



Webinar 3. Teach enquiry

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Designing for enquiry

Design criterion

Automatise enquiry skills

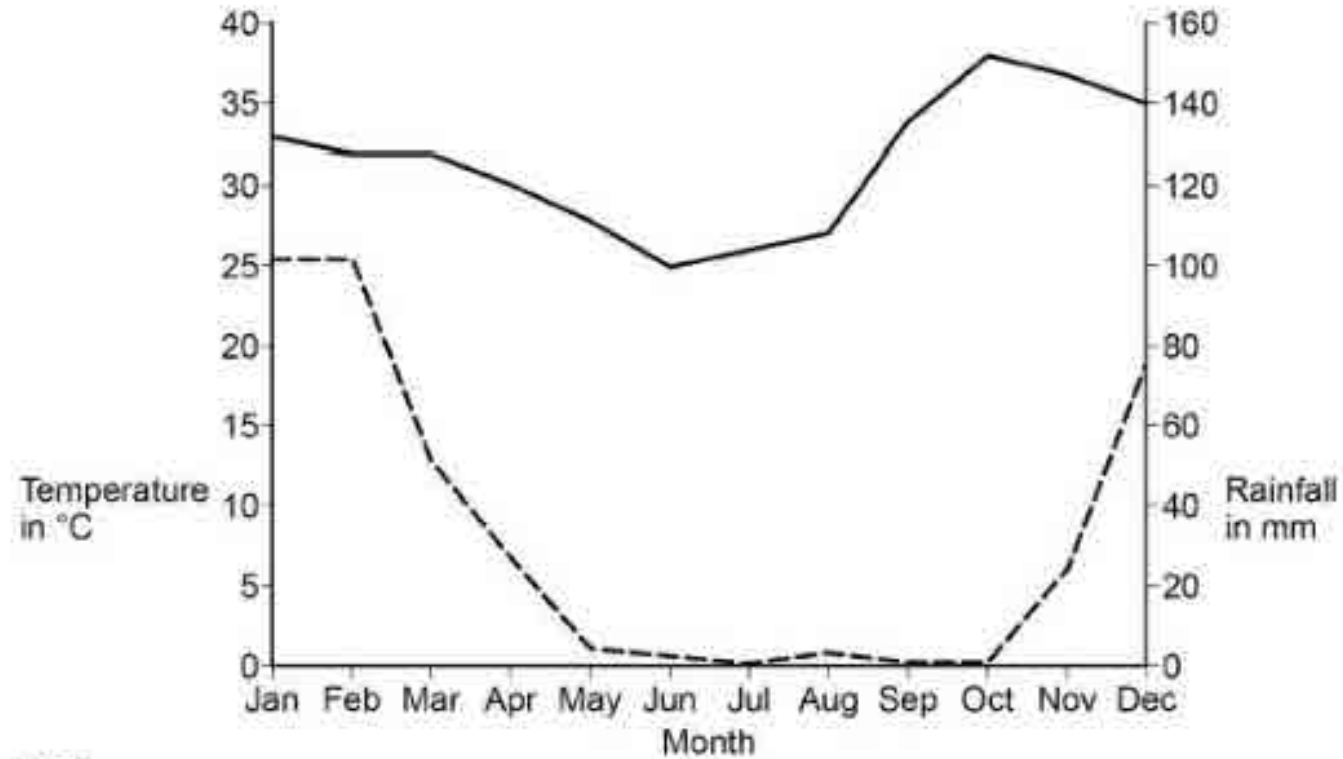
Develop 'scientific thinking' ability

(d) The Baobab tree grows in Botswana, Africa.

The tree has no leaves for up to 9 months of the year.

Figure 2 shows the average temperature and rainfall each month in Botswana.

Figure 2



Key

— Average maximum temperature in °C

- - - Average rainfall in mm

Explain how having no leaves from March to November allows the Baobab tree to survive in Botswana.

Multiple ideas

Plant transport

Transpiration rate

Photosynthesis

Adaptation

Multiple skills

Plant transport

Transpiration rate +

Photosynthesis

Adaptation

Find patterns in data

Determine variables

Review hypothesis

Challenge 1: cognitive overload

Plant transport

Transpiration rate +

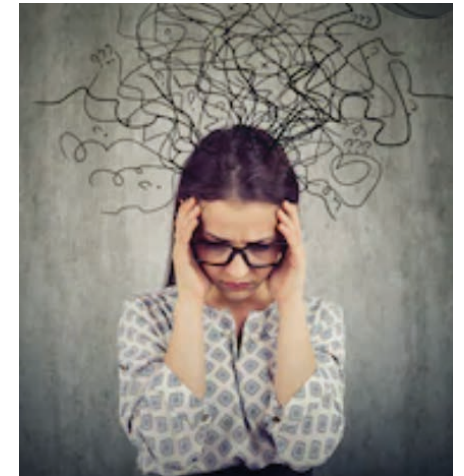
Photosynthesis

Adaptation

Find patterns in data

Determine variables =

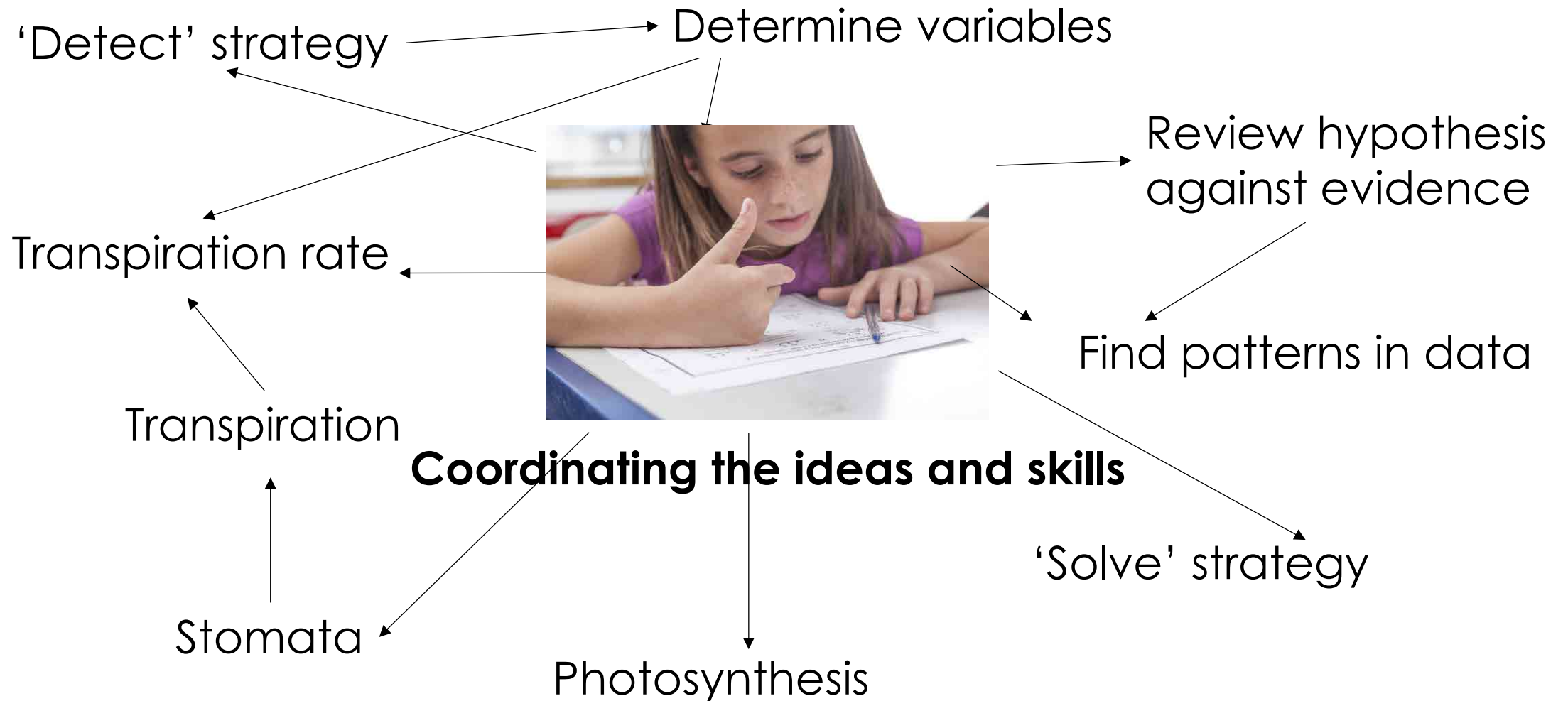
Review hypothesis



Solution

**Automatise enquiry by learning
skills to fluency**

Challenge 2: 'scientific thinking'



Solution

**Develop scientific thinking by
coaching students to think**

Progression in scientific thinking

Primary: types of enquiry

Classifying



Fair tests



Patterns



Observing



Researching



(other's explanations)

Secondary: types of thinking

Classifying

Experimental

Quantitative

Statistical

Theorising

(own explanations)

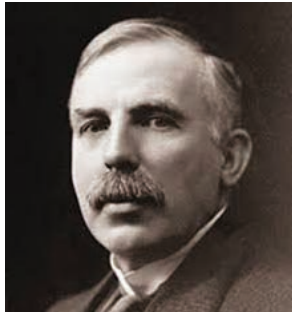
5 types of scientific thinking

- **Classifying:** categorising and distinguishing
- **Experimental:** cause-effect relationships
- **Statistical:** patterns and correlations
- **Theorising:** developing models
- **Quantitative:** mathematising

Types of thinking in action

Theorising

e.g. Atomic model



Rutherford

Experimental

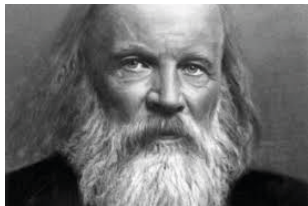
e.g. Radioactive decay



Curie

Classifying

e.g. Periodic table



Mendeleev

Statistical

e.g. System damage



Doll

Quantifying

e.g. 2nd law



Newton

Detect scientific thinking in GCSE spec

4.2.3.2 Plant organ system

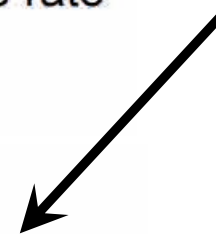
Content

Students should be able to explain the effect of changing temperature, humidity, air movement and light intensity on the rate of transpiration.

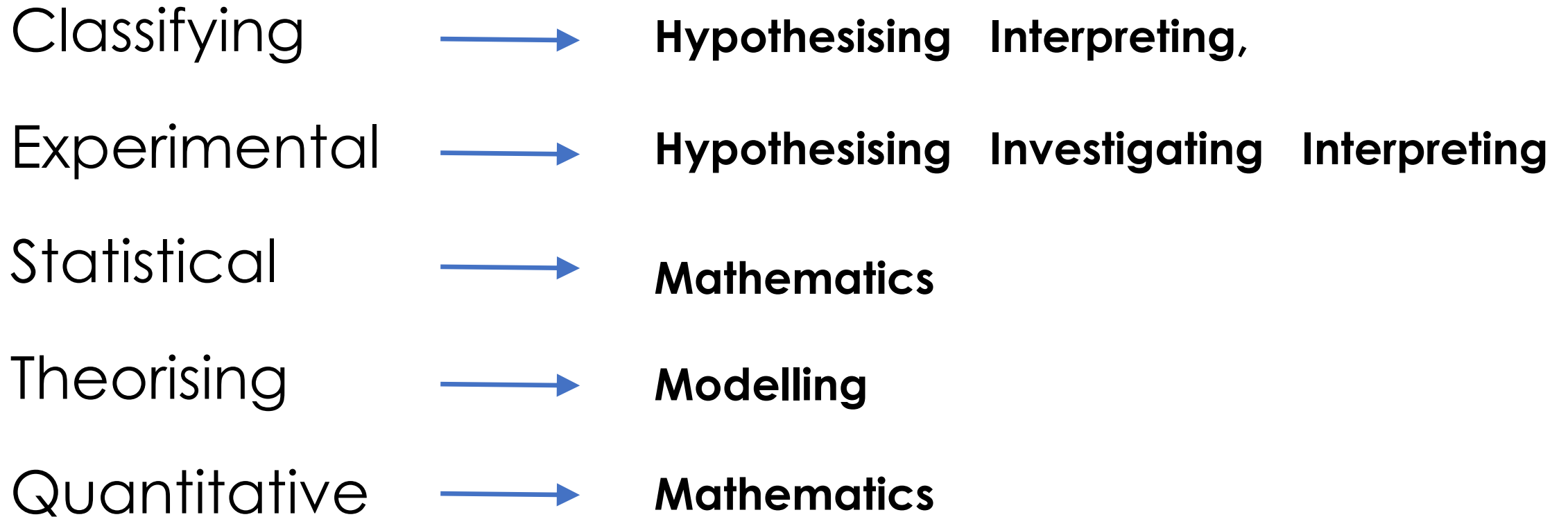
Students should be able to:

- translate information between graphical and numerical form
- plot and draw appropriate graphs, selecting appropriate scales for axes
- extract and interpret information from graphs, charts and tables.

**Transpiration is an
'experimental thinking'
idea**



Scientific thinking coordinates skills



Skills in Blueprint

Automatise enquiry by learning skills to fluency

- Blueprint defines all enquiry skills
- Blueprint integrates all skills for teaching in Y7/8
- Blueprint repeats skills regularly in Y9-11
- Blueprint assumes 'gradual release of responsibility'

Modelling

- Compare a model with observations
- Use a model's features
- Represent with a model
- Evaluate a model's limitations
- Make a reasoned prediction

Interpreting

- Recognise uncertainties
- Review a hypothesis against evidence
- Identify experimental limitations
- Draw a reasoned conclusion
- Find patterns in data

Argument

- Consider a range of perspectives
- Make reasoned arguments

Enquiry skills

Hypothesising

- Invent a scientific hypothesis
- Think up an experiment

Investigating

- Collect sufficient data
- Choose appropriate method
- Identify hazards
- Determine variables

Literacy

- Judge reliability
- Interpret complex texts
- Write with coherence

Mathematics

- Determine relationships from graphs
- Solve equations
- Use fractions and percentages
- Use proportions and ratios
- Construct charts & graphs
- Estimate true value

Integrates all skills for teaching in Y7/8

Each acquire has a linked foreground skill.

7KC-Energy

Mastery planner 7U-Energy unit

Potential energy

Level 3 Potential energy: An object can store energy because of its position. When released, potential energy can be transferred to kinetic energy.

Level 2 Gravitational energy, Elastic energy

Level 1 Magnetic potential energy, Chemical potential energy, Chemical energy store

Skill Compare actual & predicted results.



ES-Review a hypothesis against evidence

Technique Measure length

Goal To determine what factors affect the potential energy of a raised or stretched object.

Repeats skills regularly in Y9-11

7KC-Energy
8KC-Elements & compounds
8KC-Gas exchange
9KC-Periodic patterns
10KC-Photosynthesis
11KC-Classification



ES-Review a hypothesis against evidence

**Skills in your
curriculum**

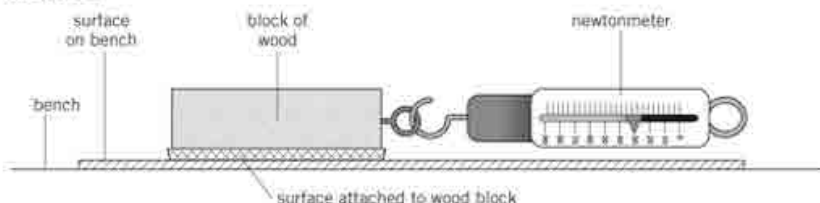
Typical 'enquiry' activity

Core Practical – Investigating Friction

Aim – To investigate how the material affects the amount of friction.

Prediction – Put the different surfaces in order from highest to lowest friction. Explain your choice.

Method –



1. Set up equipment as shown above
2. Take 3 readings for each surface by measuring the force needed to keep the block moving
3. Calculate the mean of the 3 readings
4. Record in results table

Variables – Identify the following variables.

Independent variable -

Dependent variable -

Control variables -

Results – Copy and complete this table.

Type of surface	Force needed to keep block moving (N)			Mean
	Trial 1	Trial 2	Trial 3	

Conclusion Questions – Answer in full sentences.

1. Write the order of the type of surface from highest to lowest friction.
2. Was your prediction correct?
3. Use your results to explain your answer to Q1.
4. Use your knowledge of the surface to explain your answer to Q1.
5. How repeatable were your results? Explain your answer.
6. How else could you reduce friction?
7. **Stretch:** How accurate do you think this practical is? How could you improve this experiment to get more accurate results?

Typical issues

‘Investigation’ lessons that incorporate several skills – no clear focus.

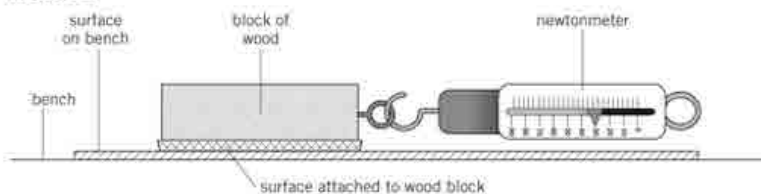
Repetition of the same skills

Core Practical – Investigating Friction

Aim – To investigate how the material affects the amount of friction.

Prediction

Method –



1. Set up equipment as shown above
2. Take 3 readings for each surface by measuring the force needed to keep the block moving
3. Calculate the mean of the 3 readings

Identify variables

Dependent variable -

Control variables -

Calculate mean

Surface	Trial 1	Trial 2	Trial 3	Mean

Conclusion Questions – Answer in full sentences.

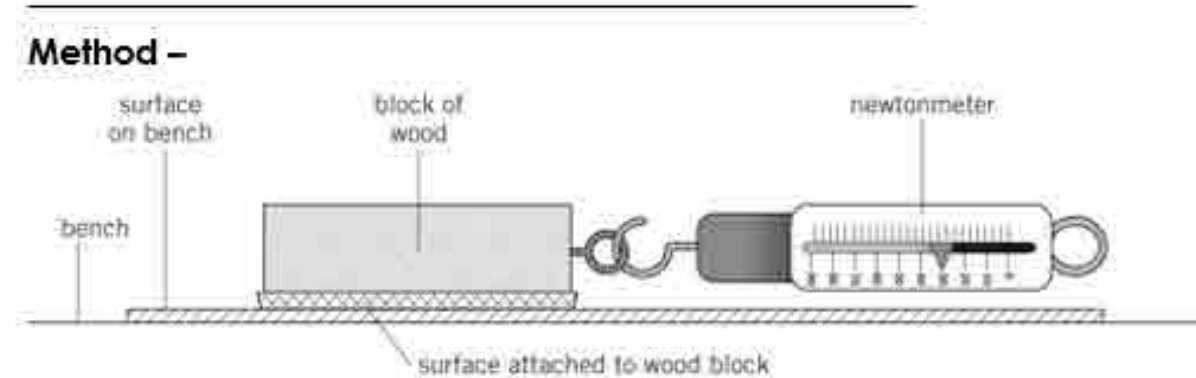
1. Write the order of the type of surface from highest to lowest friction.

Determine patterns
Repeatability
Accuracy

Typical issues

No scientific thinking:
why the skill is being
used.

Identify
variables



1. Set up equipment as shown above
2. Take 3 readings for each surface by measuring the force needed to keep the block moving
3. Calculate the mean of the 3 readings
4. Record in results table

Variables – Identify the following variables.

Independent variable -

Dependent variable -

Control variables -

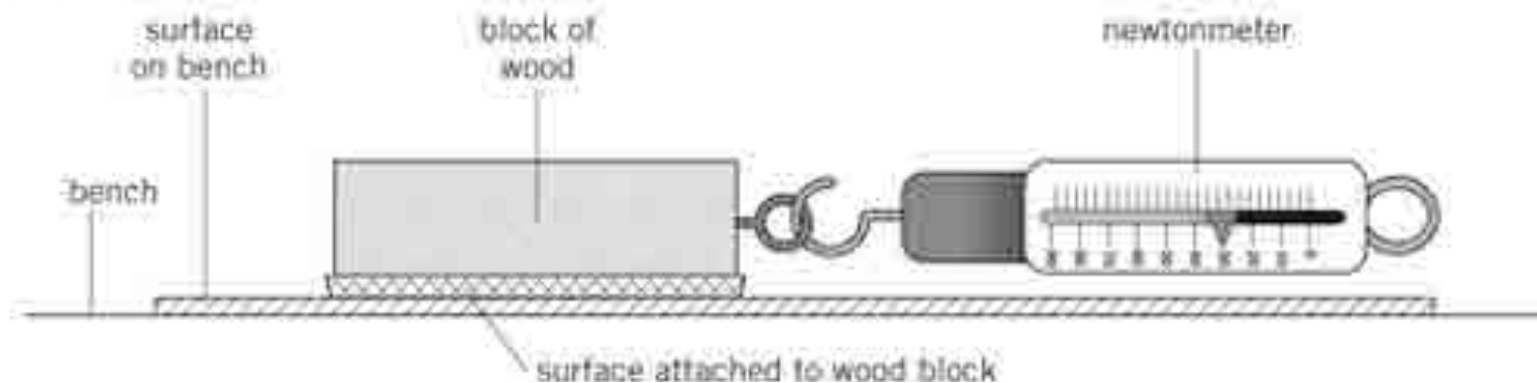
Typical issues

No experimental context to connect skill to

Aim – To investigate how the material affects the amount of friction.

Prediction – Put the different surfaces in order from highest to lowest friction. Explain your choice.

Method –



Typical issues

Skills are not taught: no teacher modelling and student practice.



Typical issues

Skills are not assessed.



How to integrate enquiry

Improve enquiry in your scheme

1. Choose associated enquiry skills
2. Add 'need to know' contexts
3. Teach the skills
4. Give opportunities for practise
5. Assess the skills

1. Choose enquiry skill

Find the enquiry skill in the relevant Key Concept planner.

Acquire

Surface friction

Level 3	Surface friction: The force always acts in a direction to resist relative motion between two surfaces. Its magnitude depends on the roughness of the surfaces and the force pushing them together.
Skill	Consider limitations of data as evidence and suggest ways of improving accuracy.
Technique	Measure force
Goal	To choose a suitable material for an application, by investigating what variables affect the frictional force between surfaces.

2. Add a 'need to know' context

Each year, 250,000 people in the UK go to hospital after a fall. Wet surfaces increases the risk.

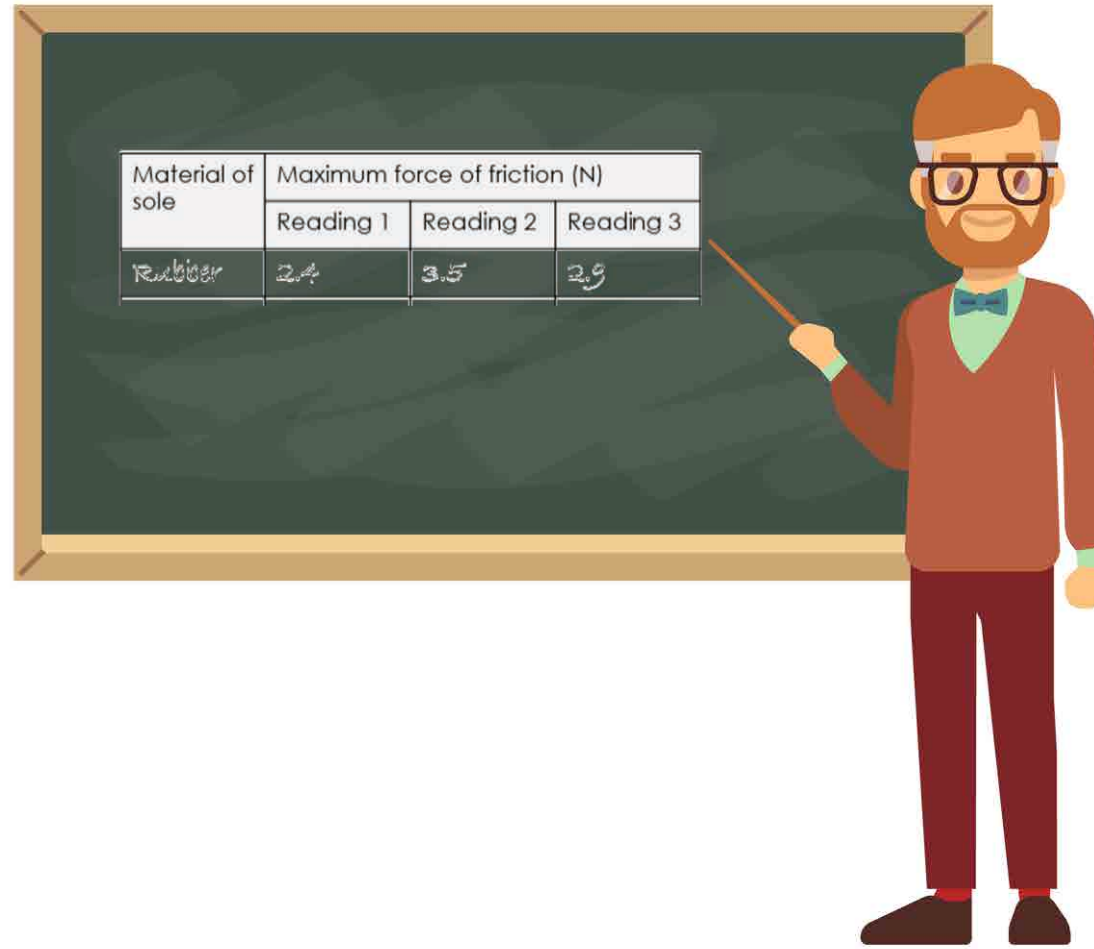


Engineers can reduce the number of falls by designing soles that don't slip.

ENGAGE

What's the best sole for wet conditions?

3. Teach the skill



4. Give opportunities for practice

Apply

Goal To interpret data about how particular variables affect friction using a model, To interpret speed-time data using resistive forces.

Analyse

Goal To draw conclusions about the effectiveness of a product in minimising friction or air resistance.

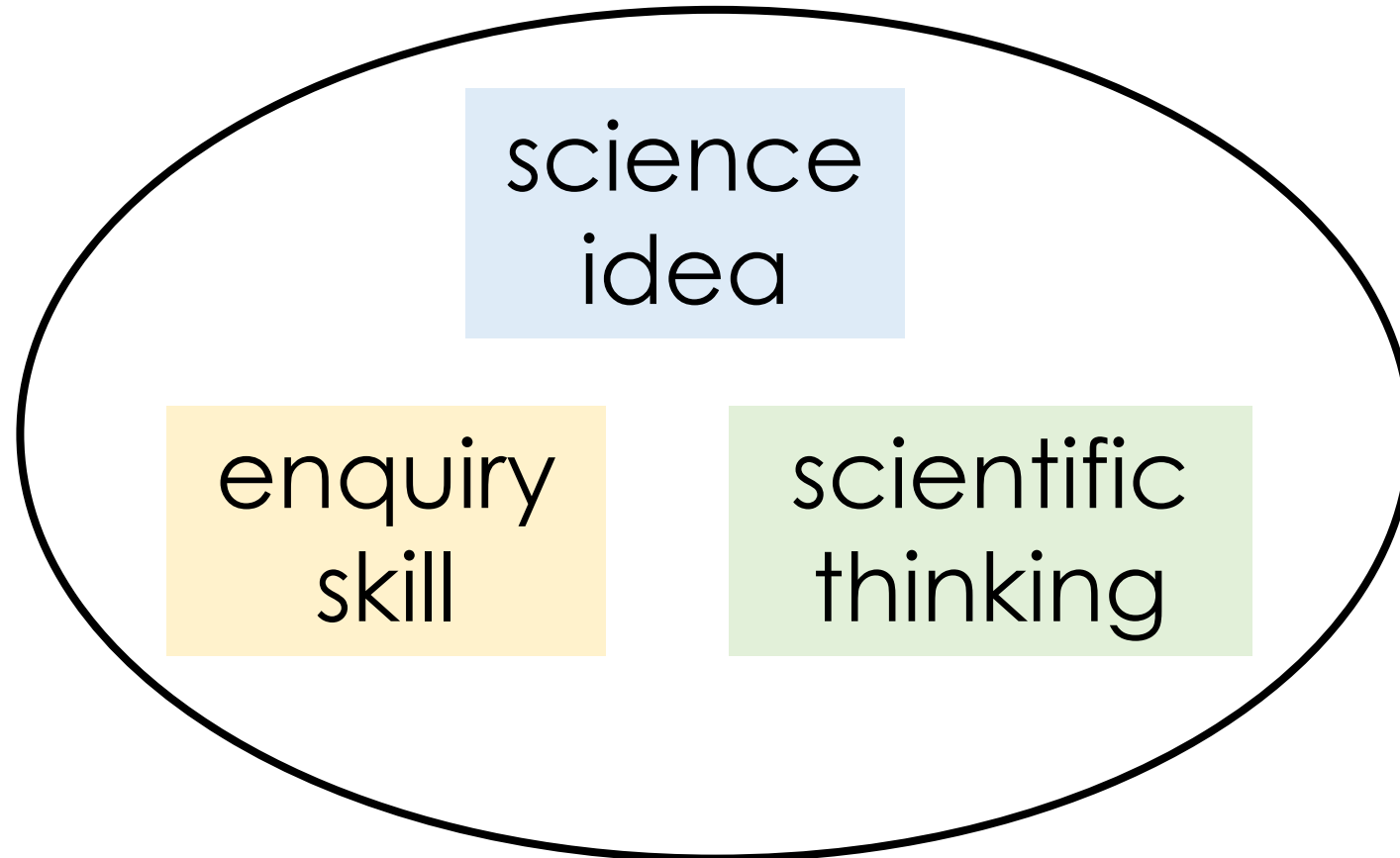
5. Assess the skill

- The evaluate stage of acquire
- As part of apply/analyse
- Summative assessment



Teach skills

Added value: blending enquiry with science ideas



How can you teach enquiry efficiently?

Explain - clarify the need for this skill and where it fits

Demonstrate – worked example

Guide – coaching/support for students

Empower – independent practice

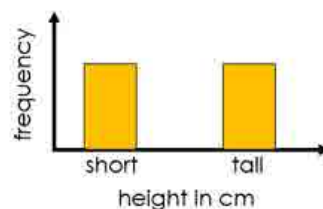
EDGE in action

Explain

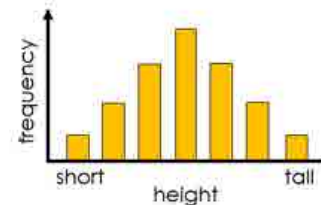
EXPLORE A

How do you think height depends on genes?

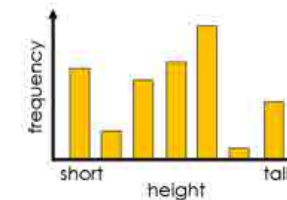
Find out how height varies in your class.
The pattern is evidence of whether one, many or no genes are involved.



one height gene



many height genes



no height genes

Activity: Collect data

SS1

- Measure your partner's height and put it in the table.
- Record the height of the whole class.
- What pattern do you think the data will show?
- What axes would be best for the chart? Why?

Demonstrate

EDGE in action

ENABLE



How do you draw a histogram?
Follow these 6 steps:



COMPUTE

1. Write out the data in order.



Mass of monsters in kg:



40, 41, 41, 42, 45, 46, 51, 51, 52 ...

Guide

Activity: Draw a histogram to show monster mass

SS2

- Continue to write the mass in order

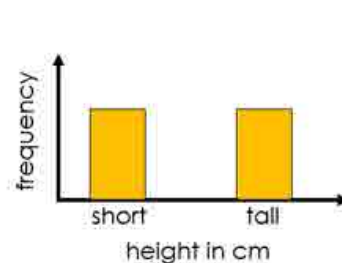
Empower

EDGE in action

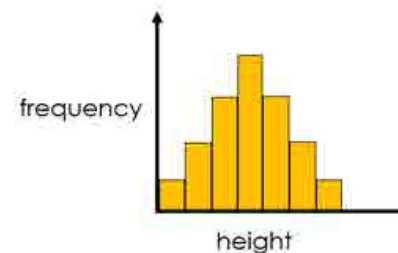
EXPLORE B

How do you think height depends on genes?

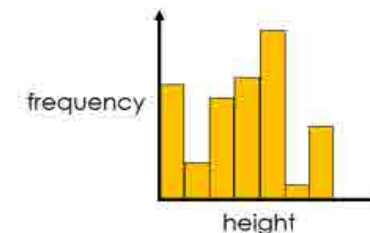
Now draw a histogram to show the pattern of heights. It will tell you whether one, many or no genes are involved.



one height gene



many height genes



no height genes

Activity: Display data

- Put the data for height into a frequency table.
- Draw a histogram.
- What does the pattern show about how height is inherited?

When should practical work be used?

1. As part of an acquire

Focus is on acquiring the main science idea, using an experiment

Battery voltage

Level 3 Battery voltage: Current flows around a circuit because of a force created by a battery. The bigger the current and the brighter the bulbs.

Level 2 Electric current

Level 1 Circuit diagram, Circuit symbols, Ammeter, Cell, Electron, Battery, Voltage

Skill Provide relevant evidence from the data, to support a conclusion.

Technique Construct circuits, Construct circuits, Measure potential difference, Measure current

Goal To determine what affects current by constructing circuits with different numbers

When should practical work be used?

2. As a practical lesson

Focus is on teaching practical techniques and the enquiry skill.

Diffusion practical

Level 3	(Practical lesson)
Level 2	Diffusion
Level 1	N/A
Skill	Decide suitable independent, dependent and control variables to test an idea.
Technique	Measure area, Measure temperature, Measure time
Goal	To determine the effect of temperature on the diffusion of a substance.

What about required practicals?

- AQA Combined science has 19 required practicals.
- These are in the planners as practical acquire lessons.
- Most are covered in a 9-11 key concept, a few in year 7/8.

Scientific thinking in Blueprint

Develop scientific thinking by coaching students to think

- Blueprint statements describe scientific thinking
- Blueprint tasks support scientific thinking

Statements describe scientific thinking

Acquire

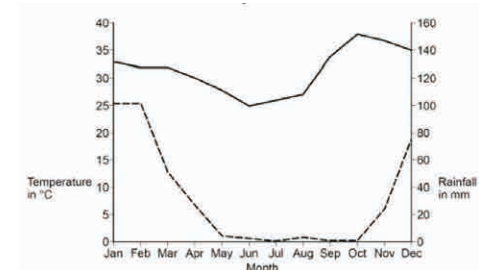
Main idea

Stomata open in light which lets in carbon dioxide for photosynthesis but causes water loss. Water is replaced via the transpiration stream, which is partly caused by diffusion of water out of the stomata. Therefore temperature, humidity, air movement, number of stomata and light intensity affects transpiration rate.



Apply

Practice questions



Tasks support scientific thinking

Acquire

Acquire task

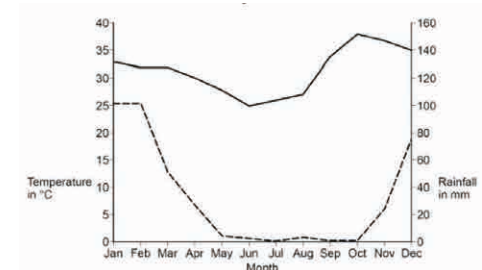
To make predictions about how variables affect the rate of transpiration and then use data taken from a potometer to check them.



Main idea

Apply

Practice questions



**Teach
scientific thinking**

acquire

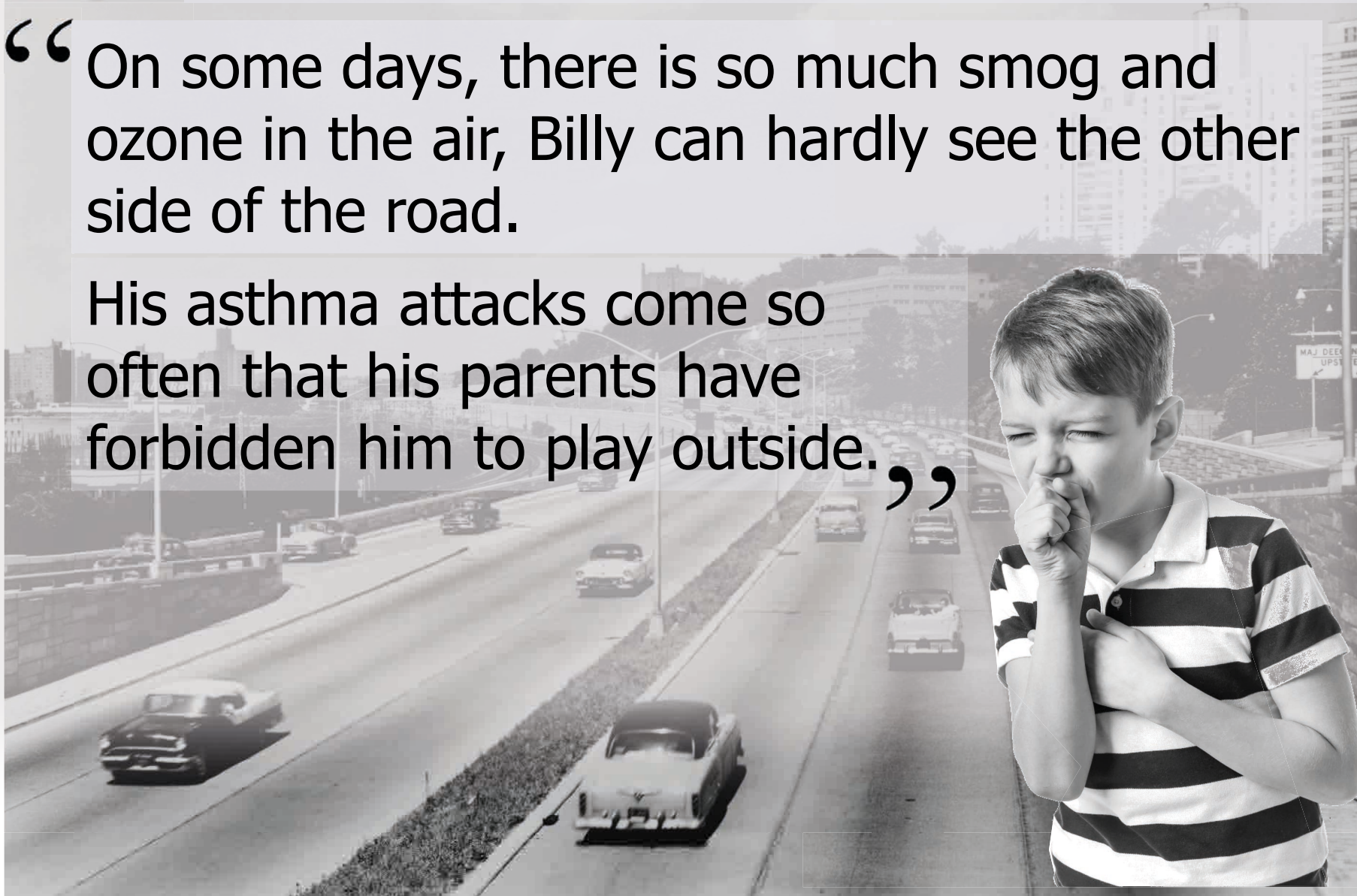


Oxidation & reduction

Lesson 1: Oxidation

“On some days, there is so much smog and ozone in the air, Billy can hardly see the other side of the road.

His asthma attacks come so often that his parents have forbidden him to play outside.”



“ Hello, I’m Eugene Houdry. Welcome to my company. Our mission is to help children like Billy.

Smog and ozone are made when gases from car exhausts react in sunlight.



Watch this clip.”



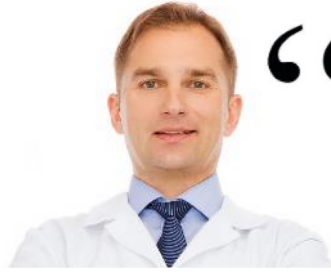
ENGAGE

Los Angeles, 2000s

“ In the future, I hope children will be able to play outside and see clear skies above LA.



How can we reduce air pollution? ”



“First, my colleague will get you up to speed with the science and skills.”

In this lesson, we will learn:



SCIENCE
IDEA

What happens when substances react with oxygen



ENQUIRY

How to make a scientific hypothesis from your ideas

ENGAGE


Here are some gases that come out of a car's exhaust pipe.



How do these compounds form?


Next steps

Get the Y7/8 planners now



7KC-Cell structure

Mastery planner 7U-Cells unit



Novice

Activate

Prior PS-Life processes: There are differences between things that are living, dead, and things that have never been alive.

Goal To show understanding of prior ideas that are prerequisite for new learning.

Acquire

Building blocks

Level 3 Building blocks: Studying living organisms with microscopes revealed that they are made of one or more cells - the smallest living units.

Level 2 N/A

Level 1 Multicellular, Microscope, Single-celled organism, Scale of cells, Calculate total magnification

Skill Argue for a claim by explaining how each piece of evidence supports it or not.

Technique Use a microscope

Goal To check a claim that an unknown specimen is alive by using a microscope to examine plant and animal cells and identifying common structures.

Life functions

Level 3 Life functions: Cells use energy to carry out life processes like growth and reproduction and have specific parts for these jobs.

Level 2 Plant cell, Bacterial cells

Level 1 Ribosome, Cell membrane, Nucleus, Cytoplasm, Mitochondrion, Chloroplast, Cell wall, Permanent vacuole, Flagella

Skill Represent a real world event, process or system using a model.

Technique ...

Goal To examine diagrams of real animal, plant and bacteria cells, identify similarities and differences, and explain how those parts keep the cells alive.

Level 3 N/A

Level 2 N/A

Level 1 N/A

Skill N/A

Technique N/A

Goal ...

Assess


Goal To show accurate understanding of the ideas and rectify gaps and misconceptions before problem-solving.

Apply

Goal To identify what type an unfamiliar cell is with reasons, by comparing its structures to those of plant and animals, To work out an explanation for how a given change in a cell will affect the whole organism.

Analyse

Goal To interpret experimental results about cells and make an argument that cells carry out life processes.



Expert

U = unit, KC = Key Concept, PS=Primary Science, Level 3 = main idea, Level 2 = other ideas, Level 1 = terms/facts

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