations because they are central to learners’ understanding of science. They also prepare learners for the science they will encounter later in their education.

To support the integration of models and representations into your teaching, for each learning objective we have suggested possible models you may wish to use.

Misconceptions

Scientific misconceptions are commonly held beliefs, or preconceived ideas, which are not supported by available scientific evidence. Scientific misconceptions usually arise from a learner’s current understanding of the world. These ideas will informed by their own experiences rather than evidence. To support you in addressing misconceptions, for each learning objective in each unit we have suggested, where relevant, possible misconceptions to be aware of.

Due to the range of misconceptions that learners can hold not all misconceptions have been provided and you may encounter learners with misconceptions not presented in this scheme of work.

Misconceptions may be brought to the lesson by the learners, reinforced in the lesson, or created during a lesson. It is important that you are aware of misconceptions that learners may exhibit so that you can address them appropriately.

It is important to note that not all misconceptions are inappropriate based on the conceptual understanding learners are expected to have at different stages of their education. Therefore, some misconceptions may be validly held by learners at certain stages of their learning. A misconception of this type is known as an age-appropriate concept. Trying to move learners away from age-appropriate concepts too soon may give rise to other, more significant, misconceptions or barriers to their understanding of science. Over time age-appropriate concepts can become misconceptions when they start to interfere with the expected level of understanding learners need to have.

The misconceptions flagged in this scheme of work are considered to be either inappropriate concepts for a learner at this stage of understanding science or important age-appropriate concepts to be aware of, so they are not challenged too early.

Health and safety

An essential part of this curriculum is that learners develop skills in scientific enquiry. This includes collecting primary data by experiment. Scientific experiments are engaging and provide opportunities for first-hand exploration of phenomena. However, they must, at all times, be conducted with the utmost respect for safety, specifically:

* It is the responsibility of the teacher in charge to adhere and conform to any national, regional and school regulation in place with respect to safety of scientific experimentation.
* It is the responsibility of the teacher in charge to make a risk assessment of the hazards involved with any particular class or individual when undertaking a scientific experiment that conforms to these regulations.

Cambridge International takes no responsibility for the management of safety for individual published experiments or for the management of safety for the undertaking of practical experiments in any given location. Cambridge International only endorses support material in relation to curriculum content and is not responsible for the safety of activities contained within it. The responsibility for the safety of all activities and experiments remains with the school.

The welfare of living things

Throughout biology, learners study a variety of living things, including animals. As part of the University of Cambridge, Cambridge International shares the approach that good animal welfare and good science work together.

Learners should have opportunities to observe animals in their natural environment. This should be done responsibly and not in a way that could cause distress or harm to the animals or damage to the environment.

If living animals are brought into schools then the teacher must ensure that any national, regional and school regulations are followed regarding animal welfare. In all circumstances, the teacher responsible must ensure all animals have:

* a suitable environment, including being housed with, or apart from, other animals (as required for the species)
* a suitable diet
* the opportunity to exhibit normal behaviour patterns
* protection from pain, injury, suffering and disease.

There is no requirement for learners to participate in, or observe, animal dissections for Cambridge Lower Secondary. Although dissection can provide a valuable learning opportunity, some learners decide not to continue studying biology because they dislike animal dissection. Several alternatives are available to dissection (such as models and diagrams) which you should consider during your planning.

If you decide to include animal dissection then animal material should be obtained from premises licensed to sell them for human or pet consumption, or from a reputable biological supplier. This approach helps to ensure animal welfare standards and also decreases the risk from pathogens being present in the material. Neither you nor your learners should kill animals for dissection.

When used, fresh material should be kept at 5 °C or below until just before use. Frozen material should be defrosted slowly (at 5 °C) without direct heat. All fresh or defrosted material should be used within 2 days. Preserved animal materials should only be handled when wearing gloves and in a well-ventilated room.

The responsibility for ensuring the welfare of all animals studied in science remains with the school.

# Unit 8.1 Gases

| Unit 8.1 Gases |
| --- |
| Outline of unit: |
| Considering the properties and behaviour of the gases that are found all around us will help learners in understanding scientific phenomenon (e.g. diffusion) and concepts (e.g. purity).  This unit begins with a review of the particle model and the properties of gases; air is described as a mixture of gases and it is clarified it is also possible to have a pure sample of gas. In addition, diffusion and air pressure are introduced.  This unit provides opportunities for learners to develop their understanding of models and representations and to carry out experiments to observe phenomenon associated with gases, diffusion and air pressure. |
| Recommended prior knowledge or previous learning required for the unit: |
| Learners will benefit from previous experience of:   * using the particle model, particularly that particles in gases are constantly moving and the spaces between the particles means a gas can be compressed * knowing that air contains nitrogen, oxygen, small amounts of carbon dioxide and other gases * identifying that gases have mass. |
| Suggested examples for teaching Science in Context: |
| ***8SIC.02*** *Describe how science is applied across societies and industries, and in research.*  Gases exert pressure; in the atmosphere, pressure changes result in weather changes. Learners could monitor weather reports to follow how weather changes as the air pressure changes and how these changes in air pressure are important in weather forecasting.  Additionally, a tyre pressure gauge is used to measure the air pressure inside a bicycle (or car) tyre. Learners could use a pressure gauge to measure the air pressure in a tyre before, and after, pumping it up. |

| Learning objective | Key vocabulary | Possible models and representations | Possible misconceptions |
| --- | --- | --- | --- |
| **8Cm.04** Know that purity is a way to describe how much of a specific chemical is in a mixture. | Pure, impure, purity, mixture, substance, chemical, sample | Diagrams of the particle model can be used to represent mixtures and pure substances.  A physical model can be created to represent different types of particles (using coloured beads) and, by changing the number of the colours present, different purities can be modelled. Ensure learners understand that there is a great deal of space between the particles and that they are moving randomly. It may be better to use a digital animation of gases where the movement of particles can be shown more readily. | Learners may be confused by the everyday use of the scientific terms ‘pure’ and ‘purity’. In particular, learners may think that air is pure if there are no pollutants. Ensure learners understand that air is a mixture of mainly nitrogen and oxygen and, therefore, it would be classed as a ‘mixture’ and not ‘pure’; a pure sample of oxygen would contain only oxygen molecules.  Talk about a ‘sample of a pure substance’ (rather than a ‘pure substance’) to clarify that the sample contains only one type of substance. |
| **8Pf.06** Use particle theory to explain pressures in gases and liquids (qualitative only).  NOTE: In this unit the focus is on gases only | Particle, compressed, compressible, incompressible, gas pressure, macroscopic, microscopic | Use a diagram, showing gaseous particles in a container, to represent pressure in gases. Arrows can be added to show the force exerted by the particles on the walls of the container.  Alternatively, learners could act as particles moving about randomly; they pretend to collide with the walls of the space, bounce back and keep moving. Learners could move more quickly, colliding more frequently with the walls, for higher temperatures (i.e. the pressure depends on the temperature) The same number of learners could act out the movement of particles in a smaller space, showing that there are more collisions in a given time (i.e. the pressure is greater). | Learners may not think that ‘still air’ has pressure and/or that pressure applies in all directions. It is therefore important to describe pressure as the result of colliding particles exerting a force on the walls of a container in situations where there is no obvious movement of wind (or air). |
| **8Pf.07** Describe the diffusion of gases and liquids as the intermingling of substances by the movement of particles.  NOTE: In this unit the focus is on gases only | Diffusion, random movement, gas, substance, particles, intermingling | The diffusion of gases can be represented by a diagram showing gas particles moving randomly. When a different substance (represented by particles of a different colour or shape) is introduced in one corner of the diagram, the random movement of particles results eventually in even distribution of the particles.  This could also be modelled by learners acting as particles and moving around each other. | Learners may think that a wind (or moving air) is required for diffusion. Be clear that diffusion occurs as particles are constantly moving in a random manner. Reinforce this concept, when using a diagram, by clearly stating that gas particles are moving randomly even in still air. |
| **8Pf.05** Explain that pressure is caused by the action of a force, exerted by a substance, on an area  (pressure = force / area).  NOTE: In this unit the focus is on gases only | Pressure, force, area, substance | Use a diagram to represent the concept of pressure; particles are shown in a container, arrows can be added to show the force exerted by the particles on the walls of the container. | Learners may struggle to understand that the collision of gas particles with the walls of a container could result in an appreciable and measurable force. Emphasise that a high number of particles moving at great speed produces a considerable force.  Learners may not understand pressure exists outside of a container (as well as inside) or make comparisons between two pressures. Use the example of a balloon that can shrink or expand. Explain that there are particles on the inside and the outside of a balloon. The balloon will shrink (when the pressure is greater on the outside) or expand (when the pressure is greater on the inside). |

# Unit 8.1 Suggested activities

| Learning objective | Thinking and Working Scientifically opportunities | Suggested teaching activities and resources |
| --- | --- | --- |
| **8Cm.04** Know that purity is a way to describe how much of a specific chemical is in a mixture. | **8TWSm.02** Use an existing analogy for a purpose. | **Modelling purity**  Explore some everyday uses of the term ‘pure’ (e.g. ‘pure air’, ‘pure water’, ‘100% pure’). Ask learners to find examples of the everyday uses of the term ‘pure’; they discuss, in groups or pairs, whether these examples would fit the scientific meaning of the term ‘pure’. Introduce several examples (e.g. seawater, distilled water, fruit juice, milk) and decide together whether each is pure or a mixture.  Show learners particle models of mixtures (containing different coloured beads) and samples of pure substances (containing a single colour of beads); explain that each bead represents a different substance.  Have two diagrams which contain representations of particles in a gas where all the particles are the same shape (or colour). Explain that these shapes represent particles which are too small for us to see. Have two more diagrams which contain representations of particles in a gas where there are particles of two or more different shapes (or colours).  *Which of these examples are models of a sample of a pure substance?*  *Which of these examples are models of mixtures*?  Introduce the analogy that the purity if like a bag of counters. Ask learners to identify how the analogy is a good model for a pure gas or a mixture of gases. Elicit the idea that it is showing the presence of only one type of particle in the pure sample and the presence of more than one type of substance in the mixture.  Ask learners to identify how the analogy is not a good model for a pure gas or a mixture of gases*.* Elicit the idea that the counters representing particles of gas are not moving around which they should be in a gas.  **Resources:** Coloured beads, diagrams of particles in a gas |
| **8Pf.06** Use particle theory to explain pressures in gases and liquids (qualitative only).  NOTE: In this unit the focus is on gases only | **8TWSm.02** Use an existing analogy for a purpose. | **Pressure in gases**  Set up a smoke cell and a digital camera; project the image onto the wall so that learners can watch the random movement of smoke particles. Alternatively, show learners a video of the phenomenon of ‘Brownian motion’. Draw particle model diagrams to help learners to understand what is happening on a microscopic level.  *How are the smoke particles moving?*  *What are they interacting with?*  Then make the link to the phenomenon of pressure. Learners blow up balloons themselves (or watch a video/teacher demonstration); with each breath the balloon gets bigger.  *Why does the balloon get bigger with each breath?*  Learners discuss, in pairs or small groups, then present their thinking.  Draw out the idea that, with each breath, there are more particles inside the balloon which leads to more collisions with the walls of the balloon. The pressure inside the balloon increases and, when the pressure inside is greater than the pressure outside the balloon, the balloon expands.  Discuss with learners what an appropriate analogy is for the pressure of gases. Provide learners with an example of a music event where you have a small audience and a larger audience.  *How could that analogy apply to pressure of gases?*  **Resources:** A smoke cell, balloons, camera, projector |
| **8Pf.07** Describe the diffusion of gases and liquids as the intermingling of substances by the movement of particles.  NOTE: In this unit the focus is on gases only | **8TWSm.01** Describe what an analogy is and how it can be used as a model. | **Diffusion of gases**  Learners observe the diffusion of perfume; place some perfume onto a paper towel (or tissue paper) and allow it to evaporate.  *What is happening to the particles in the perfume*?  Elicit the idea that the liquid perfume particles are now in the gas state and moving randomly in all directions.  *Can anyone smell the perfume?*  After waiting for diffusion to occur, some learners may indicate that they can now smell the perfume. Try to avoid having an obvious wind (or breeze of air) in the room; as learners might think a wind is necessary for diffusion to occur.  *How is it that you can smell the perfume over the other side of the room?*  Elicit the idea that the particles in the perfume are moving randomly and eventually spread throughout the room. When the particles reach the learners’ noses, the particles in the perfume interact with the receptors in their noses to trigger the sense of smell.  Ask learners to draw a diagram representing particles in a gas before, and after, a new substance diffuses around the space. Ensure learners use different colours (or shapes) for the substances that were already present and the new substance.  Explain to learners that analogies are used in science to compare a phenomenon (or system of objects) with something else that highlights how they are similar; analogies help us to explain, understand and connect to the original (and often abstract) phenomenon.  *What analogy could you use to help explain diffusion?*  Introduce an analogy for diffusion. it is like walking about blindfold on a moving platform, you are moving randomly at all times but will move from the centre.  *Is that a good analogy?*  *Does that help model the concept of diffusion?*  Learners can spend some time working on their own analogies and present them to the wide class considering: *Does this analogy reflect the idea that:*  *(1) particles in a gas are constantly moving in a random manner?*  *(2) there is a lot of space between the particles?*  *(3) the particles start concentrated in one corner and then gradually become more evenly distributed?*  **Resources:** Perfume, paper towel |
| **8Pf.05** Explain that pressure is caused by the action of a force, exerted by a substance, on an area  (pressure = force / area).  NOTE: In this unit the focus is on gases only | **8TWSm.03** Use symbols and formulae to represent scientific ideas. | **The relationship between force, pressure and area**  Provide learners with 1 ml (or 10 ml) plastic syringes; they draw air into the syringe then place their thumb over the tip. Ask learners to try to compress the air in the syringe. Learners, in pairs, then discuss the following questions:  *Why can you compress the air?*  *When you compress the air in the syringe, has the number of particles changed?*  *How has the number of collisions per second changed?*  Demonstrate the behaviour of particles by placing balls (or counters) on a tray; they should be widely dispersed. Model random motion by shaking the tray (or tipping it from side to side) to cause the ‘particles’ to move. Model compression by placing a book (or block) within the tray to reduce the available space the ‘particles’ have to move in. Explain that the ‘particles’ have a shorter distance to travel before colliding with the sides of the tray so the number of collisions per second increased. Support learners to use the analogy of the tray to understand what happens to the gas in the syringe.  Through discussion, explain that particles in a gas are widely spaced and that when the gas is compressed the same particles occupy a smaller space but that the syringe contains the same number of particles. The idea that the number of collisions per second has increased because the particles occupy a smaller space and have a shorter distance to travel before colliding with the sides of the syringe can be shown by moving the tray where the objects have reduced space to move.  *What happens to the pressure of the gas in the syringe when it is compressed?*  Explain that the number of particles, contained within the syringe, does not change but the particles collide more frequently with the walls of the syringe because they occupy a smaller space; hence the average force (i.e. number of collisions per second) increases. In addition, the particles collide with a smaller surface area and, since pressure is force divided by area, the pressure of the gas is higher.  Alternatively, use a bicycle pump to inflate a bicycle tyre. Many pumps have a measurement of pressure which could be useful to give learners a sense of how pressure can be measured.  Once learners have an intuitive sense of the meaning of pressure, introduce the formula:  pressure = force / area. Use simple whole numbers to explore the relationships between the quantities (i.e. when one variable is changed, what happens to the others).  Emphasise to learners that this formula (pressure = force / area) is a representation of how we understand pressure and the relationship between the force applied and the area over which it is applied.  **Resources**: Plastic syringes, tray, balls, book |

# Unit 8.2 Liquids

| Unit 8.2 Liquids |
| --- |
| Outline of unit: |
| The liquid phase is important to understand as it is a medium for many biological processes; this phase is often used in chemistry for the preparation, reaction and purification of substances.  This unit begins with a review of the use of the particle model to describe liquids; the model is then applied in a variety of contexts including pressure, diffusion, chromatography and the effect of temperature on solubility. Learners will have the opportunity to apply different representations of the particle model; they will decide which representation is most appropriate to convey the important aspects under study.  Learners can relate their knowledge of liquids to liquids they are with and distinguish between samples of pure substances and mixtures. They will become more familiar with the scientific terminology relating to solutions (e.g. concentration). Learners will examine the effect temperature has on solubility and understand how to use paper chromatography to separate, and identify, substances in a sample.  This unit will give learners opportunities to develop a wide range of scientific enquiry and practical skills. |
| Recommended prior knowledge or previous learning required for the unit: |
| Learners will benefit from previous experience of:   * knowing that particles in liquids are arranged closely but are constantly moving and that particles move around randomly more quickly as the temperature of the liquid increases * dissolving solids and knowing that the ability of a solid to dissolve, and the ability of a liquid to act as a solvent, are properties of the solid and liquid * describing the process of dissolving in terms of the particle model and distinguish it from melting. |
| Suggested examples for teaching Science in Context: |
| ***8SIC.02*** *Describe how science is applied across societies and industries, and in research*.  Learners can explore how hydraulic devices work by compression of liquids. Learners could study, research and collect examples of the uses of hydraulics.  Learners can explore chromatography is used in forensics (e.g. the separation of soluble inks from a pen might be used to identify the pen that was used to write an anonymous note).  ***8SIC.05*** *Discuss how the uses of science can have a global environmental impact.*  Learners could investigate how deep-sea diving equipment has been developed to withstand high water pressure at extreme depths and how it has been used to build a better understanding of life in deep sea environments. |

| Learning objective | Key vocabulary | Possible models and representations | Possible misconceptions |
| --- | --- | --- | --- |
| **8Pf.06** Use particle theory to explain pressures in gases and liquids (qualitative only).  NOTE: In this unit the focus is on liquids only | Particle, compressed, compressible, incompressible, liquid, pressure | Use a diagram to represent pressure in liquids. Draw liquid particles in a container; add arrows to show the force exerted by the particles on the walls of the container. | Many learners regard all liquids as ‘watery’ or ‘made of water’. Provide learners with experience of other liquids (e.g. oil) explaining that they are made of ‘oil particles’ whereas water is made of ‘water particles’.  Often learners’ diagrams of the particle model show too much space between liquid particles. Ensure learners have all particles touching at least one other particle and disordered. This is in contrast to solids (where the particles are all touching and ordered) and gases (where the particles are spaced far apart, not touching and disordered) |
| **8Pf.05** Explain that pressure is caused by the action of a force, exerted by a substance, on an area  (pressure = force / area).  NOTE: In this unit the focus is on liquids only | Pressure, force, area, substance | Represent the application of the particle model to the concept of pressure through the use of a diagram showing particles, in a liquid, in a space with arrows showing the forces exerted by the particles colliding with the walls of the container. | Some learners may consider pressure to be a force; it is actually the force applied by the collision of particles within a given area*.* They may also confuse the scientific meaning with everyday meanings for the term ‘pressure’. Ensure they understand, and use, the scientific term correctly. |
| **8Cm.04** Know that purity is a way to describe how much of a specific chemical is in a mixture. | Pure, impure, purity, mixture, substance, chemical | Diagrams of the particle model can be used to represent mixtures and pure substances.  A physical model can be created to represent different types of particles (using coloured beads) and, by changing the number of the colours present, different purities can be modelled. | Learners sometimes confuse the everyday meaning with the scientific meaning of the term ‘pure’. Ensure they understand, and use, the scientific term correctly.  Learners may think that a compound is ‘impure’ because diagrams often contain two or more different-coloured circles. Provide learners with some diagrams that show a sample of just one type of particle as well as mixtures of two or three different particles. Reinforce that the sample of a pure compound is still ‘pure’ despite the chemical makeup of the compound which is a distinct substance.  Talk about a ‘sample of a pure substance’ (rather than a ‘pure substance’) to clarify that the sample contains only one type of substance. |
| **8Cp.01** Understand that the concentration of a solution relates to how many particles of the solute are present in a volume of the solvent. | Concentration, concentrated, dilute, solute, solvent, solution | A diagram of the particle model can be used with many circles to represent the solvent and fewer different coloured circles (or indeed a different shape) to represent the solute particles. A more concentrated solution would have more solute particles.  A physical model of a solution can be created using different coloured beads for the solvent and solute particles; the ratio of ‘solute’ to ‘solvent’ beads can be increased to represent a more concentrated solution. | Many learners consider liquid water to be a continuous substance rather than consisting of water particles. They will often represent solutions by drawing the solute particles and then using shading to indicate the presence of water. Ensure that all representations of the particle model of solutions contain water particles as well as solute particles.  Sometimes learners mix up the terms ‘concentrated’ with ‘strong’ and ‘dilute’ with ‘weak’. It is better to only use the terms ‘concentrated’ and ‘dilute’ at this stage to avoid confusion when the concept of strong and weak acids is introduced in later years. |
| **8Pf.07** Describe the diffusion of gases and liquids as the intermingling of substances by the movement of particles.  NOTE: In this unit the focus is on liquids only | Diffusion, random movement, liquid, substance, particles, intermingling | An animation could be used to show particles constantly moving in a random fashion and the way different particles, introduced to the liquid, spread by diffusion. | Learners sometimes think that diffusion is caused by a wind (or stirring); they don’t appreciate that, even in a liquid that appears ‘still’, the particles are constantly moving. Use representations of the model (including diagrams) that indicate that the particles are moving.  Learners sometimes think that particles choose to move in a particular direction rather than moving in a random manner; ensure representations of the model include the random movement of particles. |
| **8Cc.05** Describe how the solubility of different salts varies with temperature. | Dissolve, solubility, insoluble, soluble, salt, solvent, solute, solution, temperature | Show a series of diagrams to represent the way solid particles dissolve in a liquid. The first diagram show a small amount of a solid placed into a liquid. The next diagrams show the particles in the solid state being gradually broken up and surrounded by solvent particles. The final diagram shows all of the solute particles surrounded by solvent particles. Consider repeating the diagrams at a higher temperature to show how the particles move more quickly so the process happens quicker. | Occasionally learners confuse the processes of dissolving and melting; use the particle model to explain the difference.  Learners often have an idea of the random motion of particles in a liquid but this often does not include speed in addition to direction. Explain that the particles in a liquid move faster as the temperature is raised. |
| **8Cp.02** Describe how paper chromatography can be used to separate and identify substances in a sample. | Chromatography, solvent, solute, solution, mixture, separation | Use the particle model to explain why some substances move further than others in chromatography; explain to learners that the sample is a mixture of substances. Use a first diagram to represent the particles of the sample substances ‘holding on’ to the paper particles. Then, in a second diagram, show the solvent particles moving along the paper. The particles of some of the sample substances ‘hold on’ to the solvent particles (i.e. dissolve in the solvent) and move along the paper with them. The particles of other sample substances have a greater ‘hold’ for the paper than the solvent and so they remain behind. | Learners may think that the colours within an ink wantto move further rather than moving because they dissolve in the solvent. Emphasise the aspect of random motion in the particle model.  Some learners may accept a simple description of the process of separating substances in a mixture by chromatography. Explain to learners, who wish to get a better understanding of why some substances move faster than others, that some substances have a greater ‘hold’ of the solvent particles than the paper particles. |

# Unit 8.2 Suggested activities

| Learning objective | Thinking and Working Scientifically opportunities | Suggested teaching activities and resources |
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| **8Pf.06** Use particle theory to explain pressures in gases and liquids (qualitative only).  NOTE: In this unit the focus is on liquids only | **8TWSc.04** Take appropriately accurate and precise measurements, explaining why accuracy and precision are important.  **8TWSa.05** Present and interpret observations and measurements appropriately. | **Water Pressure**  Make three small holes in a plastic bottle (a few centimetres above the base); half fill the bottle with water. Learners observe the water coming out of the holes; ask them to observe what happens to the distance travelled by the water as the bottle empties.  *Why did the water travel shorter distances as time passed?*  Explain that the water particles are colliding and exerting pressure and there is more pressure lower in the bottle as there are more particles to exert a force. As the water level goes down there is less pressure so the water is not being pushed out of the bottle as hard.  Then learners discuss and create a way to take accurate and precise measurements of how far the water travels over time. Discuss with learners why accuracy and precision are important when recording experimental data. Provide measuring equipment (including rulers and stopwatches) so learners can carry out their experiment. They make a line graph showing the relationship between ‘water distance’ and time (or height of water in the bottle) and explain their graphs based on their understanding of pressure.  **Resources:** Plastic bottles, measuring equipment |
| **8Pf.05** Explain that pressure is caused by the action of a force, exerted by a substance, on an area  (pressure = force / area).  NOTE: In this unit the focus is on liquids only | **8TWSm.03** Use symbols and formulae to represent scientific ideas. | **Quantify pressure, force and area using the formula P = F/a**  Introduce the formula ‘pressure = force / area’ by calculating the pressure that would result from applying a force of 10 N over an area of 2 m2. (Answer is 5 N/m2). Write the formula in symbols: .  To reinforce the concept of the pressure being the ratio of the force to the area ask learners  *What other combinations of force and area would give the same pressure?*  Answers could include 5 N over 1 m2, 20 N over 4 m2, 100 N over 20 m2 etc.  *If the pressure is 5 N/m2, what would the new pressure be if the same force was applied over twice the area (i.e. 4 m2?*  *What effect does doubling the area have on the pressure if the force remains the same?*  *(Answers: 10 N divided by 4 m2 = 2.5 N/m2; the pressure halves if the area doubles for the same force.)*  *If the pressure is 5 N/m2, what would the new pressure be if the force was doubled to 10 N for the same area? Answer: pressure would be 10 N/m2; the pressure doubles if the force doubles for the same area*  Demonstrate this relationship by squeezing water out of a plastic bottle with a hole in the bottom. Discuss with learners:  *Why is the water coming out further and faster when the bottle is squeezed?*  Explain that there is less space in the bottle but the number of particles has not changed. Since the particles are moving in a smaller space there are more collisions; this increases the force and, therefore, pressure.  Help learners apply their understanding of pressure to deep sea divers. As divers descend, they experience a greater force acting on them because of the weight of the water above, and around them.  **Resources:** Plastic bottle |
| **8Cm.04** Know that purity is a way to describe how much of a specific chemical is in a mixture. | **8TWSm.02** Use an existing analogy for a purpose. | **Distinguishing between pure samples and mixtures**  Start by clarifying the meanings of the scientific terms ‘pure’ and ‘mixture’. Explore some everyday uses of the term ‘pure’ (e.g. ‘pure orange juice’, ‘pure water’, ‘100% pure’). Ask learners to find examples of the everyday use of the term ‘pure’ and to discuss, in groups or pairs, whether these examples would fit the scientific meaning of the term ‘pure’. Discuss, as a class, a range of liquids, including some that are pure (e.g. distilled water, propanone/acetone) and some that are mixtures (e.g. seawater, fruit juice, milk).  Show learners a series of particle diagrams that represent: a pure sample of an element; a pure sample of a compound; a mixture of elements; a mixture of compounds and a mixture of elements and compounds. An element would be represented by a single colour whilst a compound might be represented by two or more different coloured circles joined together. Ask learners to sort the diagrams into pure samples and mixtures; ensure learners can identify the correct diagram for a pure sample of a compound.  Prepare some physical models to represent mixtures and pure substances, such as three glass containers filled with rice only; dried beans/peas only and rice mixed with beans/peas. Marbles, beads or different types of sweets could be used as alternatives. Introduce the analogy mixtures are like jars of sweets. Discuss with learners:  *Which containers are analogous to a pure substance and which are analogous to mixtures? Why?*  *What is an analogy? Can you give some examples of analogies you have used in other subjects?*  Discuss with learners how we can use ‘purity’ to compare different mixtures and identify which mixtures and more or less pure than others. Create some more physical models of a rice and beans/peas mixture; one with more rice, one with about equal quantities and one with more beans/peas.  *If we are considering rice, which one is the purest?*  *If we are considering beans/peas which one is the purest?*  Explain that we could assign a percentage value to purity if we could calculate exactly how much of a substance was in a mixture e.g. 70% pure (70% of the mass of a mixture is the substance we are considering)  **Resources:** A range of pure liquids and liquid mixtures, glass containers, rice, dried beans/peas |
| **8Cp.01** Understand that the concentration of a solution relates to how many particles of the solute are present in a volume of the solvent. | **8TWSm.03** Use symbols and formulae to represent scientific ideas.  **8TWSc.02** Decide what equipment is required to carry out an investigation or experiment and use it appropriately. | **Making solutions of varying concentrations**  Explain to learners that they will make solutions of different concentrations using a strongly-coloured, original solution (e.g. fruit drink, food colouring or tea) and water. They will need to use measuring cylinder (or syringe) to measure a small amount (1 ml, 2 ml or 5 ml) of the original solution and, in a transparent container (e.g. glass/plastic test tube) make it to a total volume of 10 ml with water. Provide a range of measuring cylinders (e.g. 1 ml, 2 ml, 5 ml, 10 ml) and encourage learners to choose the most appropriate measuring cylinder (i.e. not too small for large volumes and not too large for small volumes). If learners are struggling to choose the most appropriate equipment, support them by discussing the choices available and why they should choose the most appropriate ones.  Learners could observe the varying colours of the solutions they have made, relating the strength of the colour to the concentration of the solution:  *Which of these solutions has the most particles of solute*?  Elicit the key point that more concentrated solutions have a greater number of solute particles in the same volume.  Explain to learners that concentration describes how many particles of solute are present in a volume of solvent. It is important to know the concentration of a solution for potentially dangerous chemical reactions where low concentrations of reactants may be safe but high concentrations can result in an explosion.  Introduce the formula in words ‘concentration = mass of solute / volume of solution’.  This formula can be thought of as the concentration being the ratio of the mass of substance to the volume of the solution. The greater the ratio, the higher the concentration. High concentrations have more particles of solute in a given volume of solvent compared to low concentrations which have fewer particles in the same volume of solvent.  *What would the solution concentration be if the mass of solute is 5 g) and the volume is 1 litre?* (Answer is 5 g/L).  *If I had a solution with the same concentration (5 g/L) but I had a volume of 2 litres, what mass of solute would there be?* (Answer is 10 g)  Carry on with a range of different volumes (e.g. a volume of 0.5 litre would have 2.5 g, a volume of 0.1 litre would have 0.5 g).  **Resources:** A strongly-coloured solution, measuring cylinders, glass test tubes |
| **8Pf.07** Describe the diffusion of gases and liquids as the intermingling of substances by the movement of particles.  NOTE: In this unit the focus is on liquids only | **8TWSm.02** Use an existing analogy for a purpose. | **Diffusion of food colouring in water**  Learners, working in pairs, put two drops of food colouring into a beaker of warm water. (Note: In cold water, the food colouring can sink to the bottom because there is not enough random motion of the water and dye particles to ensure rapid diffusion). Ask learners:  *What has happened?*  *Why has the colour dispersed?*  Encourage learners to recall how the particle model describes the arrangement and movement of particles in liquids.  Show learners a tray in which you have spread several handfuls of plain rice; tell learners that the rice grains represent water particles in a beaker. Explain that this analogy is better when the tray is gently shaken to show the ‘particles’ in water moving.  Add a handful of coloured rice (or coloured paper cut into confetti) into the middle of the tray to represent the introduction of food colouring to the beaker. Ask the learners to observe what happens (and how quickly it happens) when the tray is shaken gently.  Explain that ‘rice in a tray’ is an analogy for water in a beaker and introducing the coloured rice helps illustrate what was happening when food colouring spread through the water. The two types of particles were moving randomly and intermingled to create a mixture; this process is called ‘diffusion’.  Show the learners diagrams of the particle model that represent diffusion. Discuss the strengths and weaknesses of the analogy ‘rice in a tray’.  **Resources:** Food colouring, beaker, tray, plain rice, coloured rice |
| **8Cc.05** Describe how the solubility of different salts varies with temperature. | **8TWSp.04** Plan a range of investigations of different types, while considering variables appropriately, and recognise that not all investigations can be fair tests.  **8TWSc.03** Evaluate whether measurements and observations have been repeated sufficiently to be reliable.  **8TWSc.06** Evaluate a range of secondary information sources for their relevance and know that some sources may be biased. | **Solubility investigation (requires additional resources)**  Remind learners of the terms ‘solute’ and ‘solvent’. Define the term ’solubility’ (i.e. the mass of a solute that will dissolve in a given volume of solvent). Demonstrate to learners the high solubility of sugar (or, sodium chloride/table salt) and the low solubility of chalk/calcium carbonate at room temperature.  Explain that the solubility of each substance depends on the external conditions (e.g. temperature of the solvent).  Learners plan, and carry out, an investigation to answer the question:  *How does temperature affect the solubility of copper sulfate or calcium chloride-6-water?*  Working in pairs, learners should plan an investigation to determine the masses of copper sulfate and calcium chloride-6-water (also known as calcium chloride hexahydrate) that will dissolve in water at different temperatures (e.g. room temperature, 30°C, 40°C, 50°C and 60°C).  Show learners the materials and equipment available: copper sulfate and calcium chloride-6-water; water baths (e.g. large containers, hot and cold water to mix to achieve water at each temperature); thermometers; spatulas (or teaspoons), mass balances, measuring cylinders, test tubes, stirring rods (or spoons).  Learners should consider which variables need to be controlled (e.g. volume of water; the type, size and material of the containers, how long the solutions will be stirred for). They could write each step of the activity on a separate piece of paper and then place them into a logical sequence. Learners who need greater support might be given all of the steps and asked to place them in the correct order. Their plan should include how they will mix the solutions and how long the solution will be stirred before deciding that no further salt will dissolve.  Learners should follow their plan for this activity, recording the total mass of solute that dissolved at each temperature.  The class could compare their results to evaluate whether, as a group, the measurements have been repeated sufficiently to be reliable. They need to agree how many values they need for each temperature before they have confidence in the result and are able to make a conclusion about how solubility changes with temperature.  **Resources:** copper sulfate, calcium chloride-6-water, large containers, thermometers, spatulas, mass balances, measuring cylinders, test tubes, stirring rods |
| **8TWSc.03** Evaluate whether measurements and observations have been repeated sufficiently to be reliable.  **8TWSc.06** Evaluate a range of secondary information sources for their relevance and know that some sources may be biased. | **Analysis of solubility data**  Remind learners of the terms ‘solute’ and ‘solvent’. Define the term ’solubility’ (i.e. the mass of a solute that will dissolve in a given volume of solvent). Demonstrate to learners the high solubility of sugar (or, sodium chloride/table salt) and the low solubility of chalk/calcium carbonate at room temperature.  Explain that the solubility of each substance depends on the external conditions (e.g. temperature of the solvent).  Provide learners with some data of the mass of a solute that dissolves at different temperatures. Ask them to analyse the data, to identify any anomalous results and to decide whether the measurements have been repeated sufficiently to be reliable.  Learners use secondary information sources to discover the solubilities in water (in grams per 100 ml) of copper sulfate and calcium chloride-6-water at a range of temperatures.  *What does the data and your own research tell you?*  *Is there a relationship between temperature and the solubility of a solute?*  **Resources:** Solubility data of a solute, secondary information sources |
| **8Cp.02** Describe how paper chromatography can be used to separate and identify substances in a sample. | **8TWSa.03** Make conclusions by interpreting results and explain the limitations of the conclusions. | **Paper chromatography**  Discuss with learners that there is often more than two substances in a solution because the solute and/or the solvent can be a mixture. One technique for separating out the substances in a solution is paper chromatography.  In this activity, learners use chromatography to separate the different coloured inks in water-soluble marker pens; they conclude how many different components were present in each pen ink. Alternatively, permanent marker pens can be used but, in this case, use butan-1-ol as the solvent and, because it evaporates rapidly, cover the beaker with a lid during the experiment.  **Resources:** Beakers or other container to fit a 5 x 12 cm piece of paper upright inside; filter paper or cartridge paper cut into 5 x 12 cm rectangles; solvent (water or butan-1-ol); some marker pens (water soluble if using water as a solvent, permanent markers if using butan-1-ol as a solvent);  Each learner draws a pencil line (parallel to and approximately 1 cm from the short edge) of a 5 x 12 cm rectangle of filter paper (or cartridge paper). They dab a spot of each pen ink onto the pencil line, equal distances apart, let the ink dry and then dab on more ink to ensure that sufficient ink is placed on the paper. Place the bottom of the paper in water (ensuring the water is lower than the pencil line) and clip the paper to the top of the beaker (or attach it to a pencil that is resting on the rim of the beaker).  The paper is then left until the top of the solvent has risen up to less than 1 cm from the top of the paper. The paper is taken out and allowed to dry.  At the end of the experiment, learners should be able to see the separation of the components of the ink along the paper and conclude how many different components of ink were present in their sample. They compare their results with each other to identify whether there were any anomalous results; explain that it is the relative movement of the different colours that is important (rather than the absolute distance for the movement of each spot).  *Did paper chromatography separate out the components in the ink? Was each component identifiable?*  *Did the pen inks differ in what they contained?*  **Resources:** Beakers, rectangles of filter paper, water-soluble marker pens |

# Unit 8.3 Respiration and the respiratory system

| Unit 8.3 Respiration and the respiratory system |
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| Outline of unit: |
| Living organisms require oxygen and food to support the processes of life. This unit looks in detail at this process and will learn that respiration is the process of converting oxygen and glucose (from food) into carbon dioxide and water whilst transferring energy to the cell.  Learners will consider the differences between the process of respiration at a cellular level and the respiratory systems used by many animals to transport oxygen from the air to the cells where it is needed for respiration. They will understand the role that red blood cells play in transporting the oxygen around the body.  This unit gives learners opportunities to work scientifically. Learners will make predictions and apply their understanding of models (including analogies) to biology. |
| Recommended prior knowledge or previous learning required for the unit: |
| Learners will benefit from previous experience of:   * knowing that air contains a mixture of mainly nitrogen and oxygen with a small percentage of carbon dioxide * knowing that gases (e.g. oxygen, carbon dioxide) can dissolve in water * describing the route that blood takes as it is pumped around the body by the heart and that blood travels through blood vessels to all parts of the body * describing how the human respiratory system moves oxygen from the air into the blood in the lungs. |
| Suggested examples for teaching Science in Context: |
| ***8SIC.01*** *Discuss how scientific knowledge is developed through collective understanding and scrutiny over time.*  Learners could research how the different components of blood were discovered and how our understanding of blood has changed over time. Blood was considered to be a red watery liquid. The invention, and use of, the microscope enabled scientists to identify the components of blood which led to significant advances in understanding how the body works.  ***8SIC.03*** *Evaluate issues which involve and/or require scientific understanding.*  People living with the condition ‘anaemia’ do not have enough red blood cells. Learners could research why patients with anaemia can be very tired and have pale mucous membranes (such as tongue, gums and the inside of eyelids). Studying conditions and illnesses is an important aspect of developing biological understanding. |

| Learning objective | Key vocabulary | Possible models and representations | Possible misconceptions |
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| **8Pf.07** Describe the diffusion of gases and liquids as the intermingling of substances by the movement of particles. | Diffusion, particles, random movement, liquid, intermingling, substance, concentration, net diffusion | Prepare beads of one colour in a tray to model the particles of a liquid. Introduce beads of a different colour to one corner of the tray to model the movement of a different type of particle in the liquid. | Whilst learners may be familiar with the particle model it is likely that they find it difficult to apply it in an unfamiliar situation such as the diffusion of oxygen and carbon dioxide in lungs and blood. Learners may think that oxygen molecules want to move from the air into the blood and then from the blood to the tissues. They may also think that carbon dioxide wants to leave the tissues. It is important to emphasise the idea of random movement of particles underlying the process of diffusion and that net diffusion depends on different in concentration between two different locations |
| **8Bp.05** Know and use the summary word equation for aerobic respiration. | Respiration, respire, glucose, energy, oxygen, carbon dioxide, water, aerobic, ventilation, breathing, glucose | The word equation (glucose + oxygen -> carbon dioxide + water) is a representation of the biological process of respiration. | Many learners may think that respiration and breathing are synonymous. It is helpful to use the term ‘breathing system’ in addition to ‘respiratory system’ to describe the airways and lungs. Similarly learners may have heard the term ‘artificial respiration’ which is better called ‘artificial ventilation’. Clarity around the meanings of the terms respiration, ventilation and breathing should prevent or address this misconception. |
| **8Bp.04** Know that aerobic respiration occurs in the mitochondria of plant and animal cells, and gives a controlled release of energy. | Mitochondria, respire, respiration, oxygen, aerobic, energy | A diagram (or physical model) of a generic cell (plant or animal) can be displayed showing the presence of mitochondria; arrows can be used to represent the flow of substances in/out of the mitochondria and the related transfers of energy. | Learners may think that respiration in plants only occurs at night whereas it occurs continuously in order to provide energy for growth. It might be necessary to remind learners that plant cells also contain mitochondria which will carry out respiration all the time. This can be proved in needed through the use of electron microscope images of plant cells. |
| **8Bs.04** Describe the diffusion of oxygen and carbon dioxide between blood and the air in the lungs. | Oxygen, carbon dioxide, blood, lungs, diffusion, concentration, gas exchange, respiratory system, multicellular organisms, capillary, alveolus, bulk transport | An animation could be used to show the movement of oxygen (and carbon dioxide) molecules from a region of high concentration to a region of low concentration. | Learners may not appreciate that gases such as oxygen and carbon dioxide can dissolve in water and therefore diffuse into blood and tissues. Learners could be asked to think about what happens when a carbonated (fizzy) drink is first opened, the bubbles of gas appear because the carbon dioxide gas comes out of solution.  Learners may think that only oxygen enters the lungs whereas it is air that enters the lungs and air contains oxygen amongst other gases. It is important to emphasise that the air entering the lungs has a higher concentration of oxygen than in the blood. Carbon dioxide has a higher concentration in the blood than in the airways  Learners may not realise that microorganisms are able to satisfy their oxygen requirement by diffusion and may think that microorganisms need to have lungs. This can be discussed by reviewing microscope images of microorganisms. |
| **8Bs.03** Describe how the structure of the human respiratory system is related to its function of gas exchange (in terms of lung structure and the action of the diaphragm and intercostal muscles) and understand the difference between breathing and respiration. | Respiratory, respiration, diaphragm, intercostal, breathing, lung, trachea, bronchus (plural bronchi), bronchiole, alveolus (plural alveoli), thorax, gas exchange | Build a physical model of an ‘artificial chest’ by placing a balloon (attached to a tube) inside a bell jar; a rubber ‘diaphragm’ should be attached to the bottom of the bell jar. Move the rubber ‘diaphragm’ outwards, to increase the volume in the ‘artificial chest’; the balloon will partially inflate. Move the rubber diaphragm inwards to decrease the volume of the artificial chest; this causes the balloon to deflate. | Learners may think that very small organisms have lungs when in fact they are able to get sufficient oxygen by diffusion. It may be necessary to look at diagrams or microscope images of the anatomy of selected organisms such as single-celled organisms, worms, larvae to show that they do not contain lungs.  Learners may not realise that it is the diaphragm and intercostal muscles that expand the volume of the thorax on contraction and air enters the lungs due to the difference in air pressure. Use of the ‘artificial chest’ model may help to resolve this.  Learners may confuse respiration and respiratory system – ensure that a clear distinction is made. |
| **8Bs.02** Describe the components of blood and their functions (limited to red blood cells transporting oxygen,white blood cells protecting against pathogens and plasma transporting blood cells, nutrients and carbon dioxide)  NOTE: This unit does not cover white blood cells | Red blood cells, oxygen, carbon dioxide, nutrient, plasma, oxygenated, deoxygenated, pathogens, circulatory system | A physical model could be built to show red blood cells in plasma with oxygen molecules attached to the red blood cells and carbon dioxide and nutrients attached to the plasma. | Learners may think that oxygen is carried in the blood plasma therefore it is important to emphasise that oxygen is carried in red blood cells.  Learners may think that deoxygenated blood is blue as it is often pictured this way in textbooks, and due to observation of surface level blood vessels under the skin, whereas in fact it is a darker shade of red. This can be discussed through using images or videos showing the difference between oxygenated and deoxygenated blood. |

# Unit 8.3 Suggested activities

| Learning objective | Thinking and Working Scientifically opportunities | Suggested teaching activities and resources |
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| **8Pf.07** Describe the diffusion of gases and liquids as the intermingling of substances by the movement of particles. | **8TWSm.02** Use an existing analogy for a purpose. | **Apply an analogy to diffusion.**  Demonstrate diffusion by adding food colouring (or coloured drink) to warm water; learners observe the diffusion of the colour.  *Where did the colour come from?*  *Where did the colour go to?*  Discuss with learners that in the coloured liquid there is a greater concentration of the particles responsible for the colour. When added to a liquid where there is no or little colour then through random motion the particles responsible for the colour move from the solution of high concentration into the solution of low concentration.  This can be reinforced using coloured beads (or balls) in a tray as an analogy. Beads of one colour are spread across the tray to represent the water particles. Beads of a different colour are then introduced at one corner of the tray. Ask learners to watch an individual bead as the tray is shaken.  *How does the bead you are watching move?*  *What happens to the area of high concentration?*  The individual bead moves randomly in all directions until the colours are evenly spread out and, importantly, there is net diffusion from an area of relatively higher concentration to an area of relatively low concentration.  Introduce the analogy: diffusion is like two full trains emptying onto a platform  Introduce the analogy: diffusion is like walking through a crowded shopping centre  *Are these good analogies?*  *Why may these analogies be appropriate?*  Draw diagrams to model to learners to that the human respiratory system is designed to take advantage of the diffusion from areas of relatively high concentration to relatively low concentration (e.g. oxygen diffuses from the lungs to the blood, carbon dioxide diffuses from cells to blood and from blood to the lungs).  **Resources:** Food colouring, beaker, coloured beads, tray |
| **8Bp.05** Know and use the summary word equation for aerobic respiration (glucose + oxygen -> carbon dioxide + water). | **8TWSm.03** Use symbols and formulae to represent scientific ideas. | **The word equation for aerobic respiration**  Discuss with learners that most organisms require oxygen to access the energy that is stored in food.  In animals and plants, oxygen is used within the cells in a process called ‘aerobic respiration’.  Help learners to establish the word equation for aerobic respiration by guided questioning:  *What do you think the word ‘aerobic’ means*?  Learners may be familiar with the word ‘aerobics’ (i.e. an exercise class) or recognise the stem of the word (i.e. ‘aero’) in ‘aeroplane’ (i.e. airplane). Explain that ‘aerobic’ means ‘with oxygen’.  Provide learners with cards; each card has one of the four substances (i.e. oxygen, glucose, carbon dioxide, water) written on them.  *Which one of these substances is in the food that we eat?*  Elicit the answer that glucose is in food.  *Which of these substances is a gas in the air that we breathe?*  Answers are likely to include oxygen and, possibly, carbon dioxide. Emphasise that, in the air we breathe, the concentration of oxygen is relatively high and the concentration of carbon dioxide is relatively low.  *Which of these substances do we breathe out*?  Elicit the answer that carbon dioxide is at a higher concentration in the air we breathe out than the air we breathe in.  Ask learners to place cards in order considering that we take in glucose and oxygen and breathe out carbon dioxide and water. Show them the summary word equation for aerobic respiration:  glucose + oxygen 🡪 carbon dioxide + water.  Explain to learners that this word equation represents ‘aerobic respiration’ which is a fundamental process happening in living cells all the time.  **Resources:** Word cards |
| **8Bp.04** Know that aerobic respiration occurs in the mitochondria of plant and animal cells, and gives a controlled release of energy. | **8TWSp.03** Make predictions of likely outcomes for a scientific enquiry based on scientific knowledge and understanding.  **8TWSp.04** Plan a range of investigations of different types, while considering variables appropriately, and recognise that not all investigations can be fair tests. | **Respiration: a process for release of energy**  This activity requires preparation a few days before. Place some seeds that germinate quickly (e.g. cress or mustard seeds) on damp absorbent paper that is exposed to light so they begin to germinate. Take another sample of cress seeds and expose them to extreme heat (i.e. 30 minutes in an oven at 80OC); this heat treatment kills seeds.  Learners, working in pairs, suggest life processes that organisms carry out. Ensure that the key ideas are obtained (i.e. movement, growth, reproduction, heat (body temperature above that of the surroundings), sensing the external environment). Emphasise that, in organisms, the energy required to carry out all these life processes is transferred from food (e.g. the reaction of glucose with oxygen in the process known as aerobic respiration).  *How would you show that respiration will only occur in living seedlings?*  Elicit the idea that the energy released during respiration should cause living seedlings to heat up and therefore learners could measure the temperature. Allow learners some time to discuss this and then ask them to write each step of the investigation on a separate piece of paper. Once they have generated all the steps, ask learners to predict how the temperature will change for the live seedlings compared with the dead seeds (i.e. those that were heat-treated).  Learners then carry out the investigation. They measure the temperature to see if it increases as the seeds germinate; this would indicate a noticeable release of energy as a result of respiration. The dead seeds can no longer respire; they can be used as a control.  To consolidate this activity, display pictures, with labels, of the following equipment: insulated flask of ‘living yeast’ in water; insulated flask of ‘dead yeast’ in water; two thermometers; two test tubes; two bungs with delivery tubes and a solution of glucose. Explain that ‘dead yeast’ refers to yeast that has been boiled in water and these cells will not be able to respire.  *How could you use this equipment to show that respiration occurs in ‘living yeast’ cells but not in ‘dead yeast’ cells?*  Allow learners some time to discuss. They write each step of the investigation on a separate piece of paper and, once they have generated all the steps, they put the steps in order. They write out a list of instructions for the investigation.  Ask learners to predict how the temperature of the water in the ‘live yeast’ flask would compare to the ‘dead yeast’ flask. It is also likely that the respiration of the live yeast will cause bubbles of gas to be produced.  Ask learners to predict what substance is being produced in the gaseous state to make these bubbles, eliciting the answer of carbon dioxide.  **Resources:** Cress seeds, thermometers, pictures of the equipment |
| **8Bs.04** Describe the diffusion of oxygen and carbon dioxide between blood and the air in the lungs. | **8TWSm.02** Use an existing analogy for a purpose. | **Oxygen and carbon dioxide transport by diffusion**  Start with a brief discussion of how microorganisms (e.g. bacteria, algae) get their oxygen from the water around them through the process of diffusion.  *How does oxygen travel from pond water into bacterial (or algal) cells?*  Elicit the idea that oxygen can diffuse in water.  *Why is the oxygen concentration lower inside cells than in the surrounding water?*  Elicit the idea that the oxygen inside a cell is used up when it reacts with glucose to form carbon dioxide and water. This creates a lower oxygen concentration inside the cell.  Describe the key role that blood plays in the gas exchange/respiratory system in large multicellular organisms; human cells and tissues get oxygen by diffusion from the blood as they cannot get it directly from the air. Explain that the concentration of oxygen is lower inside cells than in the blood because it is used up when it reacts with glucose to form carbon dioxide and water.  *If the concentration of oxygen is lower inside cells than in the blood, which way will diffusion occur?*  Elicit the idea that oxygen diffuses from an area of higher concentration to an area of lower concentration.  Learners can create a physical model of the diffusion of a gas from an area of high concentration to an area of low concentration. Mark out a corner of the classroom (to represent an alveolus) and an area next to it (to represent a capillary next to the alveolus). Learners, representing oxygen particles, start in the ‘alveolus’ and move about randomly until they reach the ‘capillary’ at which point they move quickly to the other side of the classroom away from the alveolus. This would represent the movement of the blood transporting the oxygen away from the alveolus. Then more learners enter the alveolus to represent new oxygen particles arriving in the alveolus as air is breathed in; they diffuse across into the blood and are taken away. Ideally, learners could work as a team to carry out this role play; one learner could act as a narrator to explain what is happening.  Ask learners what analogies could be given that are similar to this situation. Introduce the analogy: diffusion of a gas from high to low concentration is like a sports stadium emptying. Discuss if this analogy fits.  Explain that diffusion is only effective over very short distances so capillaries are needed to bring the blood near to every cell in the body. Carefully distinguish between these two modes of oxygen transport within the human body (i.e. diffusion of oxygen over the short distances between the alveoli and the adjacent capillaries and between the capillaries and cells in body tissue; bulk transport of oxygen in red blood cells around the body).  Ask learners to draw a diagram to show the transport of blood from alveoli 🡪 capillaries 🡪 red blood cells 🡪 around the body 🡪 capillaries 🡪 body cells. They include labelled arrows to show the steps where diffusion or bulk transport occurs.  **Resources:** Images to support the discussion |
| **8Bs.03** Describe how the structure of the human respiratory system is related to its function of gas exchange (in terms of lung structure and the action of the diaphragm and intercostal muscles) and understand the difference between breathing and respiration. | **8TWSm.02** Use an existing analogy for a purpose. | **Construct an ‘artificial chest’**  Introduce an image of a pair of bellows (or show a pair of bellows to the learners). Provide the analogy that the respiratory system is like a pair of bellows.  *Is this analogy a good one?*  Discuss with learners how a pair of bellows works. Explain to learners they will build a physical model of the respiratory system to test the analogy.  Learners, working in pairs, build a physical model to demonstrate the role of the diaphragm in increasing/decreasing the pressure within the chest. This change in pressure can inflate/deflate a balloon.  Attach a balloon (representing a human lung) to a drinking straw and insert the other end of the straw in small hole in the base of a plastic (or paper) cup. Seal any gaps between the straw and cup with modelling clay (or glue). Stretch a second balloon (having cut the top off) across the opening of the plastic cup, holding it in place with an elastic band. This second balloon represents the diaphragm; as it is stretched downwards, the ‘lung balloon’ increases in volume.  Model the diaphragm moving down during inhalation; this decreases the pressure in the chest cavity and causes the lungs to inflate.  *Why does the ‘lung balloon’ inflate when the ‘diaphragm balloon’ moves downwards?*  Elicit the idea that increasing the volume of the chest cavity decreases the pressure and so more gas moves inwards.  Ask learners to decide which parts of this model represent the trachea, rib cage, lung, diaphragm and identify which parts of the respiratory system do not have an similar structure in this model.  *Can you say what is good about this model?*  *Can you say what the weaknesses are with this model?*  Return to the analogy that compares the respiratory system to bellows.  *Is this analogy a good one?*  **Resources:** Plastic cup, balloons, elastic bands, a drinking straw, soft modelling clay |
| **8Bs.02** Describe the components of blood and their functions (limited to red blood cells transporting oxygen, white blood cells protecting against pathogens and plasma transporting blood cells, nutrients and carbon dioxide)  NOTE: In this unit white blood cells are not covered | **8TWSc.01** Sort, group and classify phenomena, objects, materials and organisms through testing, observation, using secondary information, and making and using keys. | **What is in blood?**  Explain that a key component of the respiratory system is the blood that moves within the circulatory system. Using secondary information sources, learners research what red blood cells and plasma look like under the microscope. They draw representations of red blood cells and plasma on pieces of card.  They research the function/(s) of red blood cells and plasma, linking the functions to the appearance and structure of each.  Show an image of centrifuged blood to demonstrate the presence of plasma; explain that plasma is water which contains proteins, ions, dissolved gases and cells.  *What needs to be transported in blood?*  This should elicit the reactants and products of aerobic respiration.  *What is the role of plasma?*  *What is the role of red blood cells?*  Learners sort and list the things that need to be transported under the headings: red blood cell; plasma.  **Resources:** Secondary information sources, an image of centrifuged blood |

# Unit 8.4 Light and colour

| Unit 8.4 Light and colour |
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| Outline of unit: |
| This unit allows learners to examine the nature of light including how light behaves at surfaces and colour.  Learners will investigate the relationship between the angle of incidence and reflection to arrive at the law of reflection by taking careful measurements, recording their observations in an appropriate form and describing trends in the results, identifying anomalous results where necessary. Learners will also develop their use of models to describe how light is affected by different mediums.  This unit also covers how a prism can show that white light is made of many colours and describes how coloured light is reflected and absorbed by different materials. |
| Recommended prior knowledge or previous learning required for the unit: |
| Learners will benefit from previous experience of:   * using ray diagrams to represent light travelling in straight lines * understanding light can pass through some objects and be reflected by others * understanding light can reflect off surfaces and describing how objects which are not light sources can be seen * knowing that light travels at a constant speed in a given medium * observing that a ray of light changes direction when it travels through different mediums, knowing that this is called refraction. |
| Suggested examples for teaching Science in Context: |
| ***8SIC.04*** *Describe how people develop and use scientific understanding as individuals and through collaboration, e.g. through peer-review.*  In 1666, Sir Isaac Newton carried out a famous experiment with sunlight and a prism to develop his ideas about the nature of colour; he put forward the corpuscular theory of light. Learners could research, and reproduce, Newton’s prism experiment; they could describe the impact of these ideas at the time and how our understanding of light has continued to advance.  ***8SIC.02*** *Describe how science is applied across societies and industries, and in research.*  Reflective materials are used on reflective clothing and on some roads in reflective studs. Learners could research how reflective clothing or road markings are designed and explain how they work. |

| Learning objective | Key vocabulary | Possible models and representations | Possible misconceptions |
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| **8Ps.01** Describe reflection at a plane surface and use the law of reflection. | Reflection, reflected, plane, light, ray, incident, normal (i.e. the line at right angles to a surface), angle of incidence, angle of reflection, law of reflection | Ray drawings can be used, as a model, to show what is happening to the light. A ray is an imaginary line that shows the direction in which the light is travelling.  A ball bouncing off a wall can be used to model light reflecting off a plane surface. Highlight to learners that | Learners may think that light stays on a mirror during reflection. A ray diagram can be used to emphasise that the light travels from the source to the mirror and then to the eye. |
| **8Ps.02** Describe refraction of light at the boundary between air and glass or air and water in terms of change of speed. | Incident, refraction, refracted, normal, interface, boundary, light, ray | The change in speed of light when it moves from air to water (or glass) is represented when a toy car slows down when it goes from a smooth surface to a rough surface (e.g. carpet, sand). If the toy car approaches the interface at an angle, one wheel is slowed down first whilst the other wheel continues at the same pace; this causes the car to change direction. | Learners may think that light travels at the same speed through all mediums; they may have heard that the speed of light is a constant. Explain that the speed of light is constant in any given medium; however, it varies from one medium to another (e.g. it is slower in glass than in air). |
| **8Ps.03** Know that white light is made of many colours and this can be shown through the dispersion of white light, using a prism. | Dispersion, prism, light, ray, colour, white light | A ray diagram of the separation of white light into distinct rays of different colours, by a prism, can illustrate to learners that white light is made of many colours. | Some learners may perceive colour differently (i.e. they have a form of ‘colour blindness’). Red-green is the most common form of colour blindness so avoid using examples (including diagrams) where only red and green are being compared.  Some learners may believe that white light ‘hides’ the other colours rather than white light being constituent parts of white light. This misconceptions will be addressed during teaching of this unit. |
| **8Ps.04** Describe how colours of light can be added, subtracted, absorbed and reflected. | Shiny, matt, absorbance, light, ray, add, subtract, absorb, reflect, colour | Ray diagrams can be used to represent how different colours of light (or colours within white light) can be added, subtracted, absorbed and reflected.  A physical model can be used to show coloured light being absorbed, reflected and added. A range of coloured balls (e.g. red, green, blue), representing the colours in white light, are placed inside a black container (representing an object). No coloured balls are seen; this represents all the light being absorbed by the object (i.e. no light is reflected to our eyes), meaning the object is seen as black. Remove a red ball from the container and pass it to a learner; this models reflection of the red light only (i.e. the other colours of light are still absorbed) and means the object is seen as red. If balls of two colours are removed at the same time then the two colours are added and the blended colour is seen (e.g. green light and blue light is blended to make cyan). | Learners often think that light reflects from shiny objects (e.g. mirrors) but not from matt surfaces. It may be helpful to show learners how a matt surface reflects light in many different directions.  Learners may think that our eyes see the colour of an object because our eyes give out something (rather than detecting the colour of the light reflected by the object). A ray diagram can be used to show how the light is travelling. |

# Unit 8.4 Suggested activities

| Learning objective | Thinking and Working Scientifically opportunities | Suggested teaching activities and resources |
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| **8Ps.01** Describe reflection at a plane surface and use the law of reflection. | **8TWSc.04** Take appropriately accurate and precise measurements, explaining why accuracy and precision are important.  **8TWSc.07** Collect and record sufficient observations and/or measurements in an appropriate form.  **8TWSa.02** Describe trends and patterns in results, including identifying any anomalous results.  **8TWSa.05** Present and interpret observations and measurements appropriately. | **Reflection of light rays**  Learners, working in pairs, use a ray box (or a torch with a narrow slit placed in front of it) to explore what happens when a light ray is shone onto a plane mirror at different angles.  *What do you notice about the light ray?*  Introduce learners to the terms:   * ‘normal’ (i.e. the line perpendicular to the surface of a plane mirror) * ‘angle of incidence’ (i.e. the angle between the incident light ray and the normal) * ‘angle of reflection’ (i.e. the angle between the reflected light ray and the normal)   Demonstrate to learners how to mark the incident ray and the reflected ray at the point the ray interacts with the plane surface, and how to use a protractor to measure the angles of incidence and angle of refection.  Learners, working in pairs, take turns to change the angle of incidence, measure the angle of incidence and angle of reflection and record their results in an appropriate table. Each learner measures five different  angles of incidence.   |  |  |  | | --- | --- | --- | | Observation number | Angle of incident | Angle of reflection | | 1 |  |  | | 2 |  |  | | 3 |  |  | | 4 |  |  | | 5 |  |  |   Learners then plot a graph of their data (i.e.the angle of reflection against the angle of incidence); they identify the trend in the results and draw a line of best fit. Learners could use one colour (or symbol shape) to plot their measurements and a second colour for the line of best fit to help them assess the accuracy and precision of their measurements. Any anomalous results should be identified on the graph.  Learners can consider the following questions:  *What trends/pattern do you see in your results?*  *How accurate were your measurements?*  *Why is it important to take accurate and precise measurements?*  *What is the relationship between the angle of incidence and the angle of reflection?*  Elicit the key point that the angle of reflection is always equal (within experimental error) to the angle of incidence. Explain that this is called the law of reflection.  **Resources:** Ray box, plane mirrors, protractors |
| **8Ps.02** Describe refraction of light at the boundary between air and glass or air and water in terms of change of speed. | **8TWSm.01** Describe what an analogy is and how it can be used as a model. | **Observing and describing refraction of light**  Make a room as dark as possible and fill a large, transparent container (ideally glass) with water. Using a ray box (or a torch with a narrow slit placed in front of it), being careful about using electrical equipment around water, direct a ray of light at an angle to the side of the container. Learners observe whether the light ray changes in any way. Show learners that the light ray changes direction as you move it to different angles.  *What do you observe about the light ray as it moves from air into a different medium?*  *Why is this happening?*  Show learners a picture of a toy car moving from a polished floor onto a carpeted floor (or sand).  *How will the speed of the car change as it moves from one surface to the other?*  Elicit the idea that the car will slow down on the rougher surface; suggest that this is because the car’s wheels are interacting with the material of the surface.  Explain that this is an analogy for the movement of light from air to water (or glass).  *What does this analogy tell you about what happens to light when it passes from air to water (or glass)?*  Elicit the idea that the speed of light is slower in glass (or water) than in air.  *Can you predict what might happen to the speed of light when it passes from glass to air?*  Elicit the idea that the light should speed up.  Help learners to make the link between the change in the speed when the car moves onto a different surface with a change in direction by considering what happens to the toy car if it approaches the boundary at an angle. One front wheel of the car reaches the boundary first and slows down whilst the other front wheel is still travelling at the original speed; this causes the car to change direction. It may be useful to demonstrate this to the class or encourage learners to investigate this for themselves.  **Resources:** Transparent container, ray box, picture of a toy car |
| **8Ps.03** Know that white light is made of many colours and this can be shown through the dispersion of white light, using a prism. | **8TWSp.02** Describe how scientific hypotheses can be supported or contradicted by evidence from an enquiry. | **Newton’s prism experiment on the nature of coloured light**  Discuss with learners where colours come from using a rainbow as an example.  *Where do the colours of a rainbow come from?*  *What is your hypothesis? What evidence or observation do you have for it?*  Learners discuss, in pairs, what their hypothesis is for the phenomenon of coloured light.  Introduce a hypothesis that pure light is white and contaminated light is coloured*.*  *Does this hypothesis sound reasonable?*  Introduce an alternative hypothesis that white light is made of many colours and we only see coloured light when the white light is separated or split.  *Does this hypothesis sound reasonable?*  Learners test the alternative hypothesis by using a light source (e.g. a torch) and a prism; they project the image onto plain paper (or white cloth) to demonstrate the colours of the rainbow.  *How many colours can you identify?*  *Where have the colours come from?*  Place a card with a slit in front of the light source, so that only one colour passes through, and show learners that the single-coloured ray of light does not split into the colours of the rainbow when a second prism is placed into its path. Now remove the card with the slit to show that the second prism can recombine the rainbow to give white light.  Ask learners to write a laboratory report including the following sections:   1. State the hypothesis 2. Describe the method 3. Record and describe the results 4. Make a conclusion explaining whether the evidence supports the hypothesis   **Resources:** A torch, prism |
| **8Ps.04** Describe how colours of light can be added, subtracted, absorbed and reflected. | **8TWSm.02** Use an existing analogy for a purpose. | **Adding and subtracting coloured light**  Explain that the colour of a surface depends on the pigments found in the surface material. Each pigment absorbs certain colours of white light and reflects the other colours. For example, a ‘green’ surface absorbs all colours except the green light which is reflected; the surface appears green because only the green light reaches our eyes.  Show learners ray diagrams to represent this concept, explaining that a ray diagram is a model for light. Ask learners to draw ray diagrams to show how everyday items (e.g. a ‘red’ flower, a ‘blue’ shirt) appear to be the colour that we see. Explain that all the colours are reflected by a ‘white’ surface and all of the colours are absorbed by a ‘black’ surface.  Explain that coloured light can be subtracted from white light by the use of a filter (e.g. a green filter absorbs all the colours of white light except for green light; we say that green light is subtracted). Ask learners to draw ray diagrams showing the subtraction of light.  Finally, explain that coloured light can be added; when all colours are added together they make white light. There are three primary colours of light (i.e. red, green and blue) and secondary colours of light are formed when two of the primary colours are combined (i.e. magenta, yellow and cyan). Learners draw three overlapping circles on a white piece of paper, colouring them in red, green or blue (other than the overlaps). They show yellow in the overlap between red and green; magenta in the overlap between red and blue; cyan in the overlap between green and blue and leave the centre (i.e. where all three circles overlap) white.  Introduce the analogy: Light behaves like mixing paint. Discuss with learners why this is a bad analogy and what a better analogy could be.  **Resources:** None |

# Unit 8.5 Atomic structure and chemical reactions

| Unit 8.5 Atomic structure and chemical reactions |
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| Outline of unit: |
| During this unit, learners will develop a deeper understanding of atoms. They will be introduced to the Rutherford model of the atom (i.e. a nucleus at the centre, containing positively-charged protons, surrounded by a cloud of electrons which are negatively charged). Later, neutrons were discovered and have no charge.  Learners will also explore chemical reactions and learn how to describe them with words. Learners will look at some examples of chemical reactions; including metals reacting with oxygen, water and dilute acids. Learners will also consider inert (or unreactive) substances (e.g. plastics) and their environmental impact.  This unit will introduce learners to some key models and representations of atoms and chemical reactions; these will be used in later stages. |
| Recommended prior knowledge or previous learning required for the unit: |
| Learners will benefit from previous experience of:   * explaining that all matter is made of atoms, with each different type of atom being a different element * knowing that a compound is made of two or more different atoms * knowing that water is a compound made of hydrogen and oxygen atoms * describing a chemical reaction that involves reactants interacting to form new substances called products * describing chemical reactions using the particle model * knowing that a chemical reaction can be observed by the loss of reactants and/or formation of products (e.g. evolution of a gas, change in colour) * knowing that an acidic solution has a pH below 7. |
| Suggested examples for teaching Science in Context: |
| ***8SIC.01*** *Discuss how scientific knowledge is developed through collective understanding and scrutiny over time.*  Learners could compose a timeline, with text and diagrams, to illustrate the development of our understanding of the atom and the different models that have reflected the understanding at the time. They could discuss how challenge and collaboration has contributed to the collective understanding of the atom.  ***8SIC.02*** *Describe how science is applied across societies and industries, and in research.*  Learners could relate their knowledge of the reactivity of metals to the ways the metals are used in society. For example, sodium and potassium are generally found in nature as metal salts (rather than as metals) whereas copper is useful for electric wires. Helium is used in balloons because it is inert whereas hydrogen is explosive and therefore dangerous in balloons.  ***8SIC.05*** *Discuss how the uses of science can have a global environmental impact.*  We use many inert substances, including plastics, to ensure objects do not react with the environment. As plastics do not breakdown in the environment, there have been several, undesirable, environmental issues (e.g. the increase of plastics in the oceans). Learners can look at the history of plastics to understand the changing relationship we have with plastics and how scientists are working to resolve this problem we have created. |

| Learning objective | Key vocabulary | Possible models and representations | Possible misconceptions |
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| **8Cm.01** Describe the Rutherford model of the structure of an atom. | Positive charge, negative charge, nucleus, atom, electron, proton, neutron, atomic model | The teaching of this objective will introduce learners to the Rutherford model of the atom. | Learners may think that atoms can be seen with a microscope; they often have difficulty appreciating just how small subatomic particles are. They could consider how small atoms must be given that, roughly, 500,000,000,000,000,000,000,000 atoms fit into a teaspoon.  Learners may not realise how much empty space there is in an atom. Use the analogy of a football stadium: if a tennis ball in the centre of the pitch represents the nucleus then the nearest electron is on the farthest row of seats and between them there is empty space.  Learners may think that only one model of the atom is correct. Emphasise that the Rutherford model can help our thinking but it has weaknesses and there may be better models. |
| **8Cm.02** Know that electrons have negative charge, protons have positive charge and neutrons have no charge. | Proton, electron, neutron, charge, atom, positive, negative | Learners can construct a representation of an atom by using objects (e.g. round discs, blank playing cards) to represent protons, neutrons and electrons. Ensure the objects are labelled with the respective charges. | Learners may confuse the term ‘charge’ with the idea of charging a battery. Take time to ensure that learners are clear about the distinction between these uses of the word. |
| **8Cm.03** Know that the electrostatic attraction between positive and negative charge is what holds together individual atoms. | Electrostatic attraction, repulsion, charge, positive, negative, proton, neutron, electron, nucleus, atoms | Learners can take on the role of the protons and electrons and roleplay the electrostatic attractions between them; showing how the structure of an atom remains stable through this interaction. | The term ‘attraction’ might imply a choice. Be careful with your choice of language to ensure learners are aware that the attraction between positive and negative charges is simply one of their properties.  Some learners may think that the presence of only protons in the nucleus should cause repulsion. If this is raised by learners, it could be helpful to introduce the idea that nuclear forces hold the nucleus together.  Learners may think that the main attraction in an atom is between protons and electrons. Emphasise with learners that the attraction is between negative electrons and the positive nucleus (as a single charge) rather than individual protons. |
| **8Cc.03** Describe the reactivity of metals (limited to sodium, potassium, calcium, magnesium, zinc, iron, copper, gold and silver) with oxygen, water and dilute acids. | Metals, sodium, potassium, calcium, magnesium, zinc, iron, copper, gold, silver, oxygen, hydrochloric acid, chloride, sulfuric acid, sulfate, dilute, concentrated, reaction, reactivity, series, hydrogen, metal salt, metal hydroxide, metal oxide, property/properties | Learners could role-play reactivity. A learner is designated as oxygen. Other learners are then designated as different metals. Each learners representing a metal is given a number (representing their reactivity) The ‘oxygen’ stands next to the metal representing the lowest reactivity and then when another ‘metal’ of a higher reactivity is nearby the new ‘metal’ takes the ‘oxygen’ away. This role-play can be carried out in a range of situations and with different elements. | Learners may think that different metals could ‘want’ to react whereas their reactivity is one of their properties. Careful use of language may be necessary here to avoid this. |
| **8Cc.01** Use word equations to describe reactions. | Reactant, product, reaction, word equation | Word equations are used to represent the phenomenon of reactants reacting to form products. | Learners may have difficulty with what the names of chemicals mean (e.g. ‘sulfuric acid’ is not made of ‘sulfuric’ and ‘acid’, ‘hydrochloric acid’ is not made of ‘hydrochloric’ and ‘acid’). Take the time to explain the conventions for naming chemicals. |
| **8Cc.04** Know that reactions do not always lead to a single pure product and that sometimes a reaction will produce an impure mixture of products. | Reaction, pure, impure, mixture, reactant, product | Coloured discs can be used to represent the atoms within reactants. Show learners that the ‘atoms’ can be combined in multiple ways and explain that some reactions (e.g. the incomplete combustion of carbon) create an impure mixture of products. | Learners may think that carbon dioxide is two products because there are two separate words. Using a diagram demonstrate that carbon dioxide is a substance made from carbon and two oxygen atoms. |
| **8Cc.06** Understand that some substances are generally unreactive and can be described as inert. | Unreactive, inert, helium, argon, gold, platinum, element, compound, molecule, atom | Inert substances could be represented in role play by people who don’t interact with objects. | Learners may think that all chemicals can be burned. Explain that some elements (e.g. helium, argon) do not form any compounds.  Learners may have heard of microplastics and think that they are different in chemical composition to plastic that they can see (e.g. plastic bottles). Explain that microplastics are just small pieces of plastic. |

# Unit 8.5 Suggested activities

| Learning objective | Thinking and Working Scientifically opportunities | Suggested teaching activities and resources |
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| **8Cm.01** Describe the Rutherford model of the structure of an atom.  **8Cm.02** Know that electrons have negative charge, protons have positive charge and neutrons have no charge. | **8TWSm.01** Describe what an analogy is and how it can be used as a model. | **What is in an atom?**  Show the Periodic Table to the learners. Discuss how we know that there are different elements and that atoms are the building blocks of compounds.  *What does an atom look like?*  *What is an atom made of?*  Discuss learners’ ideas; some learners may be familiar with the key words.  Show learners an adapted version of the Rutherford model of the structure of an atom which shows the electrons, protons and neutrons; the protons and neutrons are in a nucleus. Introduce learners to earlier models of the atom. The original Rutherford model did not have neutrons because they were not discovered until later. Before Rutherford’s experiment, the ‘plum pudding model’ was widely accepted. The negatively-charged electrons were thought to be distributed throughout a sphere of positive charge. Discuss with learners how this is an analogy because we use this description to compare an atom to a more familiar object.  *Is a plum pudding a good analogy for an atom?*  *Can we think of a better analogy?*  Explain that the overall charge of an atom is zero; protons have a positive charge and electrons have a negative charge. Therefore, we know that neutrons have no charge and that, in an atom, there must be the same number of protons and electrons. Learners could build a model of a carbon atom using labelled counters: 6 protons with + signs, 6 electrons with – signs and 6 neutrons with no sign. Alternatively, coloured counters could be used. They could make models of other elements (e.g. nitrogen with 7 protons, 7 electrons and 7 neutrons; oxygen with 8 protons 8 electrons and 8 neutrons; helium with 2 protons, 2 electrons and 2 neutrons).  **Resources:** Labelled counters |
| **8Cm.03** Know that the electrostatic attraction between positive and negative charge is what holds together individual atoms. | **8TWSp.01** Identify whether a given hypothesis is testable. | **Electrostatics**  Show learners the Rutherford model of the structure of an atom, highlighting the positive charge of the protons and the negative charge of the electrons.  *If the electrons surround the nucleus, why don’t they fly away from the atom?*  *What keeps electrons in place?*  Introduce the hypothesis that ‘the electrostatic attraction between the positive charge of the protons and the negative charge of the electrons holds individual atoms together’.  *Is this hypothesis testable?*  *What can we do to test this idea?*  Explain that different materials can become charged when they are rubbed with a piece of cloth: some become positively charged (e.g. a polythene rod, nylon, wool, silk) and others become negatively charged (e.g. a glass rod, polyester, PVC/vinyl). Learners, working in pairs, rub two polythene rods (or strips) with a piece of cloth. They use string and small paper hammocks to suspend the rods so that they can move freely. Learners bring the two polythene rods near to each other; the two rods will repel each other. They repeat the experiment using a polythene rod and a glass rod; the two rods will attract each other).  This process models what happens between charged particles in an atom.  *Is this a useful model?*  The negatively-charged electrons are electrostatically attracted to the positively-charged nucleus. It is electrostatic attraction that keeps atoms together.  **Resources:** Polythene rods, glass rods, small pieces of cloth |
| **8Cc.03** Describe the reactivity of metals (limited to sodium, potassium, calcium, magnesium, zinc, iron, copper, gold and silver) with oxygen, water and dilute acids. | **8TWSc.01** Sort, group and classify phenomena, objects, materials and organisms through testing, observation, using secondary information, and making and using keys.  **8TWSp.05** Make risk assessments for practical work to identify and control risks.  **8TWSc.05** Carry out practical work safely, supported by risk assessments where appropriate.  **8TWSa.05** Present and interpret observations and measurements appropriately. | **Reactions of metals**  Using a Bunsen burner, demonstrate the burning of metals (i.e. iron filings/wool, magnesium ribbon, copper turnings, zinc wool) in air. For safety reasons, carry out the reactions behind a safety screen and ensure that everybody is wearing eye protection. Warn learners to avoid looking directly at the flame of magnesium burning, Ideally, they should look through blue glass filters.  *Which metals reacted the most vigorously with the oxygen within air?*  Repeat the demonstration, asking learners to write their observations. Ask learners to put the metals in order starting with the metal that reacts most vigorously with oxygen within air.  Demonstrate the reactions of sodium, potassium, calcium with water; include a few drops of Universal Indicator in the water so learners can observe the colour change caused by the production of the hydroxide. Demonstrate that magnesium, zinc, iron and copper do not react with water. For safety reasons, carry out the reactions behind a safety screen and ensure that everybody is wearing eye protection. Very small amounts (similar in size to a grain of rice) of each metal should be used.  Ask learners to put the metals in order starting with the metal that reacts most vigorously with water.  *What did you notice about the reactions as the metals changed?*  Learners can carry out the reactions of magnesium, zinc, iron and copper with dilute hydrochloric acid  (1 M) and dilute sulfuric acid (0.5 M) themselves. They begin by making a risk assessment; they consult the experiment protocol to support their work.  *Why is it important to carry out a risk assessment before starting practical work?*  *What key information is needed to carry out a risk assessment?*  Learners, using secondary information sources, research the hazards associated with dilute hydrochloric acid, dilute sulfuric acid, magnesium ribbon, iron filings/wool, zinc wool and copper turnings. They should identify that suitable eye protection must be worn when handling dilute acids; ensure that learners keep their safety glasses on throughout the experiment.  Learners, working in pairs, place eight test tubes in a test tube rack. They add dilute hydrochloric acid  (1 M, 25 cm3) to four tubes and dilute sulfuric acid (0.5 M, 25 cm3) to the other four tubes. They add a small piece of each of the metals, making sure to make a note of which metal was added to each tube. They record their observations, summarising their results in a table.  Ask learners to put the metals in order starting with the metal that reacts most vigorously with water; note that copper should not react with water.  Alternatively, if the chemicals or equipment are not available videos of the reactions can be shown in place of the practical work. Learners could prepare their own card sort where each card has a metal and reactant (either water, oxygen or dilute acid) and a number from 1 to 10 to indicate how vigorous the reaction is. Learners should sort the cards in order to produce a reactivity series and create a table to summarise their results.  **Resources:** Magnesium ribbon, iron filings, zinc wool, copper turnings, Bunsen burner, Universal Indicator, metal samples (i.e. sodium, potassium, calcium), test tubes, test tube rack, bungs, Bunsen burners, wood splints, dilute hydrochloric acid, dilute sulfuric acid |
| **8Cc.01** Use word equations to describe reactions. | **8TWSp.03** Make predictions of likely outcomes for a scientific enquiry based on scientific knowledge and understanding. | **Using word equations**  Discuss with learners that observing reactions and making notes can be useful but we also need a method for representing the reaction in terms of reactants and products.  *What can we do (or write) to represent the reaction?*  Introduce a word equation structure of ‘reactant + reactant 🡪 product’  Show learners the following word equations and ask them to create a rule for naming the compounds formed when a reaction of a metal with water:   * sodium + water 🡪 sodium hydroxide + hydrogen * calcium + water 🡪 calcium hydroxide + hydrogen   Ask learners to predict the products of the reaction between:   * magnesium and water * iron and water   Explain that water is a compound of hydrogen and oxygen and, in this reaction, the atoms are rearranged to make hydroxide and hydrogen. Highlight the observation that ‘hydroxide’ contains a hydrogen and an oxygen atom.  Repeat this task with the reaction of metals with oxygen to form metal oxide and hydrogen. Explain that, in this case, the oxygen and hydrogen atoms in water are rearranged to make a compound of metal with oxygen (i.e. the metal oxide) and hydrogen gas. The term ‘oxide’ stands for oxygen in a compound with a metal.  Show learners the following word equations and ask them to create a rule for naming the compounds produced when a metal reacts with dilute hydrochloric acid:   * zinc + hydrochloric acid 🡪 zinc chloride + hydrogen * calcium + hydrochloric acid 🡪 calcium chloride + hydrogen   Learners should create a rule that includes the idea that the ‘hydro-‘ part of hydrochloric acid becomes hydrogen whilst the ‘chloric’ part becomes ‘chloride’. They should also notice that the metal (i.e. zinc, calcium) combines with chlorine atoms to become a metal chloride: emphasise that ‘–ine’ becomes ‘–ide’.  Ask learners to use their rule to predict the products of the reaction between:   * magnesium and hydrochloric acid * magnesium and hydrobromic acid   Show learners the following word equations and ask them to create a rule for naming the compounds produced when a metal reacts with dilute sulfuric acid:   * iron + sulfuric acid 🡪 iron sulfate + hydrogen * calcium + sulfuric acid 🡪 calcium sulfate + hydrogen   Learners should create a rule that hydrogen is produced and that the metal (i.e. iron, calcium) combines with sulfuric acid to become a metal sulfate: emphasise that ‘–uric’ becomes ‘–ate’.  Ask learners to use their rule to predict the products of the reaction between:   * magnesium and sulfuric acid * iron and sulfuric acid   **Resources:** None |
| **8Cc.04** Know that reactions do not always lead to a single pure product and that sometimes a reaction will produce an impure mixture of products. | **8TWSc.01** Sort, group and classify phenomena, objects, materials and organisms through testing, observation, using secondary information, and making and using keys. | **Reactions that produce a mixture of products**  Demonstrate to learners the combustion of an appropriate substance e.g. hexane, magnesium under controlled conditions. Explain that this is a combustion reaction, the substance is reacting with oxygen in the air to form products.  *What substances have been formed? What are the products of the reaction?*  *Where are the products?*  Show the corresponding word equation for combustion of the alkane.  Explain that many reactions produce multiple products rather than a single, pure product.  *What happens if the products of a reaction are in the same phase (e.g. a liquid)?*  Discuss how the products will mix together.  Prepare a variety of word equations for different chemical reactions and ask learners to sort and classify them according to whether there is only one or more than one product. Examples could include:   * hexane + oxygen 🡪 carbon dioxide + water * hydrogen + oxygen 🡪 water * sodium + water 🡪 sodium hydroxide + hydrogen * carbon + oxygen 🡪 carbon dioxide * carbon + oxygen 🡪 carbon monoxide + carbon dioxide * iron + sulfuric acid 🡪 iron sulfate + hydrogen * sulfur + oxygen 🡪 sulfur dioxide * magnesium + hydrochloric acid 🡪 magnesium chloride + hydrogen * magnesium + oxygen 🡪 magnesium oxide   Ensure learners understand that a substance (e.g. carbon dioxide), which has two words in its name, is a single substance. Explain that the ‘+ sign’ indicates that there is more than one product in the reaction.  Learners can then look at the group of reactions with more than one product. They identify which of these reactions, if allowed to go to completion in a solution, would form an impure mixture of products. Reinforce the point that the products need to be in the same phase for there to be an impure mixture.  **Resources:** Appropriate combustible substance, a source of fire |
| **8Cc.06** Understand that some substances are generally unreactive and can be described as inert. | **8TWSc.01** Sort, group and classify phenomena, objects, materials and organisms through testing, observation, using secondary information, and making and using keys. | **Sort and classify substances according to reactivity**  Introduce the terms ‘unreactive’ and ‘inert’.  *What might these terms mean in the everyday sense?* (for example they might think of idle, inactive, unused)  Help learners to think about how these terms could be applied to chemical reactions. Arrive at the idea that an ‘unreactive’ (or ‘inert’) substance is one which does not undergo chemical reactions.  Learners, working in groups of four, use secondary information sources to research substances; two learners research an unreactive substance and the other two learners research a reactive substance. These might include:   * two gases one of which is reactive (e.g. hydrogen, oxygen, chlorine) and the other unreactive (e.g. helium, neon, argon) * two plastics one of which is a starch-based biodegradable plastic and the other is a PET - polyethylene type of plastic. * two metals, one of which is reactive (e.g. iron) and the other unreactive (e.g. gold).   The two pairs of learners come together as a group to compare and contrast the substances they have researched. They could be prompted with questions:  *Can the substance be found in the Periodic Table? If so, where?*  *Is it reactive or unreactive? How do you know?*  *How long might it last in the environment?*  *What can it be used for? Does its use relate to its reactivity?*  The group then work together to prepare a poster. They use the structure of a Venn diagram to identify the similarities (placed in the overlap between the circles) and the differences (placed within the circles) between the substances.  **Resources:** Secondary sources of information |

# Unit 8.6 Health

| Unit 8.6 Health |
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| Outline of unit: |
| This unit provides learners with a deeper understanding of what is in their diet and what their bodies require to function. It begins with learners considering the importance of eating a balanced diet including protein, carbohydrates, fats and oils, water, minerals (limited to calcium and iron) and vitamins (limited to A, C and D). Learners will consider why carbohydrates and fats are particularly important for energy and can also be used as a store of energy in the body.  Learners then consider how energy is needed for movement, growth and reproduction and how muscles require energy in order to contract and move the bones.  In addition to diet, learners will examine how human growth, development and health can be affected by lifestyle, including diet and smoking. Learners then move from impacts on an individual organism and consider how toxic chemicals can be passed through food webs and can affect the health of all organisms in the web. |
| Recommended prior knowledge or previous learning required for the unit: |
| Learners will benefit from previous experience of:   * explaining that aerobic respiration occurs in the mitochondria of plant and animal cells, and gives a controlled release of energy * constructing and interpreting food chains and webs * knowing that energy is transferred through a food chain/web when one animal eats another animal (or plant) and digests and absorbs carbohydrate and fat * explaining that bones are moved by muscles contracting and relaxing * knowing that blood contains a fluid (i.e. plasma), red blood cells and white blood cells. |
| Suggested examples for teaching Science in Context: |
| ***8SIC.05*** *Discuss how the uses of science can have a global environmental impact*.  Toxic chemicals (e.g. heavy metals) accumulate in predators which may become part of the human diet. Learners could research the life cycle of heavy metals (e.g. the source of heavy metals, their use, how they get into the environment, the accumulation of heavy metals in fish, the related dangers for the human diet).and discuss how industries that use heavy metals can have a global environmental impact  ***8SIC.04*** *Describe how people develop and use scientific understanding as individuals and through collaboration, e.g. through peer-review.*  In the 18th century, James Lind carried out an experiment that was critical in understanding the importance of vitamin C in preventing scurvy. Learners could research how James Lind designed the experiment and the impact this had on the preparations made for long sea voyages. |

| Learning objective | Key vocabulary | Possible models and representations | Possible misconceptions |
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| **8Bp.01** Identify the constituents of a balanced diet for humans as including protein, carbohydrates, fats and oils, water, minerals (limited to calcium and iron) and vitamins (limited to A, C and D), and describe the functions of these nutrients. | Protein, carbohydrate, sugar, fats, oils, minerals, calcium, iron, vitamin, nutrient, constituents, function, balanced diet | Learners can construct (e.g. writing, drawing, cutting out images of food and stick them on a page) an ideal weekly menu to show what a good balanced diet could look like. | Some learners may think that vitamins are only available as supplements and not realise that they are in foods. Learners could research which foods are good sources of each of the vitamins.  Learners may think that all fats and all sugars are always bad rather than realising that they should be eaten in moderation. Discuss the biological use of fats and sugars and the impact of removing these constituents from a diet to help learners realise their important role in a balanced diet.  Learners sometimes misunderstand the word ‘balanced’ in the context of a diet. The diet should contain appropriate amounts of each component, rather than equal amounts of each component. |
| **8Bp.02** Understand that carbohydrates and fats can be used as a store of energy in animals, and animals consume food to obtain energy and nutrients. | Carbohydrate, fat, nutrient, energy, store | Learners can make a flowchart to represent the flow of energy within a single animal and how carbohydrates and fats are used as stores of energy. | Learners may be familiar with the idea of food being ‘burnt’ in respiration. Ensure that they understand that respiration involves a series of steps that transfer energy slowly.  Learners may think that all (or most) of the food we eat is used to give us energy. Explain that different components of our diet are incorporated into the body in different ways.  Learners may think that fat is limited to sub-cutaneous fat (i.e. only people who appear ‘fat’ have fat). Whereas fat is also stored internally and is an important part of many organs. Discuss with learners where fat is located in the bodies of animals, including humans, and address this misconception through looking at secondary sources of information if required. |
| **8Bs.01** Identify ball-and-socket and hinge joints, and explain how antagonistic muscles move the bones at a hinge joint. | Joint, hinge, ball-and-socket, antagonistic, muscles, oppose | Learners can make physical models of ball-and-socket and hinge joints which can be used to compare and contrast these two types of joint. | Learners may not realise that a single muscle can only pull as it contracts. Use a model to explain how two muscles, acting in opposite directions, are needed to move a limb in two opposing directions. |
| **8Bp.03** Discuss how human growth, development and health can be affected by lifestyle, including diet and smoking. | Diet, lifestyle, health, healthy, smoking, growth, development | Learners can draw diagrams to illustrate the impact of lifestyle choices on specific organs. | Learners may think that the term ‘diet’ is the same as a weight-loss programme. Explain that the term ‘diet’ simply means the kinds of food that a person eats normally. |
| **8Bs.02** Describe the components of blood and their functions (limited to red blood cells transporting oxygen, white blood cells protecting against pathogens and plasma transporting blood cells, nutrients and carbon dioxide). | Red blood cell, white blood cell, plasma, nutrient, pathogen | Learners can use physical models of blood with red discs (i.e. red blood cells), irregular-shaped white discs (i.e. white blood cells) contained in a liquid (e.g. vegetable oil) to represent the plasma. | Learners may not understand that blood is red because it contains red blood cells; they may think that blood is just a red liquid. Therefore, drawings of blood should show red blood cells and white blood cells in a liquid. |
| **8Be.02** Describe the impact of the bioaccumulation of toxic substances on an ecosystem. | Toxic, harmful, accumulation, bioaccumulation, ecosystem, contaminated, apex predator | Learners can make a flowchart to represent the accumulation of a toxic substance through a food chain (or food web). | Learners may think that toxic substances that are not visible (or can no longer be seen) are not present. Therefore it is important to emphasise that toxic substances may not be visible.  Learners may believe toxic substances have an immediate effect. Provide examples of substances which have to reach a certain level in an organism before the toxic effects of the substance become apparent. |

# Unit 8.6 Suggested activities

| Learning objective | Thinking and Working Scientifically opportunities | Suggested teaching activities and resources |
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| **8Bp.01** Identify the constituents of a balanced diet for humans as including protein, carbohydrates, fats and oils, water, minerals (limited to calcium and iron) and vitamins (limited to A, C and D), and describe the functions of these nutrients. | **8TWSc.01** Sort, group and classify phenomena, objects, materials and organisms through testing, observation, using secondary information, and making and using keys. | **A balanced diet**  Ask learners to discuss what they think the term ‘diet’ means; the word is often associated with weight loss (e.g. ‘going on a diet’). Clarify the meaning of the term in this context (i.e. the kinds of food that someone normally eats).  Before the activity, learners collect food labels (showing nutritional information). In school, they analyse the food labels to identify which foods are good sources of the different nutrients.  *What range of nutritional information can be found on the food labels?*  *Why are all of these listed?*  Discuss with learners that humans (and all organisms) need a range of substances in their diet in order to remain healthy; the substances all perform important functions.  Introduce learners to the important constituents of food: proteins, carbohydrates, fats, oils, water, minerals and vitamins. Showcase to learners why each constituent is important through case studies where humans have had a deficiency (e.g. low vitamin C intake leads to scurvy; low vitamin A intake leads to anaemia).  Learners then sort the food labels into different groups (e.g. high in carbohydrates and low in vitamin A).  *How many groups can be made?*  Discuss with learners how different foods provide different levels of the nutrients needed by humans and eating a range of foods is needed to get all the nutrients in the right amount. Explain what can happen when a human has too much of something (e.g. too much fat can lead to health issues; too much water can also be bad for human health).  **Resources:** Food labels |
| **8Bp.02** Understand that carbohydrates and fats can be used as a store of energy in animals, and animals consume food to obtain energy and nutrients. | **8TSWa.05** Present and interpret observations and measurements appropriately. | **Food as a source of energy**  Learners discuss the role of carbohydrates and fats in their diet as a source of energy.  *What happens if we take in more energy than we need? Where does the excess go?*  Discuss with learners that our bodies make fat as a store of energy and if we take in more than we need our bodies will make fat as a store and if we take in less energy than we need then our bodies use this fat as an energy source. Some learners may ask what happens if the fat store is all used up; the body starts to use protein stores explaining why starving people have reduced muscle mass as protein is used to form and maintain muscles.  Looking at food labels, learners record the nutritional information in a table with the headings: carbohydrate (in g per 100g), fat (in g per 100 g) and energy (in kJ per 100 g).  They could present this information as a bar chart to compare the amount of carbohydrate, fat and energy per 100 g of different foods.  They write a conclusion to show which foods are highest in either carbohydrate, fat or energy; they draw a conclusion on whether they would obtain more energy from fats or carbohydrates.  **Resources:** Food labels |
| **8Bs.01** Identify ball-and-socket and hinge joints, and explain how antagonistic muscles move the bones at a hinge joint. | **8TWSm.02** Use an existing analogy for a purpose. | **Building models of joints**  Introduce the idea that animals use energy gained from food for life processes (e.g. movement, growth, repair).  *What parts of the body require energy in order to move?*  Clarify it is the muscles that move. If learners state that the skeleton requires energy to move, discuss how movement requires activating muscles which move bones about a joint. Learners can feel this by moving their hand (or arm) and feeling how their muscles move.  Learners build physical models of a hinge joint and a ball-and-socket joint using cardboard strips, split pin paper fasteners, elastic bands, cups, rulers.  *How do these models represent our actual joints?*  *What do you notice about how the muscles move when the joint moves?*  *How do the different joints differ?*  Discuss how humans, seeing biological phenomena (e.g. the ball-and-socket joint, the hinge joint), have often been inspired to invent new technologies (e.g. a ball-and-socket joint has been used in cars and the pneumatic ladders of a fire engine). Discuss how these examples can be treated as analogies to help us visualise what is happening in our body.  **Resources:** Cardboard strips, split pin paper fasteners, elastic bands, cups, rulers |
| **8Bp.03** Discuss how human growth, development and health can be affected by lifestyle, including diet and smoking. | **8TWSp.02** Describe how scientific hypotheses can be supported or contradicted by evidence from an enquiry.  **8TWSa.03** Make conclusions by interpreting results and explain the limitations of the conclusions.  **8TWSc.06** Evaluate a range of secondary information sources for their relevance and know that some sources may be biased. | **Lifestyle and human health**  Explain that a machine can be used as an analogy for the human body. A machine runs smoothly when it is looked after well; a poorly-maintained machine can get damaged or stop working.  *Is this a good analogy?*  Highlight to learners that our lifestyle and behaviour affect how our bodies work and how long they will last.  Present learners with a range of hypotheses, appropriate for their specific needs and context, such as:   * Smoking causes lung cancer. * Vaping has no long-term health risk. * An inappropriate diet leads to nutritional diseases including stunting. * Humans only need a minimum of 6 hours sleep to be able to concentrate during the day * Use of phones at night causes no disruption to memory. * One hour of walking a day (in total) is enough for your body to remain healthy.   Learners, working in groups, choose a hypothesis (or create their own) and use secondary information sources to find evidence that supports or refutes it. Remind them, if needed, that one type of enquiry is ‘researching using secondary sources of information’ and science is collaborative). Learners could be asked to prepare a poster to summarise their findings (including relevant data) and write a conclusion.  Learners will need to identify key questions to research in relation to their hypothesis. They may require support:  *What questions do you need to ask?*  *Do you have enough background information to start?*  During the research discuss with learners if any of their sources may be biased. Ask learners to review the sources of information used to evaluate if they are biased. If they are then learners need to decide whether to discount the source, include it or find additional evidence. Discuss how using one source which is biased is not appropriate as they could have just found the one piece of evidence on that position.  When the learners have completed their research:  *What does your research tell you?*  *What conclusion can you make?*  *Was the starting hypothesis correct based on the evidence you have found?*  *Are there any weaknesses to your research?*  Learners present their posters to each other, this mimics scientific conferences where scientists often present posters about their finding including literature reviews.  **Resources:** Secondary information sources |
| **8Bs.02** Describe the components of blood and their functions (limited to red blood cells transporting oxygen, white blood cells protecting against pathogens and plasma transporting blood cells, nutrients and carbon dioxide). | **8TWSc.01** Sort, group and classify phenomena, objects, materials and organisms through testing, observation, using secondary information, and making and using keys. | **The components of blood and their functions**  Discuss the important role that blood plays in keeping organism healthy. Show learners images taken of blood under a microscope and discuss the components of blood; support the learners in identifying red blood cells, white blood cells and plasma.  *What does each component look like?*  *What is the function of each component?*  Run through the function of each component with the learners, linking the shape (and nature) of each component to its function:   * Red blood cells transport oxygen. * White blood cells, as part of the immune system, protect against pathogens. * Plasma transport blood cells, nutrients and carbon dioxide.   Ask learners to imagine they are teaching younger children about the different components in blood.  *Can you construct a key to help them identify the different component?*  Learners use what they know about the components of blood to make two keys: one to identify the component based on its structure and one to identify them based on their function.  Note: Do not bring blood samples into school as they can pose a health and safety risk to yourself and learners.  **Resources:** Images of blood |
| **8Be.02** Describe the impact of the bioaccumulation of toxic substances on an ecosystem. | **8TWSm.02** Use an existing analogy for a purpose. | **Bioaccumulation in a food web**  Present a food web to learners.  *What would happen if a pesticide was used to kill insects at the lower levels of the food web by coating plants?*  Learners may discuss the impact on the population of other organisms in the food web. Draw their attention to other animals which eat the plants but do not die or animals which will eat the dead insects.  Highlight how both the plant and the dead insects are now coated with / contain the pesticide. The pesticide enters a larger organism which consumes the plant/dead insects; however, the level of the pesticide may not harm the larger organism.  *How many insects would a bird eat?*  Discuss how a consumer may eat a large quantity of contaminated food. This means the toxic substance builds up in the consumer. This is the process called ‘bioaccumulation’.  Demonstrate this process by learners playing different roles within a food chain: where there is a single producer (i.e. a crop), many insects, some birds and a single apex predator (e.g. a fox, an eagle). Give the ‘plant’ learner counters (there should be enough for one counter per ‘insect’ learner), this step represents spraying the plant crop with pesticide. ‘Insect’ learners, as they eat the plant, are each given a single counter from the ‘plant’ learner. ‘Bird’ learners, as they eat several insects, are given their counters ; they each end up with multiple counters. The ‘apex predator’ learner then eats all the birds; ending up with all the counters.  The idea of bioaccumulation can be demonstrated using a pyramid of numbers where the width of each bar represents the number of animals; the bar representation, as in the example below, acts as an representation for the size of the populations. The analogy for this model is it is like a pyramid.  Ask learners to put 20 red dots in each box to represent the amount of pesticide present. Assume that all of the pesticide that is in the earthworms is eaten by the small bird. This shows diagrammatically how the pesticide becomes more concentrated and potentially damaging over time.  Discuss what could happen to the apex predator if they consume too much of the original toxic substance and their body cannot remove it – the animal gets ill and/or dies.  *What impact would removing the apex predator have on a food chain/web?*  *What impact do toxic substances have on the wider ecosystem when bioaccumulation happens?*  **Resources:** Counters |

# Unit 8.7 Speed, motion and forces

| Unit 8.7 Speed, motion and forces |
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| Outline of unit: |
| This unit builds on learners’ understanding about motion and forces. Learners will learn how to quantify and calculate speed using the formula speed = distance / time. They will also look at interpreting distance / time graphs.  Learners will consider the effect of balanced and unbalanced forces on motion (including changes in direction and speed). Then, their understanding of forces will be applied to turning forces and the calculation of moment.  Throughout this unit learners will have opportunities to handle, manipulate and interpret data. |
| Recommended prior knowledge or previous learning required for the unit: |
| Learners will benefit from previous experience of:   * measuring forces with a forcemeter * knowing that gravity on Earth is a force that pulls towards the centre of the Earth * explaining that friction is a force created between surfaces when they move against each other and it makes this movement harder * explaining that air particles cause resistance which opposes the movement of an object and that in a vacuum there is no air resistance * using force diagrams to show the name, size and direction of forces acting on an object * knowing that there are different types of force (including gravity, upthrust, friction, air resistance and water resistance) * explaining that an object may have multiple forces acting upon it, even when at rest. |
| Suggested examples for teaching Science in Context: |
| ***8SIC.02*** *Describe how science is applied across societies and industries, and in research.*  Scientists understand that increasing the distance from an applied force to the pivot will gain increased moment; this understanding of turning forces is applied in the design of many items. Learners could identify examples where turning forces are used in their lives and in product design. |

| Learning objective | Key vocabulary | Possible models and representations | Possible misconceptions |
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| **8Pf.01** Calculate speed (speed = distance / time). | Speed, distance, time, per, metres, kilometres, average speed | Learners could watch a slow-motion video of a running race where the distance travelled, time elapsed and speed is displayed in the style of a car dashboard. This might help learners to make the connection between the formula and the scenario of a running race. | Learners might not appreciate that the average speed over a whole journey can be calculated and this will account for periods of rest (meaning bursts of high speeds with long rests may result in a much lower average speed). This can be discussed with the learners and average speed can be calculated. |
| **8Pf.02** Interpret and draw simple distance / time graphs. | Speed, distance, time, gradient, slope, average speed, stationary | A distance / time graphs is a representation of the relationship between speed, distance and time. | Learners sometimes confuse a speed / time graph with a distance / time graph. It is important to be clear which is being studied.  Learners may think that the sloping line on a distance / time graph represents a hill. It is helpful for learners to create some data and draw their own graph before they start interpreting other graphs. |
| **8Pf.03** Describe the effects of balanced and unbalanced forces on motion. | Balanced, unbalanced, motion, force, normal reaction force, opposite, equilibrium, right angle, negligible | Learners can produce force diagrams based on their understanding of balanced and unbalanced forces. The magnitude and the direction of the force are indicated by the length and direction of the arrow, respectively. It may be helpful to always use the same colour (or formatting) of the force arrows to clearly distinguish them from arrows indicating movement. | Learners often only associate forces with movement and that a force is required to keep things moving. They may think that the arrow that represents the force is describing the direction of motion. It is important to demonstrate that forces may be applied to an object but it will not start to move if the forces are balanced.  Learners may think that the movement must be in the same direction as the force. Provide examples where this is not the case (e.g. throwing a ball across the room; identifying the force due to gravity acting downwards).  Learners may think that an object slows down because it runs out of force. Help learners to understand that unbalanced forces cause an object to slow down; show them examples where friction (or air resistance) has been largely eliminated. |
| **8Pf.04** Identify and calculate turning forces (moment = force x distance). | Moment, turning force, pivot | Learners can use a diagram to show which distance is measured (i.e. from the point where the force is applied to the pivot) to enter into the formula (moment = force x distance). The formula is a representation of the relationship between moment, force and distance. | Learners can find the term ‘moment’ confusing. Clarify the scientific definition of the term and provide opportunities for learners to use the term correctly. |

# Unit 8.7 Suggested activities

| Learning objective | Thinking and Working Scientifically opportunities | Suggested teaching activities and resources |
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| **8Pf.01** Calculate speed (speed = distance / time). | **8TWSm.03** Use symbols and formulae to represent scientific ideas. | **Calculating speed**  Explore learners’ ideas of what speed means in terms of distance and time. Ask learners to complete the sentence: “At the \_\_\_\_\_\_ speed you travel the longest \_\_\_\_\_ in the shortest \_\_\_\_\_”.  Ask learners to list the different units that can be used for measuring: distance (i.e., cm, m, km, mile); time (s, min, h, d) and speed (mph, km/h, m/s).  Discuss the language that is commonly used for some mathematical concepts to help learners to interpret questions expressed in words. Explain that we use the word ‘per’ to mean ‘for each’ and, mathematically, this translates to ‘divide by’. For example, 50 km/h is 50 kilometres per hour or 50 kilometres travelled each hour.  Begin calculations with simple whole numbers which can be visualised relatively easily. For example:  *If we travelled 10 km in 2 hours, how far would we travel in one hour?*  Elicit the answer 5 km in one hour.  *So what is our speed?*  Elicit the answer 5 km/h.  *If we travel 10 km in 1 hour, what is our speed?*  Elicit the answer 10 km/h.  Allow learners to practice calculating speeds (in mph, km/h, m/s) using different values for distance and time. They create scenarios, with questions, for their peers to answer; these involve calculations of speed (from a given distance and time); distance (from a given speed and time) or time (from a given distance and speed).  This activity could be extended by using calculations involving decimal places where the use of a calculator would be required.  **Resources:** None |
| **8Pf.02** Interpret and draw simple distance / time graphs. | **8TWSa.03** Make conclusions by interpreting results and explain the limitations of the conclusions.  NOTE: The limitations of the conclusions is not covered | **Interpreting distance / time graphs**  Describe a short journey. For example, I walked 5 m in 10 seconds, stopped for 10 seconds then walked 5 m in 5 seconds. Ask learners to sketch a distance / time graph to represent the journey; it may be necessary to show learners how this is done. Then, they create their own journeys, writing descriptive sentences and sketching a distance / time graph.  Learners create a distance / time graph and ask detailed questions about each part of the graph, e.g.:  *How far do they walk altogether?*  *How long does it take them to walk 10 m?*  *What is their speed over this distance?*  *What conclusions can we make from this data?*  Learners annotate the graph with the calculations.  Prepare a distance / time graph which shows: steady slow speed, steady faster speed, stationary, getting faster, getting slower.  *How do you know which part of the graph represents the fastest speed?*  Elicit the idea that the speed is reflected by the steepness of the slope (i.e. the gradient).  *What is the connection between the slope and the speed?*  *What conclusions can we make about the speed indicated in the graph?*  Learners prepare a distance / time graph that describes their journey to school and write some questions about their graph. Then, learners swap their work, they interpret a different graph and answer the questions.  **Resources:** Prepared distance / time graphs |
| **8Pf.03** Describe the effects of balanced and unbalanced forces on motion. | **8TWSp.03** Make predictions of likely outcomes for a scientific enquiry based on scientific knowledge and understanding.  **8TWSc.02** Decide what equipment is required to carry out an investigation or experiment and use it appropriately.  **8TWSc.04** Take appropriately accurate and precise measurements, explaining why accuracy and precision are important.  **8TWSa.04** Evaluate experiments and investigations, and suggest improvements, explaining any proposed changes.  **8TWSa.01** Describe the accuracy of predictions, based on results, and suggest why they were or were not accurate. | **Effects of forces on motion**  Learners will consider the four scenarios where forces are applied to a ball. Provide learners with cardboard cut-out force arrows (of varying lengths) that they can use to represent the magnitude and direction of the force; be clear that the arrows do not represent an actual motion. For each scenario, ask learners to show what forces (if any) are acting on a specific object at the start and then, choosing a point in time when the ball is moving, they add force arrows to the diagram. They describe, in words, what will happen to the speed of the ball and draw a distance / time graph.  (1) Hold a ball (e.g. tennis ball, baseball ball) at head height, with the hands at the bottoms of the ball so it is on the palms of the hands. .  *What forces are acting upon the ball?*  Elicit the answer that the force of gravity is pulling the ball downwards whilst the normal reaction force from the hand is pushing upwards with an equal and opposite force; this is why the ball doesn’t move. Explain that the term ‘normal reaction force’ is a force that acts at right angles to the surface that the object is resting on.  (2) Let go of a ball held at head height.  *What forces are now acting on the ball?*  *Is the downwards force due to gravity still there?* [yes]  *Is the upwards force (i.e. the normal reaction force) still there?* [no]  Elicit the idea that the forces are now unbalanced which explains why the ball starts to move.  (3) Roll the ball on a piece of carpet.  Roll the ball, to start it moving, and leave it to continue moving without applying any further force. The piece of carpet should be long enough for the ball to travel several metres.  (4) Roll the ball on a polished surface.  (5) Show videos of situations where friction is negligible.  The videos should show an object (e.g. ice skater, hovercraft) being pushed by a contact force to start it moving. The learners watch how the speed changes with time.  Ask learners to compare scenarios (3), (4) and (5). Having identified the forces from the force diagram, they explain the differences in speed.  Reinforce these ‘thought experiments’ by getting learners to carry out practical work in pairs. They will:   * drop a ball from head height * roll a ball along a carpet and a polished surface.   Ask learners to predict how the speed will change by sketching graphs for these scenarios.  Learners plan an experiment to test the predictions. They choose the appropriate equipment: the simplest method is a measuring tape and stopwatch. Alternatively, light-activated sensors could be used to start and stop a timer as a ball passes by. Show learners a video (or photograph) to show how an experiment using sensors would be performed.  Learners complete the practical work, recording measurements in an appropriate table, and present them in a graph.  Ask learners to consider whether the measurements were sufficiently precise and accurate; they suggest improvements that might be made to the method (or equipment) that would improve the quality of the data.  Learners compare their results with their predictions; they explain whether the prediction was accurate or not. If the prediction was not accurate, they suggest why. They share their findings with other learners and discuss the benefits of collaboration in analysing scientific enquiry.  **Resources:** Cardboard force arrows, balls, pieces of carpet, a smooth floor surface, videos of scenarios where friction is negligible, stopwatches, measuring tapes |
| **8Pf.04** Identify and calculate turning forces (moment = force x distance). | **8TWSm.03** Use symbols and formulae to represent scientific ideas | **Calculating moments**  Prepare a series of activities that involve turning forces (e.g. a door opening, a door handle turning, a spanner) and some pictures of turning force scenarios (e.g. a wheelbarrow, a tap) showing a scale bar. This could be arranged as a carousel activity with learners working in pairs. For each example, they add a force arrow to show where the force is being applied.  Ask learners to identify the pivot in each example. Using a ruler (and a scale, if appropriate) they measure the distance from the pivot to the force arrow. They calculate the moment using the formula: moment = force x distance.  Ensure that learners use the correct units (i.e. distance in metres, forces in Newtons (N) and moment is Nm) and they present them with the numerical answer.  *What is the moment in each example?*  *What does the moment represent?*  **Resources:** A spanner, pictures of turning force scenarios |

# Unit 8.8 Earth and the Solar System

| Unit 8.8 Earth and the Solar System |
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| Outline of unit: |
| In this unit, learners will continue their studies of the Earth. They will learn that the Earth has a magnetic field, generated by the planet’s core that protects us from ionising radiation; this will be supported by carrying out experiments and observations of magnetic fields.  Learners will then consider the ecosystems on Earth and the effect invasive species can have to that ecosystem. This then moves to considering Earth’s atmosphere and the evidence that the Earth's climate exists in a cycle between warm periods and ice ages. Learners will consider the impact of atmospheric change on the Earth's climate and the differences between climate and weather.  The unit ends the wider Solar System and how the Earth is one planet amongst others in the Solar System. They will also learn that asteroids are smaller than planets and are formed from rocks left over from the formation a planetary system and then go beyond our system to consider the components of a galaxy.  Through this unit, learners will appreciate that Earth is a closed system with multiple interconnecting phenomenon and Earth exists as one planet in the Solar System, which is itself one planetary system of many. |
| Recommended prior knowledge or previous learning required for the unit: |
| Learners will benefit from previous experience of:   * explaining that planets are formed when gravity pulled together dust and gas; gravity is a force of attraction between any two objects, the size of the force being related to the masses of the objects * knowing the characteristics of planets, moons, asteroids, stars and planetary systems * knowing that the atmosphere is made largely of nitrogen and oxygen with small amounts of other gases (e.g. carbon dioxide, water vapour, argon) * knowing that a navigating compass points towards the North Pole * distinguishing between a magnet and a magnetic material * explaining that forces act over a distance between magnets, and between a magnet and a magnetic material, and the poles of a magnet can repel or attract at a distance * knowing that magnets have a north pole and a south pole and can have different magnetic strengths. |
| Suggested examples for teaching Science in Context: |
| ***8SIC.02*** *Describe how science is applied across societies and industries, and in research.*  The magnetic compass has been used since ancient times for navigation; it is dependent on the magnetic field of the Earth. Learners could research the development of the navigation compass to understand how this vital invention helped, and continues to help, humans traverse the Earth.  ***8SIC.04*** *Describe how people develop and use scientific understanding as individuals and through collaboration, e.g. through peer-review.*  The composition of the atmosphere has changed over the last 4.5 billion years. Learners could explore, present and evaluate the evidence scientists have gathered for this change. They could discuss the important role that peer-review plays in examining conflicting evidence and/or the strength of evidence that has been gathered by scientists. |

| Learning objective | Key vocabulary | Possible models and representations | Possible misconceptions |
| --- | --- | --- | --- |
| **8Pe.01** Describe a magnetic field, and understand that it surrounds a magnet and exerts a force on other magnetic fields. | Magnetic field, magnet, magnetic, iron, north pole, south pole, attraction, repulsion, repel, repulsive force, attractive force, north-seeking pole, south-seeking pole | Learners can draw field lines around a magnet, adding arrows to indicate the direction. Learners can then add labels to show where the field is stronger (i.e. the lines are closer together) and the north-seeking pole and south-seeking pole. | Learners may think that all magnets are made of iron and that the strength of a magnet is based on its physical size. Allow learners to explore a range of different sizes and types of magnets so they connect the strength of a magnet to its magnetic field rather than its physical form.  Learners may confuse magnets and magnetic materials. Clearly explain that a magnet produces a magnetic field and a magnetic material is something which experiences a force in a magnetic field.  Learners may believe magnetic fields are two dimensional as they are often drawn and demonstrated in this way. Give learners the opportunity to experience the three dimensional field of a magnet for themselves. For example, hang a magnet on a string off a clamp stand; they feel the pull on a magnetic material in multiple locations in the space around. |
| **8ESp.01** Know that the reason the Earth has a magnetic field is that the core acts as a magnet. | Magnetic field, magnet, magnetic, iron, North pole, South pole, compass | Learners can draw a diagram of the Earth with magnetic field lines going between North and South poles.  A physical model of the magnetic field (using a globe and pipe cleaners) can be used to show learners that the magnetic field is three dimensional field. (Note: This is a challenging model to make, and therefore not so suitable for learners to create themselves). | Learners may think the Earth has a giant magnet inside rather than the magnetic field being generated by electric currents in the Earth’s core.  Explain to learners that the Earth’s core acts as a magnet even if it is not physically like the magnets we have.  The link between electricity and magnetism will be addressed in later stages.  There is often confusion between the geographic North pole (which is typically written with a capital N) and the north pole of a magnet. Clear use of language can be helpful here: ‘north-seeking pole’ and ‘south-seeking pole’ can refer to the poles of a magnet. If learners use the term ‘north’ for compass direction then the pole itself is the south magnetic pole. |
| **8Be.01** Identify different ecosystems on the Earth, recognising the variety of habitats that exist within an ecosystem. | Ecosystem, habitat, desert, ocean, aquatic, rainforest, organisms, marine, freshwater, savannah, tundra | A diagram can be used to represent an ecosystem; the different components are represented by boxes and arrows are used to show how the components are interlinked. | Learners may not appreciate that ecosystems are dynamic and change as a result of both natural and human-influenced processes and it may be necessary to make this clear.  Learners may give plants and animals human characteristics (i.e. anthropomorphise) and assume that all plants and animals coexist ‘happily’. Use language carefully. |
| **8Be.03** Describe how a new and/or invasive species can affect other organisms and an ecosystem. | Ecosystem, invasive, invasion, species, organism | Learners can create a food web and include numbers to show the number of organisms within a system which is stable. They consider the impact of introducing a new organism on the numbers of the other organisms within the system (e.g. a new organism eats a plant so the number of plants decreases, the numbers of other animals which also eat that plant also decreases). | Learners may think that an invasive species actively kills (or poisons) other species but this is not common. In most cases, the invasive species competes more successfully than the native species for food sources (i.e. nutrients), light or space. Look at how some invasive species have gradually become an integrated part of a local ecosystem. |
| **8ESc.03** Describe the difference between climate and weather. | Climate, weather, extreme weather event, barometer | Learners can make their own analogies to show their understanding. For example, ‘The weather is like… while the climate is like….’ | Learners may think that an extreme weather event means a change in climate. Clearly explain the different meaning of these terms. |
| **8ESc.02** Understand that the Earth's climate can change due to atmospheric change. | Atmosphere, atmospheric, climate, gases, oxygen, nitrogen, carbon dioxide, radiative, greenhouse effect, precipitation | Learners can draw diagrams to illustrate the role atmospheric composition has in the phenomenon of radiative warming. For example, showing that increases in some gases can result in more radiative warming. | Learners may think that the Earth’s climate is only changed by the amount of carbon dioxide. Introduce learners to a range of gases which can enter the atmosphere, naturally or through human activity, and can affect the climate. |
| **8ESc.01** Understand that there is evidence that the Earth's climate exists in a cycle between warm periods and ice ages, and the cycle takes place over long time periods. | Climate, ice age, period, cycle | Learners can use a large outdoor space to show the changes in temperature over the long time periods. | Learners may struggle to interpret the data in temperature / time graphs. Support them as they label the time axis and examine the data carefully. Learners may also think that ice ages were a long time ago. Data, and referencing reputable external sources, can clarify to learners that we are, by scientific definitions, in an ice age and ice ages are marked by multiple shorter-term periods of warmer temperature and colder temperature. |
| **8ESs.02** Describe asteroids as rocks, smaller than planets, and describe their formation from rocks left over from the formation of a planetary system. | Asteroids, planets, planetary system | Learners could make relative sizes of asteroids and planets could be modelled by making scale models from modelling clay and model their formation using these scale models. | Learners may think that asteroids are the remnants of a planet. Explain that asteroids fill a place in a planetary system where a planet was prevented from forming by the gravitational force of a larger planet (probably Jupiter within our Solar System). |
| **8ESs.01** Describe a galaxy in terms of stellar dust and gas, stars and planetary systems. | Planetary system, planet, asteroid, galaxy, universe, stellar | A concept map could be used to link the terms: galaxy, stars, planetary systems, planets and asteroids. Learners could make a physical model of part of a galaxy showing many stars and some planetary systems associated with stars. | Learners may think that galaxies only contain stars and are far, far away. Explain that the Sun is a star, and that our own Solar System is part of the Milky Way galaxy. |

# Unit 8.8 Suggested activities

| Learning objective | Thinking and Working Scientifically opportunities | Suggested teaching activities and resources |
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| **8Pe.01** Describe a magnetic field, and understand that it surrounds a magnet and exerts a force on other magnetic fields. | **8TWSc.01** Sort, group and classify phenomena, objects, materials and organisms through testing, observation, using secondary information, and making and using keys. | **Magnets and magnetic fields**  Demonstrate to learners how to suspend a magnet so that it can move freely (or show them a pre-prepared version). This could be done using a cotton (or wool) loop attached to the bar magnet at one end and to a wooden rod (or stand) at the other end.  *What will happen when another bar magnet is brought near to the suspended magnet?*  Provide learners with the necessary resources so they can set up their own version. They record what happens when they change the distance between the magnets and the orientation of the magnet (relative to the suspended magnet).  Show learners some materials (e.g. cardboard, wood, aluminium, cloth, plastic).  *Do you think that putting a material in front of the suspended magnet will stop the effect?*  Learners investigate the materials to see if they ‘block’ what is happening. Introduce learners to the concept of magnets have a ‘magnetic field’ (i.e. an invisible region where magnetic forces can act between magnets or between magnets and magnetic materials).  Give learners the opportunity to visualise the magnetic field around the whole magnet by exploring the effect of a magnet on iron filings. They evenly spread ‘iron filings in a bag’ on some card, they use iron filings with a small amount of water in sealed, clear, plastic bags to allow the filings to move but avoid spillages. If learners are handling loose iron filings, they should use eye protection.  They bring two bar magnets under the card and tap them gently to see the iron filings move into lines. Ask learners to sketch the pattern of the iron filings when the magnets are present. Then ask the learners to change the orientation of one of the magnets by 180° and make another drawing.  *What differences do you observe between your two drawings*?  *What effect has changing the orientation of the magnets had on the magnetic field?*  Elicit the answer that one drawing will show the fields repelling and the other will show the fields attracting.  Explain to learners that iron filings, while useful to show a magnetic field, do not show the whole field as a magnetic field is three dimensional. Remind learners that the suspended magnet was influenced in multiple directions; if appropriate, demonstrate it again.  **Resources:** Iron filings in a bag, bar magnets, a range of materials to be tested |
| **8ESp.01** Know that the reason the Earth has a magnetic field is that the core acts as a magnet. | **8TWSm.02** Use an existing analogy for a purpose. | **Earth’s magnetic field**  In an open space, learners stand a few metres apart. Provide each learner with a compass; they point them in the direction of north as shown on their compass.  *What is happening with the compass?*  *Why is that happening?*  *What are the compasses responding to?*  Learners could move to a different location (or turn so they are facing in a different direction) and repeat the activity. Their compasses should still point in the same direction.  Alternatively, learners can make their own compasses by rubbing a thin, iron nail; piercing it through a cork and then placing the cork in a small bowl of water so the nail can rotate freely.  In class, discuss how the compass is made of a magnet which is responding to the magnetic field generated by the Earth. Show learners an image of the Earth.  *Where does the magnetic field come from?*  Present learners with a fruit which has a stone in the centre (e.g. a plum) and introduce the analogy that the Earth is like the fruit. Cut it in half (around the stone) and explain the analogy: the skin of the fruit represents the crust, the flesh represents the mantle and the stone represents the core of the Earth. Explain how the Earth’s core is still being studied but we do not think it is solid; it is more like a liquid however we believe it is mostly composed of iron. This means the core of the Earth produces the magnetic field our compasses respond to.  Learners, using wire and a fruit with a stone, make a three-dimensional model to represent the Earth and its magnetic field.  **Resources:** Magnetic compasses, an image of the Earth, a fruit which contains a stone, wire |
| **8Be.01** Identify different ecosystems on the Earth, recognising the variety of habitats that exist within an ecosystem. | **8TWSc.01** Sort, group and classify phenomena, objects, materials and organisms through testing, observation, using secondary information, and making and using keys. | **Ecosystems**  Show learners an image (or globe) of the Earth. Discuss how there are many ecosystems on Earth.  *What is an ecosystem?*  *What is the difference between and ecosystem and a habitat?*  Explain that an ecosystem is broader than a habitat (i.e. several habitats can make up an ecosystem); the types of ecosystems are aligned to habitats. Introduce the term ‘marine ecosystem’.  *What habitats are within this ecosystem?*  Explain that there are open ocean, reefs, coastal waters and deep sea trenches.  A healthy ecosystem has stable populations of organisms in a stable environment. A change in either/both of the two components of the ecosystem (i.e. the living organisms, the physical environment) will disrupt the ecosystem.  Learners, using secondary information sources, research an ecosystem (e.g. tundra, desert, tide pools, tropical rainforest); they describe the living and non-living parts of the ecosystem. They choose an organism, living within the ecosystem, exploring its specific habitat; they present their findings to the class. Working together, the class develops a key which could be used to differentiate between an ecosystem and a habitat.  **Resources:** Images of ecosystems, secondary information sources |
| **8Be.03** Describe how a new and/or invasive species can affect other organisms and an ecosystem. | **8TWSa.05** Present and interpret observations and measurements appropriately. | **The effects of invasive species on the health of an ecosystem**  Show learners a picture of a pond with an invasive weed covering the surface; present the following sequence of events:   * The invasive weed covers the surface of the pond. * Plants underneath this invasive weed don’t get any light. * Plants underneath die and sink to the bottom of the pond. * Microorganisms at the bottom of the pond feed on the dead plants; as they carry out respiration they use up oxygen.   *What effect will this have on the fish in the pond?*  Elicit the answer that they will die because there is too little oxygen in the water to keep the fish alive.  Provide learners with a template for a flowchart poster; this is a useful way of representing cause and effect. Ask learners to create a poster to explain the sequence of events when an invasive weed affects a pond.  Learners then identify the cause and effect of a new species entering other similar ecosystems (e.g. cane toads in northern Australia, the Nile perch in Lake Victoria, East Africa, African bees in Brazil). A similar activity could centre on or an example of an invasive species relevant to your context. Use questions to prompt learners to create their flow chart, such as:  *Why were cane toads introduced to northern Australia from South America?*  *What do the cane toads prey upon in South America and in northern Australia?*  *What predators exist for them in South America and in northern Australia?*  *Based on your observations, why are cane toads considered to be an invasive species?*  For each example, discuss how the introduction of a new species does disrupt an ecosystem but it is rare for it cause an ecosystem to collapse completely. A new species can cause an existing species to die if it is better suited to the ecosystem and outcompetes the existing species for resources.  Discuss an example where humans have introduced a new species to an ecosystem without knowing it (e.g. rats in New Zealand/Mauritius), draw out the point that humans can be responsible for the introduction of a new species to an ecosystem by accident as well as on purpose.  **Resources:** Picture of a pond, Flowchart template |
| **8ESc.03** Describe the difference between climate and weather. | **8TWSa.02** Describe trends and patterns in results, including identifying any anomalous results.  **8TWSc.03** Evaluate whether measurements and observations have been repeated sufficiently to be reliable.  **8TWSa.03** Make conclusions by interpreting results and explain the limitations of the conclusions. | **Climate and weather**  Discuss with learners the weather in their local context:  *What is the weather is today? What is it likely to be tomorrow? What was the weather was like last week?*  Then ask learners:  *What is the climate here?*  Learners may provide similar answers to when they were discussing the recent weather.  Explain that there is a difference between climate and weather. The term ‘weather’ describes the conditions (e.g. raining, snowy, hot and sunny) at a specific time or for a short time. The term ‘climate’ describes long-term weather patterns (i.e. over 30 years).  Check understanding by asking learners to indicate which of these statements are about climate and which are about weather:   * It is raining today. * This month has been quite hot. * There has not been any snow for the last three winters. * The average snowfall for January during the last century is 10 cm. * We live in an arid country (change ‘arid’ to a suitable climate for your context, e.g. tropical, temperature, polar).   Learners then build a weather station to make measurements of their local weather, such as:   * They measure the maximum and minimum temperature each day. * They make a rain gauge (by placing a funnel over a measuring cylinder). * They set up a wind vane to determine wind direction. (This can be made from a cardboard arrow, glued to a hollow cylinder, and placed on a stick/rod so that it can move freely in the wind to show wind direction) * They make a device to measure wind speed. (Learners suspend a flat plate, made from card; they direct it so that it is facing the wind. The angle of the tilt of the plate can be measured to reflect wind speed.) * They record air pressure (if a barometer is available).   Learners take measurements for at least one week (but ideally, several weeks). They plot the data on a graph to help them identify the trends. Discuss with learners how many measurements they should take at one time to ensure their data is reliable.  *How reliable is your data?*  *Does your data agree with that of your peers?*  *What patterns do you notice about the weather?*  *How much variability is there in the weather?*  Learners use secondary information sources to look for longer-term weather statistics for their region. They write a description of their local climate including information about the rainfall, average maximum (and minimum) temperatures and humidity for each month of the year.  *What do you notice about your data?*  *What climate does the data indicate?*  *Are there any limitations to the data?*  Ask learners to describe the annual trends in temperature and rainfall; they decide whether their own data fits with this trend.  Learners can then compare the two sets of weather and climate data. They discuss how variability in the weather (over several weeks) is not an indication of a climate; weather data should be collected over a long period of time to correctly identify the climate.  *Are your weather records consistent with the climate you’ve identified?*  **Resources:** Thermometers, funnels, measuring cylinders, card, stands, secondary information sources |
| **8ESc.02** Understand that the Earth's climate can change due to atmospheric change. | **8TWSa.02** Describe trends and patterns in results, including identifying any anomalous results.  **8TWSa.03** Make conclusions by interpreting results and explain the limitations of the conclusions. | **Does atmospheric change result in a climate change?**  Show learners recent videos, headlines and articles about the changing climate. Discuss how many of these claims are linked to a changing atmospheric composition.  *What is our atmosphere made of?*  Highlight, using a pie chart, the approximate composition of the Earth’s atmosphere (i.e. 78% nitrogen, 21% oxygen, 0.93% argon and small amounts of other gases, e.g. carbon dioxide, water vapour.)  Show learners a diagram of the ‘greenhouse effect’ and explain the impact that ‘greenhouse gases’ (e.g. carbon dioxide, methane, water vapour, nitrous oxide) have on the Earth’s atmosphere, i.e. as more of these gases enter the atmosphere, global temperatures rise which results in climate change.  *Does atmospheric change result in a climate change?*  Tell learners that we can look at evidence to help answer this question for example we can look at the impact of humans on the environment.  Show learners data on the levels of greenhouse gases (usually in parts per millions) over time (at least the last 50 years). This should be presented in a graph. Ensure you collect your data from a reputable source.  Show learners graphical data, for the same time period as the greenhouse gases data, of:   * average global air temperature * humidity levels * cloud cover * wind speed * precipitation * frequency of extreme weather events.   Discuss with learners that the occurrence of one extreme weather event is not evidence of climate change (because extreme weather events can happen at any time) but the frequency of extreme weather events is useful data.  Learners compare the data they have to identify if there are any trends, patterns or anomalous results.  *What trends/patterns do you notice?*  *Is there a link between the levels of greenhouse gases, the composition of the atmosphere, and climate?*  Ensure learners understand that although there has been an increase in both the levels of greenhouse gases and the Earth’s atmospheric temperature, this does not automatically mean one causes the other; there may be other factors to take into account.  **Resources:** Data on atmospheric composition over time, data on climate over time, diagram of the ‘greenhouse effect’ |
| **8ESc.01** Understand that there is evidence that the Earth's climate exists in a cycle between warm periods and ice ages, and the cycle takes place over long time periods. | **8TWSc.06** Evaluate a range of secondary information sources for their relevance and know that some sources may be biased.  **8TWSa.02** Describe trends and patterns in results, including identifying any anomalous results.  **8TWSa.03** Make conclusions by interpreting results and explain the limitations of the conclusions. | **History of the Earth’s climate**  Show learners images of two climates (i.e. the Artic, forest); they discuss the differences between them. Explain how the Artic has not always been the polar climate that it is now; scientists have collected samples of the Earth’s core that show it was once a tropical climate.  *If the artic was once tropical and is now polar, will it be tropical again in the future?*  *What evidence do we need to make that prediction?*  Discuss how we need to look at data over a long period of time to understand if there is a cycle to the Earth’s natural climate.  Provide learners with long-term climate data, and enable them to carry out their own research (using secondary information sources) to identify trends and discuss if there is a cycle or not.  Highlight to learners that some secondary information sources on this topic may be biased.  *Why may some information sources be biased?*  *What do you need to do to check the data?*  Encourage learners to find multiple sources which support the same point (or separate sets of data that align). Focus the learners on the data which, unlike the interpretation of the data, which will not include conjecture and bias.  Once learners have collected sufficient evidence they feel confident in, they make a conclusion.  *What does your data tell you?*  *What limitations are there to the data?*  **Resources:** Secondary information sources, long-term climate data |
| **8ESs.02** Describe asteroids as rocks, smaller than planets, and describe their formation from rocks left over from the formation of a planetary system. | **8TWSc.01** Sort, group and classify phenomena, objects, materials and organisms through testing, observation, using secondary information, and making and using keys. | **Creating a concept map for a planetary system**  Show learners an image of the Earth.  *What is our location in space?*  *Can you describe our location and any surrounding objects?*  Discuss how we are in orbit around the Sun and we are the third planet from the sun. We have a natural satellite we call the Moon.  If asteroids are not mentioned by learners, introduce them to the ring of asteroids that are found between Mars and Jupiter. Explain that they are often called the asteroid belt.  *What is an asteroid?*  *How are they formed?*  Listen to learners’ theories, discussing the advantages and disadvantages of each one.  Describe the formation of asteroids from the rocks left over from the formation of the Solar System approximately 4.6 billion years ago.  The theory is that during the formation of the Solar System, the large gravitational force of Jupiter prevented any planetary bodies from forming in the gap between Mars and Jupiter. This caused the small objects that were between Mars and Jupiter to collide with each other and fragment into the asteroids seen today. This can be modelled with a role play: one learner represents Mars, another learner represents Jupiter and other learners represent asteroids.    Provide learners with an ‘Asteroids fact sheet’ that summarise some key features and facts of asteroids (e.g. general size range, age, composition, surface area, surface gravity) and ‘Planetary Body information cards’ that describe different, mystery planetary bodies (use codes rather than names, e.g. PB-001 which may relate to Neptune). They sort the planetary bodies into those that are asteroids and those that are not.  Discuss with learners that our theories of asteroid formation also apply to other planetary systems.  **Resources:** Images of Earth and asteroids, ‘Asteroids fact sheet’, ‘Planetary Body information cards’ |
| **8ESs.01** Describe a galaxy in terms of stellar dust and gas, stars and planetary systems. | **8TWSa.05** Present and interpret observations and measurements appropriately. | **Build a model to represent a galaxy**  Show learners, images of the following, in sequence:   * their school * their village/town/city * their country from space * their continent from space * the planet Earth from space * an image of the Solar System (explain we do not have an image due to the scale)   *What comes next?*  *What should the next image be?*  If the learners do not mention the term ‘galaxy’, introduce them to it.  *What is a galaxy?*  *What is included within it?*  Show learners images taken by space telescopes (e.g. Hubble) which show nebulae within galaxies, and a range of different types of galaxies (e.g. spiral, elliptical).  *What can we observe from these images?*  *What do we think a galaxy is?*  Explain how a galaxy is a large cluster of stars, with many stars the centre of its own planetary system. Galaxies also contain stellar dust and gas created when star explode and the remnants of the origin of the universe. Discuss how gravity shapes galaxies in the same way that it shapes planetary systems.  Learners, using images from space telescopes, present their understanding of what a galaxy is in a form of their choosing.  NOTE: You may need to explain to learners that our Solar System is an example of a planetary system and is named the Solar System due to the Latin name of the Sun being Sol, derived from Solis. Solar means ‘relating to the sun’).  **Resources:** Images as described, a range of images from space telescopes |

# Unit 8.9 Applications of science

| Unit 8.9 Applications of science |
| --- |
| Outline of unit: |
| This unit focuses on how we apply some of our scientific knowledge to improve our lives.  Learners start by considering non-renewable resources include fossil fuels which can be used to make materials such as plastic and can be burned for heating and for electricity generation. Learners will consider how burning fossil fuels is a chemical reaction and an example of an exothermic reaction which can be identified by an increase in the temperature of the surroundings. In contrast, an endothermic reaction can be identified by a decrease in the temperature of the surroundings: endothermic reactions are also useful.  Learners will then be taught about how renewable resources are being used to make materials such as bioplastics as well as for electricity generation. Wind power relies upon moving air to turn a turbine whereas tidal power relies upon moving water to turn a turbine: in both cases the turning motion leads to electricity generation.  To finish the unit, learners will look at how we use our understanding of magnets and electricity to make electromagnets which have a variety of applications. |
| Recommended prior knowledge or previous learning required for the unit: |
| Learners will benefit from previous experience of:   * knowing that electricity is a flow of electrons around a circuit * explaining that chemical reactions involve the rearrangement of atoms where reactants interact to form new substances called products * understanding that a magnetic field surrounds a magnet and exerts a force on other magnetic fields. |
| Suggested examples for teaching Science in Context: |
| ***8SIC.02*** *Describe how science is applied across societies and industries, and in research.*  Learners could research the use of electromagnets in a variety of applications (e.g. to lift scrap cars, to sort different types of metal waste, in maglev trains, in an alarm bell).  ***8SIC.03*** *Evaluate issues which involve and/or require scientific understanding.*  Learners could evaluate the use of renewable or non-renewable power sources for electricity generation, identifying the advantages and disadvantages of each; they could present a case for the most suitable method(s) of electricity generation for their region.  ***8SIC.05*** *Discuss how the uses of science can have a global environmental impact.*  Learners can look at the product life cycles of renewable and non-renewable materials to start to understand the environmental impact of each. They can then consider the environmental impact of a product (alongside the cost, desire and practical use) when justifying their purchasing decisions. |

| Learning objective | Key vocabulary | Possible models and representations | Possible misconceptions |
| --- | --- | --- | --- |
| **8ESp.02** Identify renewable resources (including wind, tidal and solar power, and bioplastics) and non-renewable resources (including fossil fuels) and describe how humans use them. | Renewable, non-renewable, fossil fuels, hydrocarbons, petrochemical, petroleum-based, fuels, tides, tidal, bioplastics, biological, starch, cellulose, protein, plastics, power, solar, wind, turbine, generator | Learners can use diagrams of renewable and non-renewable resources and label them with their benefits and issues. | Learners may have difficulty appreciating the timescales required for generation of fossil fuels and while the process is ongoing fossil fuels are effectively non-renewable due to the time scales involved. Learners can create a scaled timeline where each learner represents a key point in the timeline of a fossil fuel over a timeline that is as large as possible e.g. a school field. |
| **8Cc.02** Know that some processes and reactions are endothermic or exothermic, and this can be identified by temperature change. | Endothermic, exothermic, reaction, temperature | Reaction diagrams can be helpful to represent energy changes between the reactants and the surroundings. In a reaction diagram, the temperature is on the vertical axis and the reactants or products are on the horizontal axis. An exothermic reaction produces an increase in the surrounding temperature (i.e. the products have less energy that the reactants). An endothermic reaction causes the surrounding temperature to decrease (i.e. the products have more energy than the reactants). | Learners may be confused about which temperature is changing in a reaction; it is the temperature of the surroundings. In an exothermic reaction energy is transferred to the surroundings and the temperature of the surroundings increases. The opposite is true for endothermic reactions. |
| **8Pe.02** Describe how to make an electromagnet and know that electromagnets have many applications. | Electricity, current, electromagnet, magnetic field | Learners can draw diagrams to show the magnetic field around an electromagnet. Three different sets of arrows can be used to represent the magnetic field, the electric current and the movement. | Learners may think that a magnetic field is a pattern of lines rather than a field of force around a magnet. Allow learners to experience the force of attraction/repulsion of magnets. The alignment of iron filings on paper over a magnet can also show the field. |
| **8Pe.03** Investigate factors that change the strength of an electromagnet. | Electricity, current, electromagnet, magnetic field, strength | Learners may think strength is a property of the electromagnet rather than the magnetic field it creates. Demonstrate to learners if possible it is the magnetic field that becomes stronger in how strongly it attracts magnetic materials at an increased distance. |

# Unit 8.9 Suggested activities

| Learning objective | Thinking and Working Scientifically opportunities | Suggested teaching activities and resources |
| --- | --- | --- |
| **8ESp.02** Identify renewable resources (including wind, tidal and solar power, and bioplastics) and non-renewable resources (including fossil fuels), and describe how humans use them. | **8TWSa.03** Make conclusions by interpreting results and explain the limitations of the conclusions. | **Renewable and non-renewable resources**  Resources can be used to make materials and/or to generate electricity. In this two-stage activity, learners collect information about some resources and come to a conclusion about which is best.  Discuss, with learners, what the terms ‘renewable resource’ and ‘non-renewable resource’ mean for both electricity and for materials.   * Electricity – the terms ‘renewable’/’non-renewable’ refer to the way in which the electricity is generated. Renewable electricity is generated without using up the original source of energy (e.g. solar panels generate electricity without using up the pre-existing, ongoing, solar energy). (Note that solar panels are often manufactured from non-renewable materials). * Materials – the terms ‘renewable’/’non-renewable’ relate to the reactants used to make the material. (Note that the manufacture of a renewable material may require the use of non-renewable electricity sources).   Highlight the label of renewable and non-renewable can help identify the immediate impact of a material (or source of electricity) but it is not the full story.  Learners, using secondary information sources, compare and contrast petroleum-based plastics which can be made from hydrocarbons with bio-based plastics made from biological substances (e.g. starch, cellulose or protein). They research how the materials are made, what their properties are, and what happens to them when they are disposed of. They could then make a conclusion as to which type of material is best for either: (i) wrapping a magazine, (ii) wrapping food and (iii) making a water bottle.  Learners could choose one method of electricity generation (e.g. wind, tidal, solar, natural gas).  *Is the resource renewable or non-renewable?*  *What are the advantages and disadvantages of this method of electricity generation?*  Present learners with a brief that their town is going to need a new electricity generation plant. Ask them to apply their understanding of renewable and non-renewable electricity generation, consider the evidence in the brief and to determine the most appropriate method of electricity generation for the town. They make a short presentation to convince the ‘town mayor’ (represented by the headteacher) or a ‘town meeting’ (represented by a group of parents).  **Resources:** Secondary information sources, ‘Electricity-generation plant’ briefing sheet |
| **8Cc.02** Know that some processes and reactions are endothermic or exothermic, and this can be identified by temperature change. | **8TWSp.05** Make risk assessments for practical work to identify and control risks.  **8TWSc.01** Sort, group and classify phenomena, objects, materials and organisms through testing, observation, using secondary information, and making and using keys. | **Hot and cold reactions (requires additional resources)**  Show a video of an exothermic reaction (e.g. combustion) or carry out a teacher demonstration. Discuss that one of the more beneficial aspects of chemical reactions is whether energy is released, or required, by a reaction. Where energy (e.g. heat, light) is released during a reaction, this is called an ‘exothermic reaction’ (‘exo’ means ‘out’ and ‘thermic’ relates to heat).  *Where are exothermic reactions useful?*  Not all reactions release energy, some reactions require energy. This means the temperature around the reaction drops as heat is taken from the surroundings by the reaction; this is called an ‘endothermic reaction’ (‘endo’ means ‘in’ and ‘thermic’ relates to heat). This is a less desirable outcome but is very important. Highlight that photosynthesis is an endothermic reaction as it requires light energy for the reaction to happen.  Learners can now carry out exothermic and endothermic reactions by themselves. Provide them with a list of the chemicals that they will be using, i.e. magnesium powder, magnesium ribbon and six different 0.4 M solutions (sodium hydroxide, hydrochloric acid, sodium hydrogen carbonate, citric acid, copper (II) sulfate, sulfuric acid). Ask learners:  *Why do we carry out a risk assessment?*  They use secondary information sources to carry out a risk assessment.  Once the risk assessments have been completed, learners begin the practical work. Ensure learners wear eye protection at all times as the solutions would cause irritation at this concentration (i.e. 0.4 M). For each of the four reactions, they put 10 cm3 of the first solution into an insulated plastic cup and they measure the temperature with a thermometer (or temperature probe). They add 10 cm3 of the second solution and stir. They record the temperature ‘before mixing’ and ‘after mixing’ in an appropriate table.  (A) sodium hydroxide solution and dilute hydrochloric acid  (B) sodium hydrogen carbonate solution and citric acid  (C) copper (II) sulfate solution and magnesium powder  (D) dilute sulfuric acid and magnesium ribbon  Ask learners to classify the reactions as exothermic or endothermic. Explain that A, C, D are exothermic reactions (i.e. the temperature increases) and B is an endothermic reaction (i.e. the temperature decreases).  **Resources:** Video of combustion; secondary information sources, six different 0.4 M solutions (sodium hydroxide, hydrochloric acid, sodium hydrogen carbonate; citric acid; copper (II) sulfate; sulfuric acid); magnesium powder; magnesium ribbon; insulated plastic cups; thermometer; test tubes |
| **8TWSp.05** Make risk assessments for practical work to identify and control risks. | **Hot and cold reactions**  Show a video of an exothermic reaction (e.g. combustion) or carry out a teacher demonstration. Discuss that one of the more beneficial aspects of chemical reactions is whether energy is released, or required, by a reaction. Where energy (e.g. heat, light) is released during a reaction, this is called an ‘exothermic reaction’ (‘exo’ means ‘out’ and ‘thermic’ relates to heat).  *Where are exothermic reactions useful?*  Not all reactions release energy, some reactions require energy. This means the temperature around the reaction drops as heat is taken from the surroundings by the reaction; this is called an ‘endothermic reaction’ (‘endo’ means ‘in’ and ‘thermic’ relates to heat). Highlight that photosynthesis is an endothermic reaction as it requires light energy for the reaction to happen.  Obtain a chemical handwarmer (available from outdoor shops) and cold pack (available from pharmacies for treating injuries) and follow the instructions.  Learners could read the safety information that goes with the devices to determine what they might need to consider for a risk assessment.  Learners could feel the outside of the handwarmer and the cold pack to feel that the temperature has changed and classify them as exothermic or endothermic reactions.  **Resources:** Video clip of combustion, handwarmers, cold packs |
| **8Pe.02** Describe how to make an electromagnet and know that electromagnets have many applications. | **8TWSp.04** Plan a range of investigations of different types, while considering variables appropriately, and recognise that not all investigations can be fair tests. | **Build an electromagnet**  Show learners a magnet.  *How does a magnet behave?*  *Why does a magnet attract magnetic materials?*  Discuss how magnets have many uses in the world, highlighting some common uses (e.g. sorting metals, maglev trains). These magnetic technologies often use electromagnets because they generate very strong magnetic fields.  *What do you think an electromagnet is?*  Explain that the term ‘electro’ relates to electricity. Electricity can be used to make an electromagnet. Show a diagram of an electromagnet and explain how the electricity induces a magnetic field.  Learners, working in pairs or groups, make their own electromagnets. Learners use wire strippers to remove approximately 2.5 cm of insulation from each end of a 3 m length of insulated copper wire. Starting from one end of a 15 cm iron nail, they neatly wrap the wire fairly tightly around the nail and work towards the other end of the nail.  *Why are we using an iron nail? Why not gold?*  They attach one end of the wire to the positive terminal (and the other end of the wire to the negative terminal) of a D-cell battery. Learners should not leave electromagnets connected for long periods of time because wires and batteries can become very hot.  Test the electromagnet to see if metal paper clips are attracted to it. Repeat, using different core materials (e.g. an aluminium bar, a plastic rod), to check which material is best for the core of the electromagnet. Ask learners to consider what variables they need to keep the same (e.g. the number of turns of the wire, the distance between the wire and the core, the voltage of the battery) in order to determine the effectiveness of the different core materials.  *Why do you think electromagnets are useful to us?*  Discuss learners’ thoughts about some common applications of electromagnets. Give them an opportunity to use secondary information sources to research applications of electromagnets, especially those relevant to their local context.  **Resources:** Diagram of an electromagnet, iron nails, plastic rods, aluminium bars, copper wire, D-cell batteries, wire strippers |
| **8Pe.03** Investigate factors that change the strength of an electromagnet. | **8TWSp.04** Plan a range of investigations of different types, while considering variables appropriately, and recognise that not all investigations can be fair tests.  **8TWSa.03** Make conclusions by interpreting results and explain the limitations of the conclusions. | **The strength of an electromagnet**  Show learners a pre-made electromagnet.  *Does the number of times you wrap the wire around the nail affect the strength of the electromagnet?*  *What do you think the term ‘strength’ means in this context?*  Explain that a stronger electromagnet has a more powerful magnetic field so they attract/repel magnetic materials more strongly and at a greater distance.  Provide pairs of learners with two batteries, 3 m of insulated copper wire, a 15 cm iron nail, two D-cell batteries, wire strippers and some paperclips. Ask them to plan an investigation to determine the effect of: i) the voltage and ii) the number of turns of wire around the nail on the strength of the magnetic field that is generated.  *What question are you asking?*  *What do you need to do to answer the question?*  Once their plan has been approved, they should carry out the practical and reach a conclusion about how the voltage and the length of the wire affect the strength of the electromagnet.  *What did you observe?*  *What conclusion have you found?*  *Are there any limitations to your conclusion?*  *How could your investigation be improved?*  Learners should not leave electromagnets connected for long periods of time because wires and batteries can become very hot.  **Resources:** Iron nails, insulated copper wire, D-cell batteries, wire strippers, paperclips |

# Sample Lesson 1

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| --- | --- |
| CLASS: | |
| DATE: | |
| **Learning objectives** | **8Pe.02** Describe how to make an electromagnet and know that electromagnets have many applications.  **8TWSp.04** Plan a range of investigations of different types, while considering variables appropriately, and recognise that not all investigations can be fair tests. |
| **Lesson focus /**  **success criteria** | I can make an electromagnet  I can describe what electromagnets can be used for  I can plan and conduct a fair test  I can consider the variables involved |
| **Prior knowledge / Previous learning** | Learners will need to have prior knowledge and experience of constructing circuits and handling magnets. This includes understanding what a magnetic field is and being able to describe electricity e.g. through a model. |

**Plan**

| **Lesson** | **Planned activities** | **Notes** |
| --- | --- | --- |
| **Introduction** | Show learners a magnet.  *How does a magnet behave?*  *Why does a magnet attract magnetic materials?*  Hear learner’s ideas. Provide learners with some paper, a magnet and some iron filings. Placing the magnet under the paper, the learners pour their iron filings over the paper and then by brushing off the excess identify where the magnets are being attracted. Demonstrate this yourself and identify the magnetic field of a magnet.  Look at a magnetic material and repeat and identify that the magnetic material does not have a magnetic field. | Resources:  Paper, magnet, iron filings, magnetic material |
| **Main activities** | Discuss how magnets have many uses in the world, highlighting some common uses (e.g. sorting metals, maglev trains). These magnetic technologies often use electromagnets because they generate very strong magnetic fields.  *What do you think an electromagnet is?*  Explain that the term ‘electro’ relates to electricity. Electricity can be used to make an electromagnet. Show a diagram of an electromagnet and explain how the electricity induces a magnetic field.  Learners, working in pairs or groups, make their own electromagnets. Learners use wire strippers to remove approximately 2.5 cm of insulation from each end of a 3 m length of insulated copper wire. Starting from one end of a 15 cm iron nail, they neatly wrap the wire fairly tightly around the nail and work towards the other end of the nail.  *Why are we using an iron nail? Why not gold?*  They attach one end of the wire to the positive terminal (and the other end of the wire to the negative terminal) of a D-cell battery. Learners should not leave electromagnets connected for long periods of time because wires and batteries can become very hot. Test the electromagnet to see if metal paper clips are attracted to it.  Explain to the learners they will now investigate how changing the core of an electromagnet affects the strength of the electromagnet. Provide learners with a range of different core materials (e.g. an aluminium bar, a plastic rod). Learners then plan out their investigation:  *What are you going to do?*  *What is the independent variable?*  *What is the dependent variable?*  *What are the control variables?*  *What type of enquiry are you running?*  Some of variables learners may need to keep the same include; the number of turns of the wire, the distance between the wire and the core, the voltage of the battery.  Learners evaluate each other plans. Once evaluated and they have had at least two peers ‘sign off’ their plan they carry out their investigation.  Learners share their findings and rank the different cores by effectiveness. Discuss with learners what material makes the best core for an electromagnet. Discuss why this is important.  *Why do you think electromagnets are useful to us?*  *Why do we need to consider the best electromagnetic core?*  Discuss learners’ thoughts about some common applications of electromagnets | Resources:  Diagram of an electromagnet, iron nails, plastic rods, aluminium bars, copper wire, D-cell batteries, wire strippers |
| **End/Close/ Reflection/Summary** | If time is available, give learners an opportunity to use secondary information sources to research applications of electromagnets, especially those relevant to their local context. | Secondary information sources |

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| **Reflection Use the space below to reflect on your lesson. Answer the most relevant questions for your lesson.** |
| *Were the learning objectives and lesson focus realistic? What did the learners learn today? What was the learning atmosphere like? What changes did I make from my plan and why?*  *If I taught this again, what would I change?*  *What two things went really well (consider both teaching and learning)?*  *What two things would have improved the lesson (consider both teaching and learning)?*  *What have I learned from this lesson about the class or individuals that will inform my next lesson?* |
| **Next steps**  **What will I teach next, based on learners’ understanding of this lesson?** |

# Sample Lesson 2

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| --- | --- |
| CLASS: | |
| DATE: | |
| **Learning objectives** | **8Bs.03** Describe how the structure of the human respiratory system is related to its function of gas exchange (in terms of lung structure and the action of the diaphragm and intercostal muscles) and understand the difference between breathing and respiration.  **8TWSm.02** Use an existing analogy for a purpose. |
| **Lesson focus /**  **success criteria** | I can explain how the respiratory system functions to draw air into the lungs  I can use, and evaluate, an analogy  I can explain the difference between breathing and respiration |
| **Prior knowledge / Previous learning** | Learners should know before the lesson that the respiratory system consists of the trachea, bronchi, bronchioles, air sacs, lungs, ribs, diaphragm, and intercostal muscles. |

**Plan**

| **Lesson** | **Planned activities** | **Notes** |
| --- | --- | --- |
| **Introduction** | Display an unlabelled diagram of the respiratory system. Explain that learners will have 3 minutes to talk with their neighbour and think about how each part should be labelled. Elicit the correct positions of the labels for the trachea, intercostal muscles, ribs, diaphragm, bronchi, bronchioles and air sacs.  Remind learners what an analogy is and how it can be used to help understand concepts.  Introduce the analogy: the respiratory system is like a pair of bellows.  Discuss with the learners what a pair of bellows is.  Show learners some bellows, or if time can be given learners make a set of bellows.  *Do you agree that the respiration system is like a pair of bellows?*  *Is the analogy a good one?*  Explain that this lesson they will build a physical model to help compare the respiratory system to bellows and see if the analogy is a good one. | Resources:  Bellows (or equipment to make bellows) |
| **Main activities** | Explain that learners will work in pairs to build a model which is a physical model of the respiratory system.  Display the picture below and set out the equipment for learners to collect.    Once learners have assembled their model lung explain that if they pull the balloon that has been stretched over the opening, this represents expanding the diaphragm. They do so and observe what happens.  Ask learners to discuss, in pairs, to explain why the balloon attached to the straw inflates. Go around the class, listening to their explanations and prompting where necessary. Bring the class together and go through the explanation, asking learners for their contributions.  Ask learners to identify which parts of the model correspond to the trachea, lung, diaphragm.  Show learners the bellows again and compare it to their physical models.  Ask learners to what extent the respiratory system being like bellows is a good analogy and to identify any aspects where it is less accurate.  This activity can be extended by asking learners to identify how the physical model might be improved and what the limitations of using a physical model to evaluate an analogy might be. | Resources:  Drinking straws  Modelling clay/glue  Balloons  Plastic cups  Elastic bands  Scissors |
| **End/Close/ Reflection/Summary** | To check that learners have understood how we breathe, ask them to sketch a diagram of the model and annotate it to explain how we breathe.  Discuss with learners how breathing, and the action of the respiratory system, is different to respiration. |  |

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| **Reflection Use the space below to reflect on your lesson. Answer the most relevant questions for your lesson.** |
| *Were the learning objectives and lesson focus realistic? What did the learners learn today? What was the learning atmosphere like? What changes did I make from my plan and why?*  *If I taught this again, what would I change?*  *What two things went really well (consider both teaching and learning)?*  *What two things would have improved the lesson (consider both teaching and learning)?*  *What have I learned from this lesson about the class or individuals that will inform my next lesson?* |
| **Next steps**  **What will I teach next, based on learners’ understanding of this lesson?** |

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