UNIVERSITY OF BATH

Bath's first Science Festival

Bath Taps into SCIENCE

Science Fair Project Guide:

Teachers' handbook – Key Stage 2/3

Contents

Introducing the Project

This booklet provides all the information necessary to run a six week Science Project that spans the Key Stage 2 and Key Stage 3 syllabus. The project gives pupils the opportunity to come up with their very own experiment, including a research question and hypothesis, run this experiment and then present their findings in poster form.

The booklet is split into six sessions, which can be run in a one off hour long session, or can be spread out over a week (Recommended). Each week covers curriculum points from the Lower Key Stage 2, Upper Key Stage 2 and Key Stage 3 syllabus. Please use your discretion when delivering the sessions, in terms of pitching the activities at the correct level.

Inside there are a number of worksheets which will need photocopying. Any worksheet that needs photocopying is marked with the following symbol...

If the worksheet also requires the children to write on it, it will be marked with the following symbol...

On these worksheets, there a number of higher level questions with a bronze Trophy next to them. Using your discretion, more able students should be encouraged to complete these questions.

If a student completes all of these questions, they are eligible to apply for a bronze quest award. More information can be found at www.crestawards.org.

Once the project has been completed, the students should have a nice set of worksheets which they can staple together into a booklet.

Good Luck!

Week One

Key

Blue Text = Lower Key stage 2

Green Text = Upper Key stage 2

Red Text = Key stage 3

'Lesson' Plan

Curriculum Points Covered

- make predictions using scientific knowledge and understanding

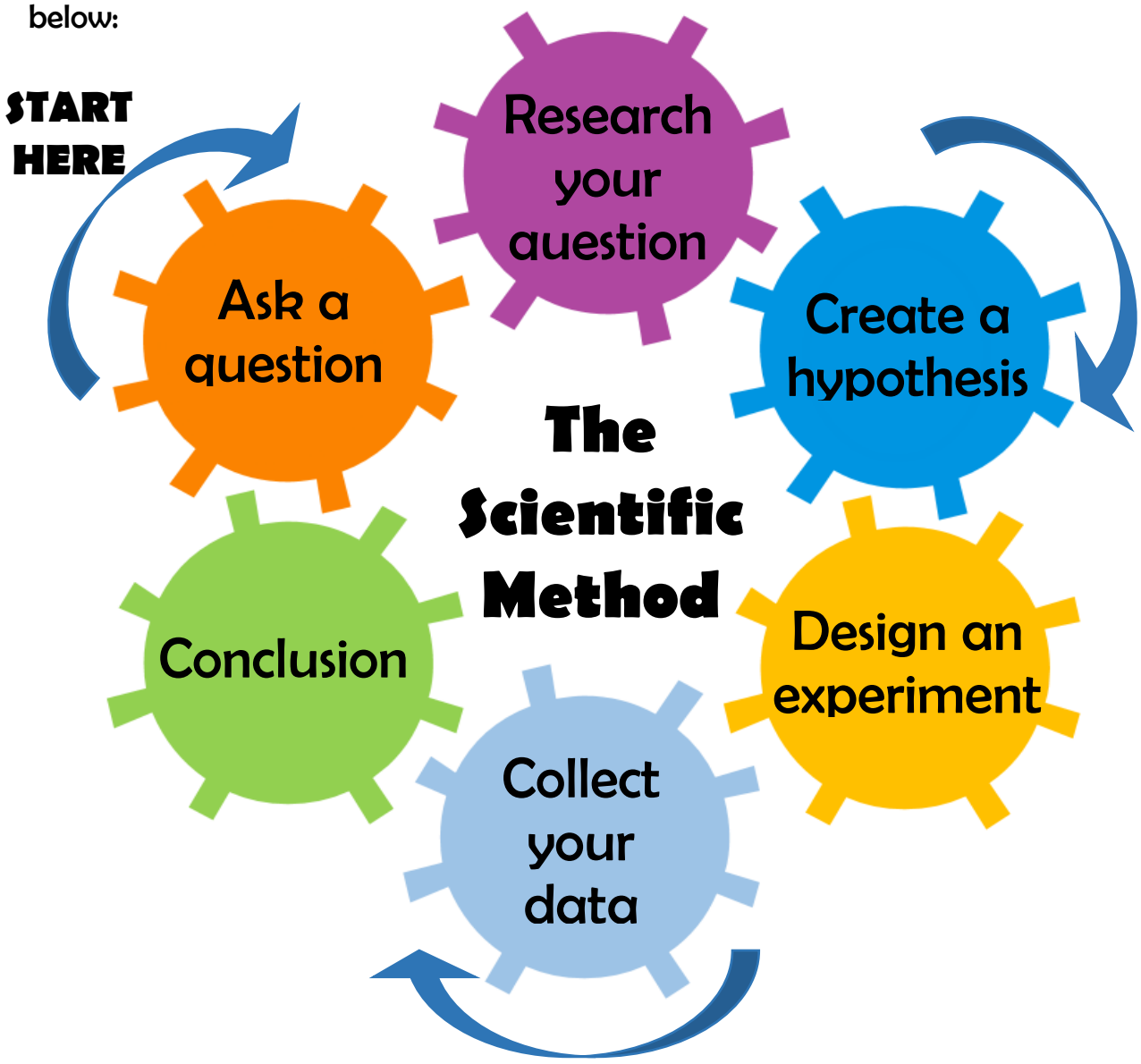
Aims

- To ensure students understand what they will be doing over the 6 week period
- To understand how to phrase and ask a scientific question
- To develop a hypothesis that can be tested in the following weeks

Preparation	Learning activities	Resources
Photocopy worksheets (4 in total) Cut out cogs	Intro: What is the project? • Over the next 6 weeks you will be developing a science project that you will present in groups at a science festival. • Consult 'Introduction to the project' on page... • Split pupils into groups (These are the groups they'll be working in for the next 6 weeks) Activity 1: Scientific method activity **WORKSHEET** • Place cut out cogs on students desks, ask them to work in groups to put them in the correct order • Explain correct order and explain this is what we'll be doing over the next few weeks Activity 2: Brainstorm ideas **WORKSHEET** • Pupils brainstorm their ideas on ideas web • See completed brainstorm worksheet for help Activity 3: Ask a question **WORKSHEET** • Pupils write down their final research question (Everyone in the group must have the same question) Activity 4: Construct a hypothesis **WORKSHEET** • Define hypothesis • Write 2-3 hypotheses based on their question Plenary • Cogs – whoever completes the order the quickest wins a prize • Questions and prizes (what is a hypothesis? What is the next stage of the process?)	• Pens and paper • Scientific Method activity • Brainstorm worksheet • Hypothesis worksheet • Questions and prizes

What is the scientific method?

To help scientists answer questions, they use a process called the scientific method. Scientists have been using this for centuries to help organise ideas and design appropriate experiments to answer scientific questions. In this project your pupils will go through each stage of the scientific method to answer their question. The scientific method is illustrated in the diagram below:

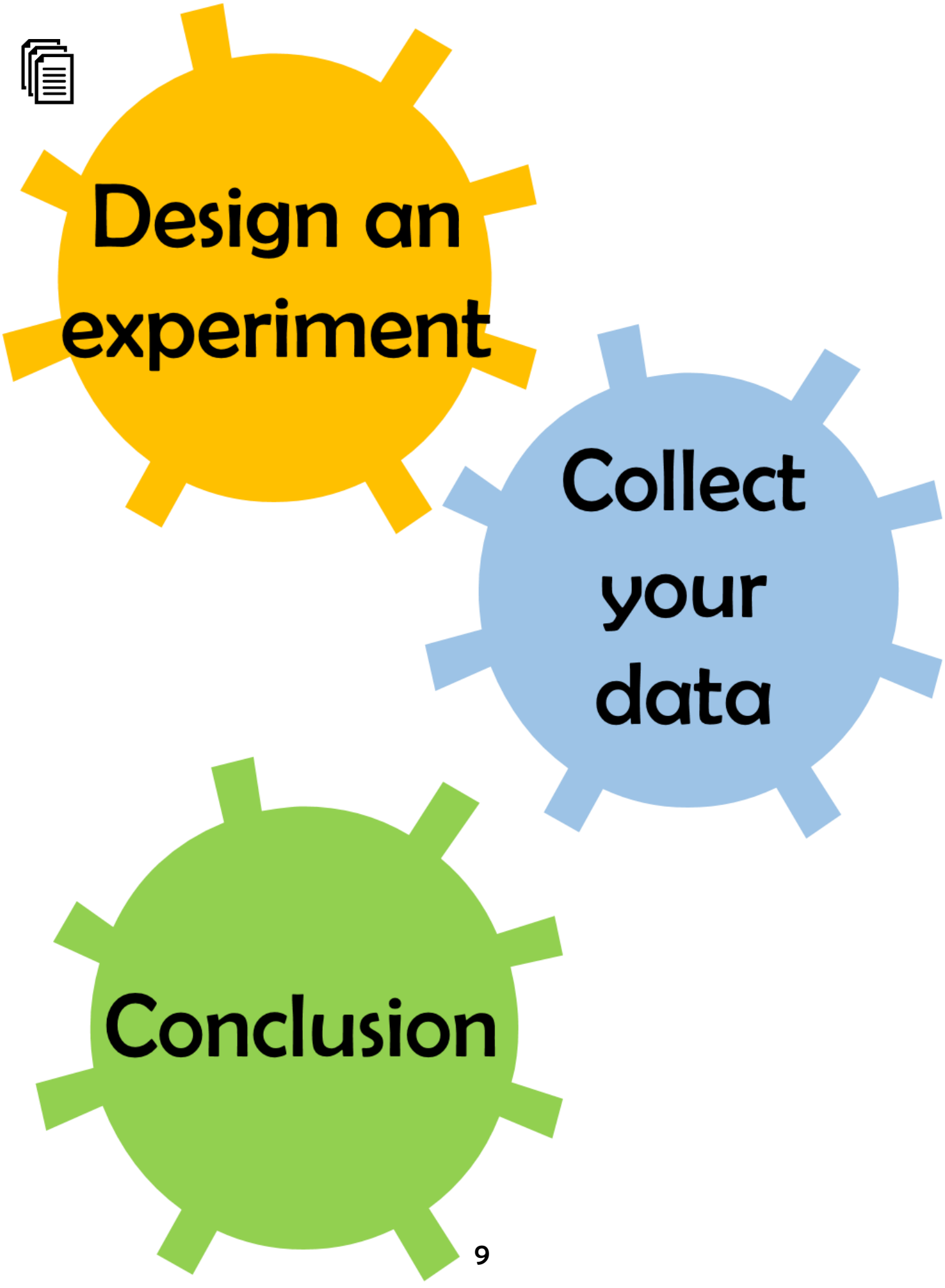


You and your pupils will be able to identify which stage of the process they are in as they go through the booklet. Each time this cycle appears, one of the 6 circles will be glowing, indicating the stage of the cycle the pupils are on. Don't worry if the pupils don't understand each stage to begin with, it will become clear to them as they work through each stage. To help them with this, cut out the cogs (one set per group) and ask your pupils to try and put them in the right order.

Ask a question

Research your question

Create a hypothesis


Design an experiment
Collect your data
Conclusion

Coming up with a good question

Deciding on a topic

Before coming up with a question it is important the pupils decide on a topic they are interested in.

Finding a topic can be difficult so the 'Ideas web' on page 6 is designed to help the pupils collect and focus ideas.

Ideas web – Activity 2

- Using Ideas Web on page 6, or the uncompleted web on page 7, the pupils should start by writing down things that they are interested in and/or things that they enjoy at school. They can use the ideas already on the worksheet to help them start.
- Encourage pupils to write down everything that comes into their head, even if it seems crazy, stress the importance of being creative. Pupils should draw lines to link different ideas (some have already been drawn!). Thinking about how interest's link together can often result in creative projects. For example, if you are interested in airplanes and in making things you could build and test planes with different drag.
- Give the pupils approximately 5-10 minutes on this task, or until they are completely out of ideas. After this time is up, the pupils should read through their ideas and cross off ones they don't like (as well as adding any new ideas that come into their head).
- Once they have done this, the pupils should write down their favourite topic or idea, on page 8.

Living things (biology): This is the science behind life and living organisms. It can include the study of plants, animals, insects, the human body and human health. For each of these topics you might think about investigating its function, structure, growth, distribution and/or classification.

Materials (chemistry): This is the science behind the discovery, creation and properties of different materials. It can include the creation of medicines, sustainable fuels and food products. One area is the study of the properties of solids, liquids and gases (collectively called states of matter). In this category you may be interested in changing between states of matter (e.g. water vs ice), material properties (e.g. metals vs wood), heat (e.g. conductors vs insulators) and/or changes in materials (irreversible changes such as burning and reversible changes such as dissolving).

Physical processes (physics): This is the science behind how things behave. It involves understanding the very small and the very large, for example the minute atom or the expanse of the universe. One area is how atoms interact to produce phenomena such as gravity. In this category you might be interested in electricity, magnetism, sound, light, solar system, the weather and forces.

How things work (engineering): This topic combines the knowledge of the sciences listed above and it is applied practically to design, invent and build with the intention of

improving structures, processes and systems such as machines, buildings, bridges, and communication systems.

Building Blocks (Maths): This is the study of numbers. At a high level, maths helps us to understand complex scientific phenomena such as the concept of time and the vast expanse of space. At simpler level, maths can be used to understand concepts that we encounter daily such as probabilities, shapes, maps and coordinates.

Tip:

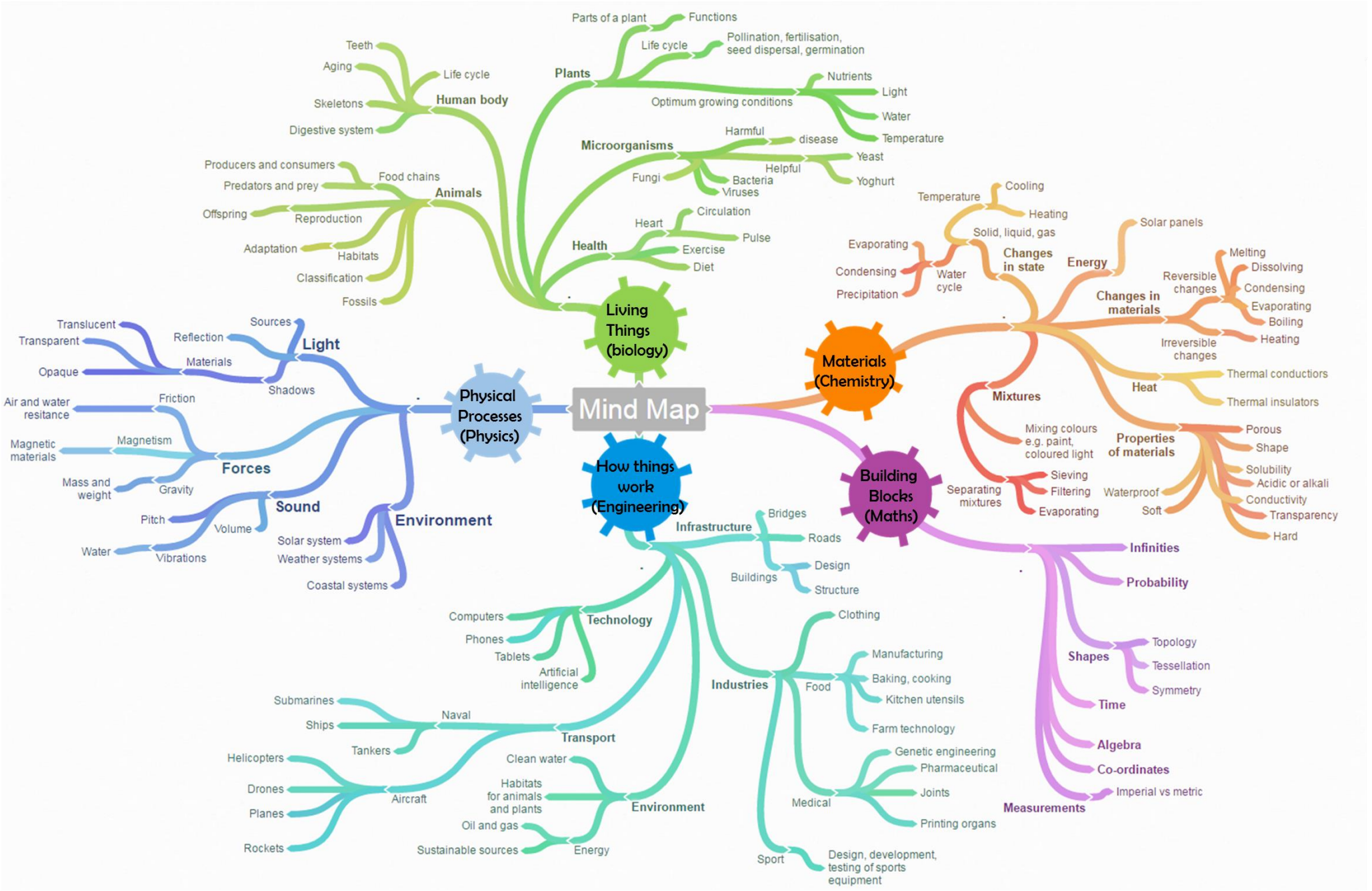
Useful resources to help you if the pupils are struggling for ideas!

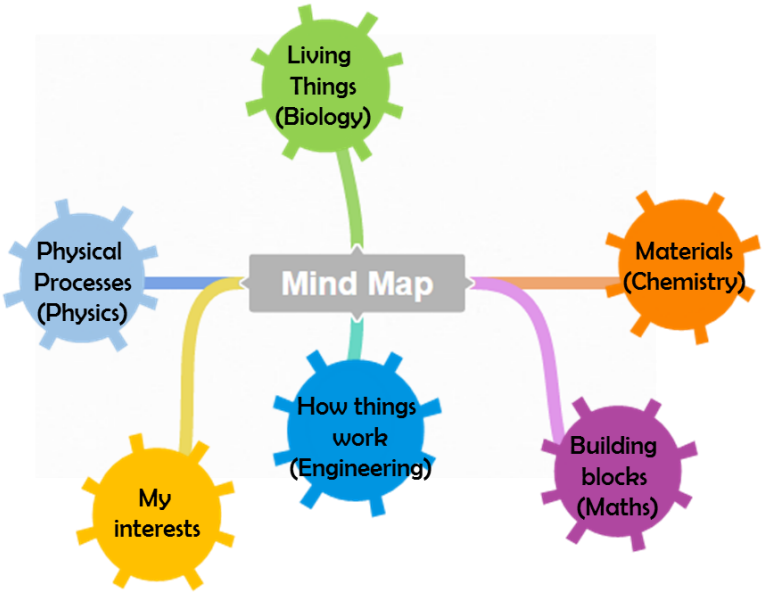
Games and videos on this link to help pupils with ideas:
http://www.kidsciencechallenge.com/year-four/create.php

It is great practice for the pupils to come up with their own topic, but if they are really struggling, use these links to help them select a topic:

http://www.sciencebuddies.org/science-fair-projects/recommender_register.php

http://school.discoveryeducation.com/sciencefaircentral/Getting-Started/idea-finder.html


Mind Map
Living Things (biology)
Plants
Parts of a plant
Functions
Life cycle
Pollination, fertilisation, seed dispersal, germination
Optimum growing conditions
Nutrients
Light
Water
Temperature
Microorganisms
Harmful
disease
Helpful
Yeast
Yoghurt
Fungi
Bacteria
Viruses
Health
Heart
Circulation
Pulse
Exercise
Diet
Human body
Life cycle
Teeth
Aging
Skeletons
Digestive system
Animals
Food chains
Producers and consumers
Predators and prey
Reproduction
Offspring
Habitats
Adaptation
Classification
Fossils
Physical Processes (Physics)
Light
Sources
Reflection
Materials
Translucent
Transparent
Opaque
Shadows
Forces
Friction
Air and water resitance
Magnetism
Magnetic materials
Gravity
Mass and weight
Sound
Pitch
Volume
Water
Vibrations
Environment
Solar system
Weather systems
Coastal systems
How things work (Engineering)
Infrastructure
Bridges
Roads
Buildings
Design
Structure
Technology
Computers
Phones
Tablets
Artificial intelligence
Transport
Naval
Submarines
Ships
Tankers
Aircraft
Helicopters
Drones
Planes
Rockets
Environment
Clean water
Habitats for animals and plants
Oil and gas
Energy
Sustainable sources
Industries
Clothing
Food
Manufacturing
Baking, cooking
Kitchen utensils
Farm technology
Medical
Genetic engineering
Pharmaceutical
Joints
Printing organs
Sport
Design, development, testing of sports equipment
Materials (Chemistry)
Changes in state
Temperature
Cooling
Heating
Solid, liquid, gas
Water cycle
Evaporating
Condensing
Precipitation
Energy
Solar panels
Changes in materials
Reversible changes
Melting
Dissolving
Condensing
Evaporating
Boiling
Irreversible changes
Heating
Heat
Thermal conductors
Thermal insulators
Mixtures
Mixing colours e.g. paint, coloured light
Separating mixtures
Sieving
Filtering
Evaporating
Properties of materials
Porous
Shape
Solubility
Acidic or alkali
Conductivity
Transparency
Hard
Waterproof
Soft
Building Blocks (Maths)
Infinities
Probability
Shapes
Topology
Tessellation
Symmetry
Time
Algebra
Co-ordinates
Measurements
Imperial vs metric


Living Things (Biology)
Physical Processes (Physics)
Mind Map
Materials (Chemistry)
How things work (Engineering)
My interests
Building blocks (Maths)

KEY

Living Things (Biology) — This is the study of animals and plants.

Physical Processes (Physics) — This the study of how things behave such as electricity, sound and light.

Materials (Chemistry) — This the study of different materials such as rocks, gases and liquids.

Building blocks (Maths) — This the study of numbers such as probability, shapes and maps.

How things work (Engineering) — This combines all of the categories above to help us invent new things.

My interests — Here you can write your interests and link to all the other different areas.

My favourite topic or idea that I would like to investigate is

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Asking a question

After choosing a topic it is important that the pupils create a scientific question which they can base their project on. It should be an interesting question that the pupils will want to work on for the next few weeks. Try to ensure that pupils' questions are focused, so that they can answer it with a simple experiment. Science questions usually start with how, what, where, when, why, which or does. Below are some examples of science questions to get the pupils thinking about how they might structure a question based around their chosen topic.

> Tip: A good question will allow you to measure changes in important factors (variables) using a quantity e.g. length, height, width, time, volume, velocity.

How does/do _____ affect _____?

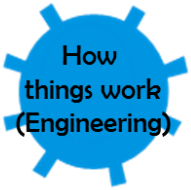
- How does **temperature** affect **plant growth**? (words in bold can be changed)
- How do **different materials** affect **bridge strength**?
- How does the **type of paper** affect **airplane flight**?

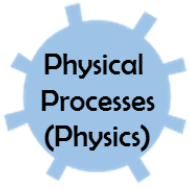
What is the effect of _____ on _____?

- What is the effect of **exercise** on **memory**?
- What is the effect of **temperature** on **magnet strength**?
- What of the effect of **salinity** on the **freezing point of water**?

The pupils do not have to stick to these structures, these are just suggestions. There are many other ways that you can ask a scientific question...

- Why do **cars have four wheels**?
- What is the best way to **reduce** the **odour of shoes**?
- How do **bridges work**?
- How do **planes fly**?
- How can you **lift a heavy weight without touching it**?
- What **length lever** is best at **unscrewing a tight knot**?
- Why do **buildings have so many windows**?
- Why are **pitched roofs** better than **flat roofs**?
- How do **buildings withstand earthquakes**?
- What type of **ball bounces** the **highest**?
- Why does **popcorn** go **'pop'**?
- How does a **teacher leaving the classroom** affect **noise levels**?
- What type **of surfaces reflect light well**?
- What type of **material** gives **the darkest shadow**?
- How do you **increase the air resistance** of a **falling object**?
- Why can't you keep a **bank card with a mobile phone**?
- How does a **compass work**?
- How does **sound travel through the air**?





- What **foods** do **worms** prefer in a **compost bin**?
- How does **diet** affect **mood**?
- How does **exercise** affect **heart rate**?
- How does **yeast** make **bread rise**?
- Does a plant need **light** to **survive**?
- Why is **seed dispersal of a plant important**?
- Why does **a plant have petals**?
- Why is **sugar** bad for our **teeth**?
- What happens to **our memories as we age**?
- How do the **joints in our bodies work**?
- Why are **humans** top of the **food chain**?
- How does **a sundial work**?
- Why is a **football** made of **hexagons**?
- What is **zero**?
- What is a **negative number**?
- Why is **honeycomb** made of **hexagons**?
- Is a **2D globe map an accurate representation of a 3D globe**?
- Can I use **global coordinates** to **map out a route**?
- What is the difference between **metric** and **imperial measurements**?
- Are **faces symmetrical**?
- What **living things in the garden are symmetrical** and why?
- What is the **probability of rolling a 4 using one die**?
- What is the **probability of rolling a seven using two dice**?
- How do you **separate salt and sand**?
- What is the best **material for keeping a drink warm**?
- What is the best **material to make a boat with**?
- Why is **cutlery made from metal**?
- Which **detergent** is best at **removing stains**?
- How much **salt** can you **dissolve in water**?
- How does the **type of chocolate** affect **melting time**?
- What happens to **water when it evaporates**?
- How do you **separate salt, sand and iron filings**?

Living Things (Biology)

Building blocks (Maths)

Materials (Chemistry)

There are many more example questions available on this link...

http://school.discoveryeducation.com/sciencefaircentral/Getting-Started.html

Pupils should use the worksheet on the following page to write down their own research question.

Ask a question – Activity 3

- After choosing a topic it is important to create a scientific question that you can base your project on.
- It should be an interesting question that you want to work on for the next few weeks.
- It helps if it is focused so that you can answer it with a simple experiment.
- Science questions usually start with how, what, where, when, why, which or does.

My research Question is

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Why do you want to do your project? How does it link to everyday life? Does it affect you or people you know?

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How could I find out the answer to my question?

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What is the best way to find out the answer to my question and why?

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Researching a question

How to research a question

Background research is important to help the pupils understand their research question, so that they can design an experiment. Pupils should start by identifying key words in their research question and then coming up with questions to help focus their background reading.

Sometimes researching a topic can be overwhelming as you can be presented with a lot of information, especially when searching on the internet. In order for the pupils to order their research, encourage them to devise 5 – 10 questions to focus their background reading. They will be using this information later to predict what might happen in their experiment, so it is important they have read around the topic well. It is also a good opportunity for the pupils to think about how they might conduct their experiment, as they can find out what other people have done and whether it worked or not.

EXAMPLE

How does the **type of chocolate** affect **melting time**?

Questions:

- What are the different ways of melting chocolate?
- What temperature does chocolate melt at?
- What the difference between melting time and boiling point?
- What are the different types of chocolate?
- How can you measure melting time?
- Why would different types of chocolate affect melting time?
- Who discovered chocolate?

As you can see these questions often start with words such as how, what, where, when, why, which or does. They are similar to the research question but have a more straight forward answer. The words underlined are nouns (chocolate, temperature) and verbs (melting). Help the pupils to highlight the key nouns and verbs in their question, this may allow them to swap the underlined words here to match their research question. This is just an example to get you and the pupils started; they do not have to stick to these questions! In fact, it is even better if they come up with them themselves - it shows they are already thinking about how they will plan their experiment and what the outcomes might be!

List of resources to help with reading…

- There is a useful table on this link to help the pupils generate questions related to their research question: http://www.sciencebuddies.org/science-fair-projects/project_background_research_plan.shtml#makingabackgroundresearchplan
- Encourage pupils to use their local or school library to read books, magazines, newspaper articles and articles from the internet (search engines).
- Encourage pupils to discuss their topics with teachers, parents, siblings, experts (doctors, scientists, university ambassadors) either in person or via telephone and email.

Tip: sometimes websites such as universities or companies have email addresses of experts who may be able to help answer your questions.

How to organise your reading

Scientists find it useful to keep track of the source of their information. If someone asks them a question about their background reading then they will be able to say where they got that information from. To help the pupils keep track of their research, they can use the table below. It might be useful for the pupils to fill out a row for each of their questions as shown in the example.

EXAMPLE

Question	Information	Source
What are the different ways of melting chocolate?	Heating in the oven	Discussed with Mum
	Melt over a pan of water on a low heat	Cook book
What are the different type of chocolate?	Wrapped, unwrapped, milk, dark, white, small, big, chocolate with nuts and sweets in	Supermarket



Question	Information	Source

Forming a prediction/hypothesis

Once a scientist has come up with a question and has read around the topic, it is possible to generate a hypothesis. A hypothesis is a prediction of what might happen if you try to test your problem. Get the pupils to ask themselves the question – 'what do I think will happen?' This is where their knowledge from the previous section comes in handy. It is important the pupils are able to test their hypothesis experimentally as the next step will involve carrying out an experiment to prove their hypothesis correct or incorrect.

EXAMPLE

Problem: How does the type of chocolate affect melting time?

Ask: what do you think will happen?

Hypothesis 1. White chocolate will melt faster than dark chocolate

Hypothesis 2. Chocolate in wrappers will melt faster than unwrapped chocolate

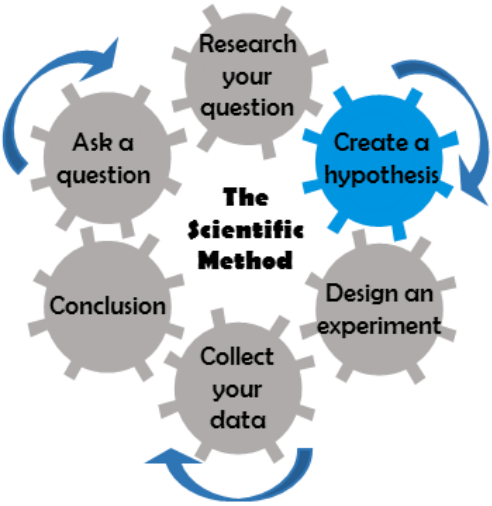
Hypothesis 3. Chocolate containing ingredients, such as nuts, will melt slower than pure chocolate.

Fact: Hypothesis is derived from the Greek word 'hupothesis' meaning 'foundation'

Using the background research from the previous section, I have thought of 3 different things that might happen if I were to test my question. So I have come up with 3 different hypotheses. Usually for a science fair there may only be time to test one of these hypotheses. But all of these answer my main question 'How does the type of chocolate affect melting time?' so I can choose which one to take onto the next stage.

Below is space for the pupils to write down their own hypothesis (or hypotheses). If they do come up with more than one, make sure that they choose one to test in the next section (if there's time, they may have the opportunity to test the others).

Create a prediction/hypothesis



- Once you have come up with a question and read around the topic, you can create a hypothesis.
- A hypothesis is a prediction of what might happen if you try to test your problem.
- To help predict what will happen ask yourself the question – 'what do you think will happen in my experiment?'
- You have to be able to test your hypothesis experimentally as the next step will involve carrying out an experiment to prove your hypothesis correct or incorrect.

My prediction/hypothesis is

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Week Two

Key

Blue Text = Lower Key stage 2

Green Text = Upper Key stage 2

Red Text = Key Stage 3

'Lesson' Plan

Curriculum Points Covered

- asking relevant questions and using different types of scientific enquiries to answer them
- setting up simple practical enquiries, comparative and fair tests
- planning different types of scientific enquiries to answer questions, including recognising and controlling variables where necessary
- ask questions and develop a line of enquiry based on observations of the real world, alongside prior knowledge and experience
- select, plan and carry out the most appropriate types of scientific enquiries to test predictions, including identifying independent, dependent and control variables, where appropriate

Aims

To understand what a fair test is

To understand the different variables in their experiment: independent, dependent and control

To use their knowledge to design their own fair test

Preparation	Learning activities	Resources
	Activity 1: Paper Airplane Activity Activity 2: Match variables to definitions and Identify variables in own experiments **WORKSHEET – Key Stage 3** • Define all variables and fair test • Ask them to identify the different variables in their experiment and group them into independent, dependent and control. Activity 3: Writing experimental methods **WORKSHEET** • Each group to write the list of materials they need for their experiment • Each group to write their own methods, keeping in mind the variables they have just identified • Should be like a recipe, someone else should be able to follow/replicate it – reference Great British Bake off technical challenge... Plenary • Where are we in the scientific method cog wheel? • Quiz: what is a control/dependent/independent variable, what is the next step?	• Different shapes, sizes and types of paper • Glue • Pens and paper • Variable worksheet • Experimental methods worksheet

Designing an experiment

In this section the pupils will learn how to carry out a fair test and the steps to go through to design an experiment. An example is used throughout the section and a worksheet is provided at the end for the pupils to plan their experiment.

What is a fair test?

Now that the pupils have a hypothesis, they can start to design an experiment to help test whether it is correct or incorrect. Before they can do this, they need to understand what a fair test involves. When conducting an experiment it is important that one factor is changed at a time and all other conditions remain the same. Give the pupils the following two scenarios, and see if they can decide which one is the fair test.

Hypothesis: 'White chocolate will melt faster than dark chocolate'.

Scenario 1

I use the same brand of dark and white chocolate. I leave the dark chocolate outside in the sun and the white chocolate in the fridge before starting my experiment.

Scenario 2

I use the same brand of dark and white chocolate. I leave both the dark and white chocolate in the fridge for 2 hours before starting my experiment.

Which one is the fair test?

The pupils should hopefully recognise that scenario 2 is the fair test. Scenario 1 is not a fair test because the dark chocolate will melt in the sun before the experiment is started. This is not a fair test because I want to measure melting time! The only thing that should change between the 2 chocolates is whether it is dark or white. They should both start the experiment at the same temperature. These changing factors in experiments are called variables. To ensure that their test is fair, the pupils must change only one variable at a time, whilst keeping all the others the same. These variables that stay the same, are known as control variables.

Paper airplane activity – Activity 1

In order to further reinforce the idea of a fair test and controlling variables, run this activity with your pupils.

- Split your class into groups of four or five (Or whatever works best)
- Give your pupils a range of different types, sizes and shapes of paper and ask them to make a paper airplane. (Guides for making a paper plane can be found on the internet if your pupils are struggling)
- Once all your students have made a plane, chose one pupil from each group to come to the front and throw their paper plane. Explain that the aim of the test is to see who can throw their plane the furthest.
- Pick up plane that flew the furthest vs one that did not fly as far and ask them why, consider: weight/texture of material, wing shape, size, force used to throw (4 forces acting on a plane: thrust, drag, lift, gravity). Write differences on the board.
- The aim of the test was to make a plane and see who could throw it the furthest… Ask the students if they think this was a fair test. Hopefully they will recognise that it wasn't fair, because everyone was given different materials and the planes were all made differently.
- Explain again to the pupils that all these things that can be changed in an experiment are called variables, and that to ensure their experiment is a fair test, they most only change one variable at a time, whilst keeping the others the same.
- Ask your pupils what they would do to make the airplane test fair? Depending on their answers, explain that they would all need to use the same size, shape and type paper, and make the plane using the same design. Reinforce the fact that these variables that stay the same must be controlled, and are called control variables.

Identifying variables

If your pupils are Ks3, it's important that they understand, and can recognise the other two types of variables (Independent and Dependent). Therefore, there are 3 different types of variable pupils should be aware of:

- The **variable you want to change** is called the **independent variable**
- The **variable you are measuring** is called the **dependent variable**
- **All other variables are the control variables** (because these are not being tested or measured they must be kept the same throughout the experiment)

Use the paper airplane experiment to discuss the independent variable and dependent variable. Ask your pupils what they think the independent variable (The person launching the plane) and the dependent variable (Distance flown) was in this experiment.

Further reinforce this using the example below and then check the pupils understanding using the activities at the bottom of this page and the top of the following page.

EXAMPLE

Hypothesis: 'White chocolate will melt faster than dark chocolate'.

The independent variable in my experiment is the type of chocolate

The dependent variable in my experiment is the time it takes for the chocolate to melt

The control variables in my experiment are (all of these remain the same throughout the experiment):

- Starting temperature of the chocolate
- The method I use to melt the chocolate
- The brand and age of chocolate
- Weight, surface area and shape of the chocolate
- Point at which I start measuring melting from

Match the word to the correct definition – Activity 2

Independent variable	Variables that remain constant throughout the experiment (as they are not measured)
Fair test	The variable you are measuring
Control variables	The variable you want to change
Dependent variable	Change one variable at a time whilst keeping all others the same

Identify and group the different variables in your experiment

The **independent** variable in my experiment is

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The **dependent** variable in my experiment is

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The **control** variables in my experiment are

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Ks3

Writing a list of materials

When carrying out an experiment, it is good practice to think about all the things you may need for your experiment. It is important that any in any equipment, you are using accurate equipment to measure your dependent variable. In this example I am measuring melting time of chocolate so it will be useful to have a stopwatch that accurately records seconds instead of an analogue clock. It may be useful for the students to do this section in conjunction with the next step where they will write their experimental methods.

Writing experimental methods

This section involves the students writing a step-by-step recipe for their experiment. The scientific term for this is 'experimental methods'. A good methods section is very detailed and enables someone else to replicate your experiment (much like a recipe in a cook book).

Stress the importance of carrying out an experiment more than once to confirm the results are consistent. Each time the experiment is repeated, under the same conditions, you should obtain similar values for your dependent variable. This tells you that the answer to your question was not down to chance. Each time an experiment is performed is called a repeat. The minimum number of repeats that should be done is 3. If you have the time and resources for your pupils to run their experiment more than 3 times then even better!

Now get the students to complete the written activities, more able students may be able to complete the question with a bronze trophy next to it.

List of materials – Activity 3

In this section you should write a list of everything you will need for your experiment. This is important because you will need to remember to bring everything when you start experimenting. Use the space below for a diagram if you would like.

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Experimental methods

This section involves writing a step-by-step recipe for your experiment. The scientific term for this is 'experimental methods'. A good methods section is very detailed and enables someone else to replicate your experiment (much like a recipe in a cook book).

Are there any health and safety risks with your experimental plan?

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Use this space to plan your time and organise who does what in your group.

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Why have you chosen this idea or approach to answer your question? You can use diagrams or words to explain this.

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Week Three/four

Key

Blue Text = Lower Key stage 2

Green Text = Upper Key stage 2

Red Text = Key stage 3

'Lesson' Plan – Week 3

Curriculum Points Covered

- making systematic and careful observations and, where appropriate, taking accurate measurements using standard units, using a range of equipment, including thermometers and data loggers
- gathering, recording, classifying and presenting data in a variety of ways to help in answering questions
- taking measurements, using a range of scientific equipment, with increasing accuracy and precision, taking repeat readings when appropriate
- recording data and results of increasing complexity using scientific diagrams and labels, classification keys, **tables**, scatter graphs, bar and line graphs
- use appropriate techniques, apparatus, and materials during fieldwork and laboratory work, paying attention to health and safety
- make and record observations and measurements using a range of methods for different investigations

Aims

To learn how to record data for their experiment

To create a results table

To begin collecting or planning how to collect data

Preparation	Learning activities	Resources
Get all resources for the different experiments ready	Intro: use cog scientific method diagram to show what we have covered so far and what we will cover today – data collection Activity 1 : create a table for own experiments in workbooks • Emphasise where each variable sits in the table • Design table if haven't got equipment for experiments Activity 2: collect data • Collect data in the classroom • Take photos of students collecting data to go on poster boards – Plenary • Groups to explain to the rest of group what their question is and how they will test it	• Pens, pencils and paper • Rulers • Camera

Lesson Plan – Week 4

Curriculum Points Covered

- making systematic and careful observations and, where appropriate, taking accurate measurements using standard units, using a range of equipment, including thermometers and data loggers
- gathering, recording, classifying and presenting data in a variety of ways to help in answering questions
- taking measurements, using a range of scientific equipment, with increasing accuracy and precision, taking repeat readings when appropriate
- recording data and results of increasing complexity using scientific diagrams and labels, classification keys, **tables**, scatter graphs, bar and line graphs
- use appropriate techniques, apparatus, and materials during fieldwork and laboratory work, paying attention to health and safety
- make and record observations and measurements using a range of methods for different investigations

Aims

To learn how to record data for their experiment

To create a results table

To begin collecting or planning how to collect data

Preparation	Learning activities	Resources
Get all resources for the different experiments ready	Intro: use cog scientific method diagram to show what we have covered so far and what we will cover today – data collection Activity 1: Continue to collect data • Collect data in the classroom • Or think about your group will need to collect data outside the classroom • Take photos of students collecting data to go on poster boards – need to ask teachers beforehand. Can't take photos of students but could take photos of experiments on phones Back up activity 1: Data collection • Explain we going to measure heart rate before and after jumping – how would we create a table for this? • Find pulse, measure heart rate and write on board in table. Jump up and down for 1 minute then measure pulse again and write on the board • At the end ask them to identify the variables. Before and after jumping is the independent variable and the dependant variable was the heart rate.	• Pens, pencils and paper • Rulers

Collecting results

Before the pupils start their experiment it is important they think about how they will record their observations. The pupils should create a table so they can record their observations as they happen. In the example you will see a data table drawn up for my chocolate experiment. The variable you change (the **independent** variable) goes in the **left** hand column and the variable you are measuring (the **dependent** variable) goes in the **right** hand column. It is also useful to have multiple rows for each repeat. So in this table I have 6 rows as I am repeating the experiment 3 times with each type of chocolate.

It is also important to have a section where you can note down any observations. Although the students will have planned their experiment before they start, sometimes they may need to tweak their method slightly or they may observe something exciting or unexpected. It is good practice to write these down as they happen so an extra column on their data collection table titled 'other observations' may come in use.

Once you have gone through the example (On the next Page) with the class, ask them to draw their own results table, either on the following page or on a separate sheet of paper.

EXAMPLE

Tip: take photos of your experiment to use on your poster board for the Science Fair!

List of materials

- White and dark chocolate squares (equal weight, surface area, shape, same brand)
- Oven set at 40°C
- Stop watch
- Weighing scales
- Knife to cut chocolate
- Tray to place chocolate on
- Oven gloves

Experimental methods

1) Prepare 3 x white and 3 x dark chocolate samples by weighing out equal amounts and ensuring each has the same surface area.
2) Turn the oven on to 40°C 20 minutes and allow it to warm up to temperature for 20 minutes.
3) Place 1 x white and 1 x dark chocolate samples on the oven tray.
4) Put the tray in the oven and start the timer. Watch the chocolate and note down the time that each of them melts.
5) Repeat steps 3 & 4 with the other samples.

Collecting data

Average calculations

Dark chocolate: $\frac{134+156+170}{3} = 153$

White chocolate: $\frac{268+290+287}{3} = 282$

Results table

Independent variable ↓ Dependent variable ↓

Type of chocolate	Repeat number	Melting time (seconds)	Other observations	Average melting time (seconds)
Dark chocolate	**1**	134		**153**
	2	156		
	3	170		
White chocolate	**1**	268		**282**
	2	290		
	3	287		

Table of results – Activity 1

Pupils should use this space to draw their results table (or alternatively, use a separate sheet of paper and staple it in to the booklet)...

Week Five

Key

Blue Text = Lower Key stage 2

Green Text = Upper Key stage 2

Red Text = Key stage 3

'Lesson' Plan

Curriculum Points Covered

- recording findings using simple scientific language, drawings, labelled diagrams, keys, bar charts, and tables
- recording data and results of increasing complexity using scientific diagrams and labels, classification keys, tables, **scatter graphs, bar and line graphs**
- make and record observations and measurements using a range of methods for different investigations
- present observations and data using appropriate methods, including tables and graphs

Aims

To understand the different ways there are to display data

To make figures using their data

Preparation	Learning activities	
	Intro: use cog scientific method diagram to show what we have covered so far and what we will cover today – data analysis Activity 1 • show other ways of displaying data, Give students different scenarios and get them to think about the best way to display the results and feedback Activity 2: analyse data they have collected • Remind students about spacing numbers evenly on each axis Activity 3: • If there's time, move onto week 6 Plenary • What have you learnt today? Prizes • What is the next stage? Where have we got to so far? What do we need to do next?	• Poster making equipment • Graph paper • Rulers • Rubbers • Glue

Data Analysis

Once the students have collected their data, it is important to use charts and graphs to help them analyse your results. This will help your pupils to explain what happened during their experiment. Some pupils may need to perform simple calculations, for example, calculating the average of their results. However, they may want to display it as individual data points. Or they may want to summarise the data as percentages or ratios. It is important that any calculations they do will help them and others to understand the data from their experiment. Make sure pupils aren't performing calculations for the sake of it!

Graphs

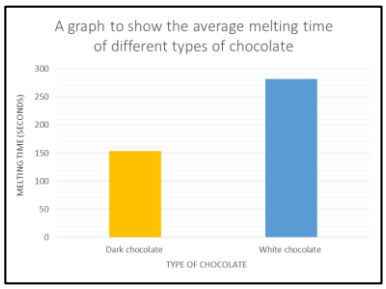
Graphs are a great way to visually display data. When drawing a graph it is important to remember to...

1. Place the **independent variable** (the one you change) on the **x axis** and the **dependent variable** (the one you measure) on the **y axis.**
2. Label the x and y axes of the graph – remember the units! (E.g. seconds, litres, centimetres) and remember to give the graph a title, this can begin with 'This graph shows...'

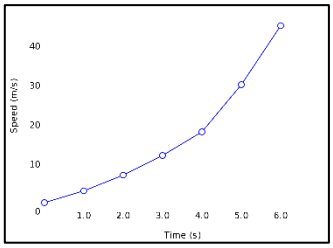
Tip: Spreadsheet programmes such as Microsoft Excel are great for producing different styles of graph

Depending on the experiment, you can use different types of graph:

- A **bar graph** is useful when comparing different experimental groups. A bar graph should be used if the independent variable is not numerical. I have used this in my chocolate experiment as I have 2 non-numerical categories (white and dark chocolate). I have averaged the data for both groups (see below).

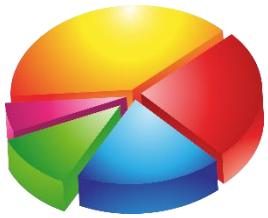


- A **line graph** can be used to show the relationship between the independent and dependent variable. Both variables **have** to be numerical for this graph. For example, if you were investigating the effect of temperature on plant growth you might change the temperature (x axis) and measure the plant growth after a period of time (y axis).



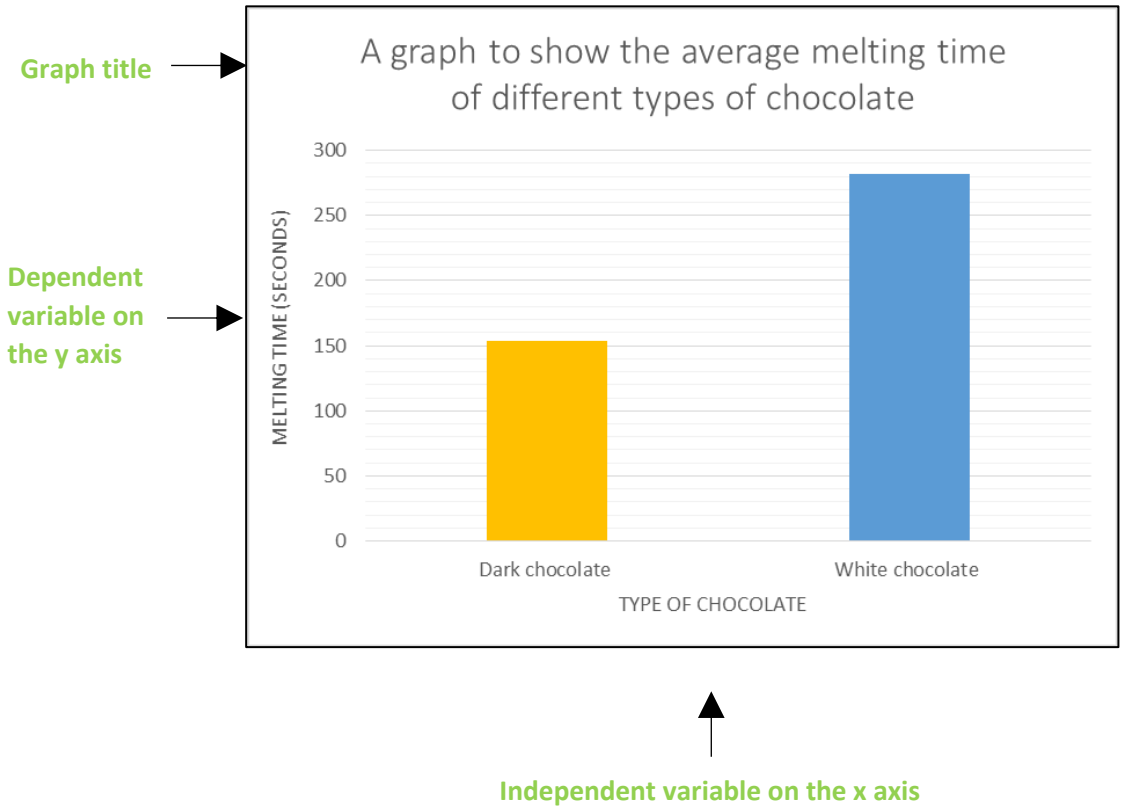
- A **time-series** is a type of line graph. You use this graph if your independent variable is time and your dependent variable is numerical. For example, if you were investigating plant height over time you might have a graph plotting days (x axis) against plant height (y axis).

- A **pie chart** is a good way to display percentages of groups. All of the pieces of the pie need to add up to 100 %. This type of graph is useful if conducting surveys. For example, if you are investigating what people in your class had for breakfast then you could conduct a survey, group the answers and calculate the percentages for each group.



Data analysis

As my independent variable (white and dark chocolate) is non-numerical I have decided to plot a bar graph showing the average melting time of the dark and white chocolate. In order to do this I have added an extra column onto my table to record my average melting times. I have then plotted the data on the bar graph here:



Tip: If you pupils are drawing graphs by hand it is important to be accurate so please use graph paper. You can download some from this link: http://www.mathsphere.co.uk/resources/MathSphereFreeGraphPaper.htm

If you are using spreadsheet software it is important you understand how the data has been extracted from the table and plotted onto the graph.

If you are using spreadsheet software it is important you think about which axis the variables should be on as sometimes Microsoft Excel does not put them in the right place.

Data Analysis

Pupils should use this space for any calculations they may need to complete before plotting graphs (e.g. calculating the average)

Week Six

Key

Blue Text = Lower Key stage 2

Green Text = Upper Key stage 2

Red Text = Key stage 3

'Lesson' Plan

Curriculum Points Covered

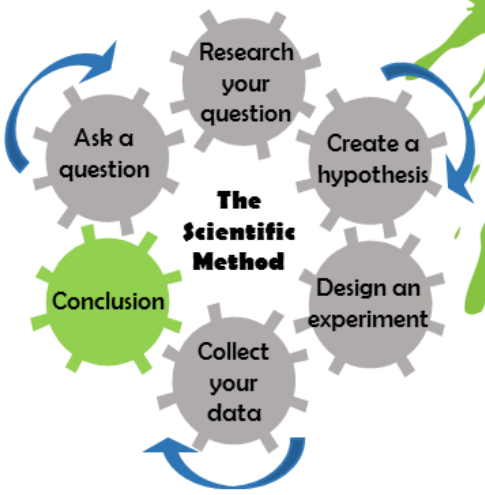
- reporting on findings from enquiries, including oral and written explanations, displays or presentations of results and conclusions
- using results to draw simple conclusions, make predictions for new values, suggest improvements and raise further questions
- using test results to make predictions to set up further comparative and fair tests
- reporting and presenting findings from enquiries, including conclusions, causal relationships and explanations of and degree of trust in results, in oral and written forms such as displays and other presentations

Aims

To learn how to draw conclusions from their data

Preparation	Learning activities	Resources
Photocopy Worksheets	Intro: use cog scientific method diagram to show what we have covered so far and what we will cover today – conclusions from experiment and create poster boards. Leave this if time is short! Activity 1: Conclusion questions **WORKSHEET** • Work in research group to work through answers Activity 2: Poster board activity Each person takes one section: title, question and hypothesis, method, results (table and graph), conclusion, evaluation • Explain: poster board will help you present research at the festival, presenting alongside academics and people from industry, the audience will be year 5&6 • Identify key sections that should go on the poster board (each section of scientific method should have a page and photos of experiment) • Match up labels to poster board **WORKSHEET** • Start planning and making poster boards	Poster making equipment

Drawing conclusions



In the conclusion, pupils should summarise their results and identify whether their results prove or disprove their hypothesis. Get your pupils to ask themselves a few simple questions to help them conclude their project...

- What did you find out?
- Do your results prove or disprove your hypothesis?
- If you were to do the experiment again, would you change anything?
- Research often leads to more questions. Do you have any more questions now that you have completed your experiment?
- What is the application of your research? Or in other words how can your experiment be used in a real life situation?

EXAMPLE

- What did you find out?
  My results showed that dark chocolate melted slower than white chocolate.
- Do your results prove or disprove your hypothesis?
  Original hypothesis: White chocolate will melt faster than dark chocolate
  My results disprove my hypothesis.
- If you were to do the experiment again, would you change anything?
  I would have made sure both the white and dark chocolate samples were at the same temperature before putting them in the oven. I could, for example, have placed them in the fridge for an hour before starting the experiment.
- Research often leads to more questions. Do you have any more questions now that you have completed your experiment?
  - *Does milk chocolate melt faster than dark chocolate?*
  - *Does the material the oven tray is made off affect the melting time?*
  - *Do different brands of chocolate melt at a similar rate?*
- What is the application of your research? Or in other words how can your experiment be used in a real life situation?
  When scientists design chocolate they may be interested in melting time when transporting it from one place to another.

Stress to your pupils that it **DOESN'T MATTER** if they prove their hypothesis correct or incorrect. The point of the project is **NOT** to prove it correct, the point is to find out more about how the world (biologically, physically or chemically) works. Proving or disproving a hypothesis provides valuable information that can be used to generate a further hypothesis. No matter the outcome it is important that the pupils understand their project and that you carried out each step of the scientific method.

In your conclusion you should summarise your results and identify whether your results prove or disprove your hypothesis. Asking yourself the following questions can help when concluding your project...

Activity 1

What did you find out?

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What did you learn?

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Do your results prove or disprove your prediction/hypothesis?

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Was your project successful? Why? What went well in your project? Were you able to answer your research question?

What impact could your project have on other people? For example does it relate to environmental issues or provide a solution that may improve people's lives?

What would you do differently if you were doing this project again? Why? What could you have done to make this project even better?

Creating a display board

Tip: When you read a science display board you usually start at the top left and read down each column...

Now that your pupils have finished their research, it is time to for them to prepare their display board for the science fair! Stress to your pupils the important of making the display board attractive. They may be an expert in their chosen topic but if they don't make their display board attractive then people may not be interested in their work!

Below is an example of a display board at a primary school science fair,. You can use this format help your students create their display boards. The shaded labels are part of the scientific method used throughout the project, pupils can use these as titles for each section of their poster.

Trifold cardboard display board

Catchy title

Clearly labelled sections with large text

Abstract: Summary of your research

Results: including graphs

Hypothesis

Photos of the results or you carrying out the experiments

Background research

Conclusion and future directions/ further experiments

Materials

Experimental methods/ procedure

Examples of materials used in the experiments that you can use to help you explain your research

Activity 2

Use a pencil to label the display board below...

Photos of the results or you carrying out the experiments

Materials

Catchy title

Results: including graphs

Trifold cardboard display board

Conclusion and future directions/ further experiments

Abstract: Summary of your research

Experimental methods/ procedure

Background research

Examples of materials used in the experiments that you can use to help you explain your research

Hypothesis

Clearly labelled sections with large text

Display board examples

The display board does not have to be all singing and dancing, the idea is to get pupils excited and enthusiastic about doing STEM research. Here are some examples of display boards that have been produced in the past...