Dr Tony Sherborne

mastery science

What are your goals?

GCSE success

What are your goals?

Pass GCSE

Pass GCSE

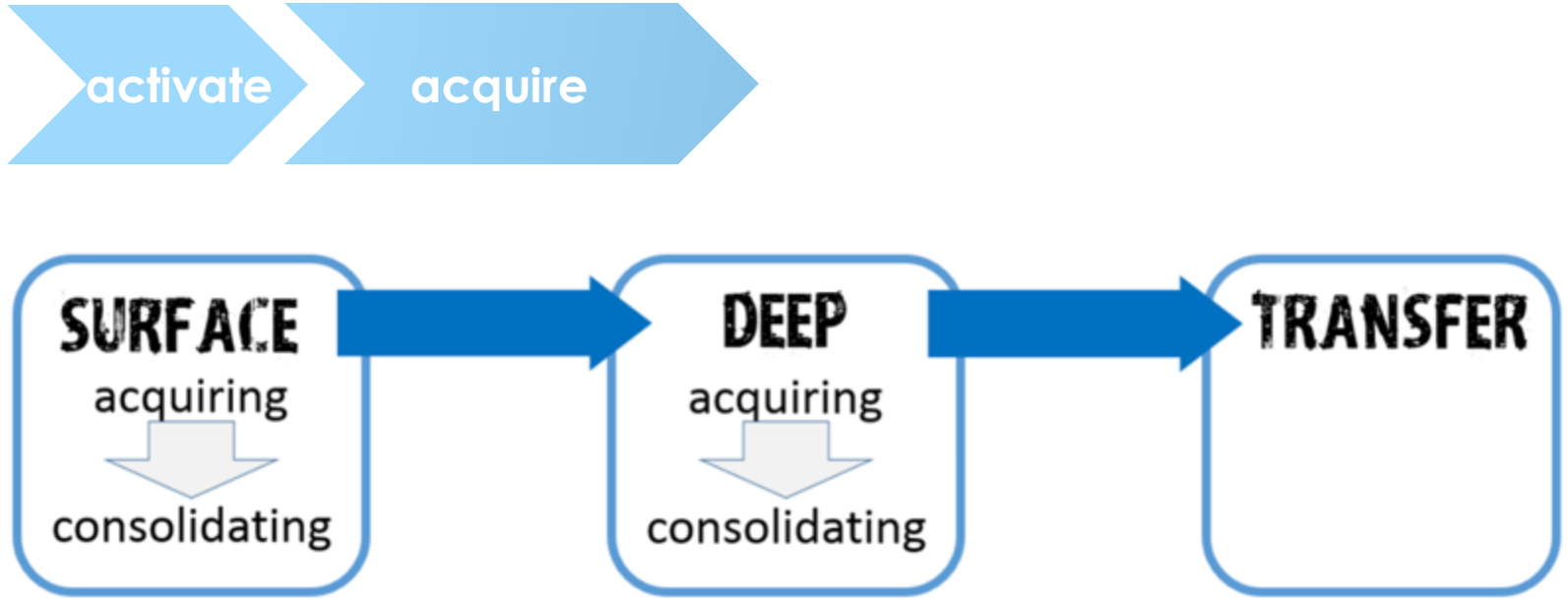
Preparation for further study

Interest in STEM career

Scientifically literate citizen

Will you adopt Hattie's learning model

Surface learning curriculum



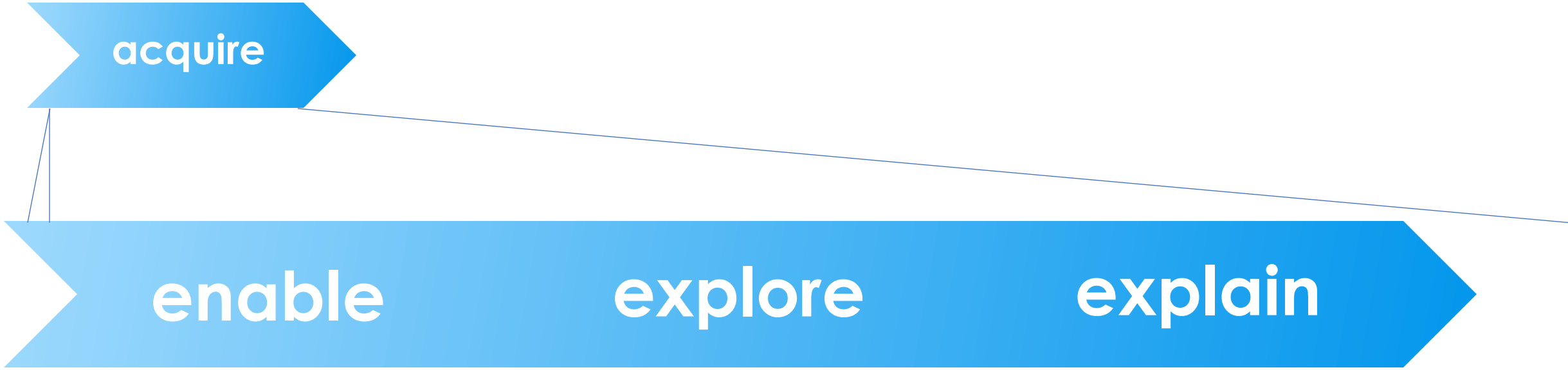
"it is important to have the right balance: you need to have surface to have deep; and you need to have surface and deep knowledge and understanding in a context." *John Hattie*

Our our mastery learning model?

Surface learning

Deep, transferable learning

How does it fit with direct instruction?



Direct instruction **Guided** enquiry Direct instruction

~~5 lesson tweaks~~

5 curriculum design habits

1. Create curiosity
2. Build models
3. Concrete preparation
4. Just-in-time skills
5. Use analogies

mastery science


1.Create curiosity

Will this create curiosity?

Introduce energy transfer

Energy stores: Introduce energy stores to students giving examples of each type. Students suggest another example of each type by trying to use examples in the room.

It's an investment strategy for mental energy

It could be a major factor in learning:

"A hungry mind is a core determinant of individual differences in academic achievement"

"alongside the core pillars of intelligence and effort"

Review of meta-analysis by von Stumm, S., Hell, B., & Chamorro-Premuzic, T. (2011)

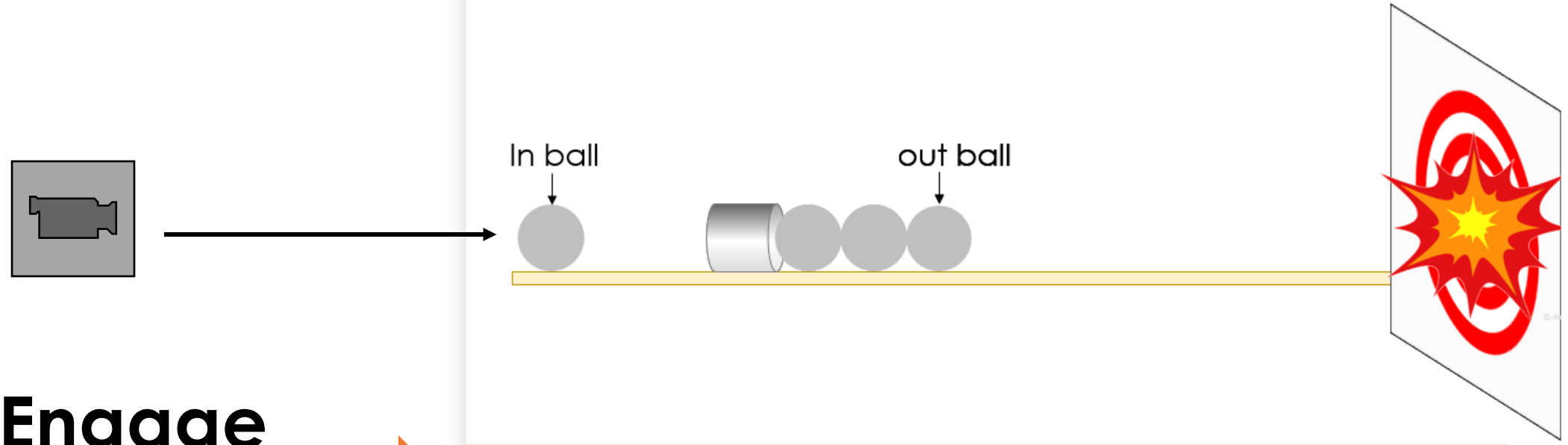
activate

Hook → **Engage question** → **Explore question**

- Surprising phenomenon
- Narrative
- Dilemma question

REVIEW

You can make a version of a Gauss cannon that destroys a target - if you know how it works.



Engage question

Why does the out ball move so fast?

activate | acquire

What does the kinetic energy store depend on?

Activity: Investigate kinetic energy

- Try changing the two variables: speed and mass
- Write your predictions
- Do the experiments
- Do speed and mass make a difference to kinetic energy?

How to write a prediction

Surface learning approach

‘Trigger interest’ in energy and temperature

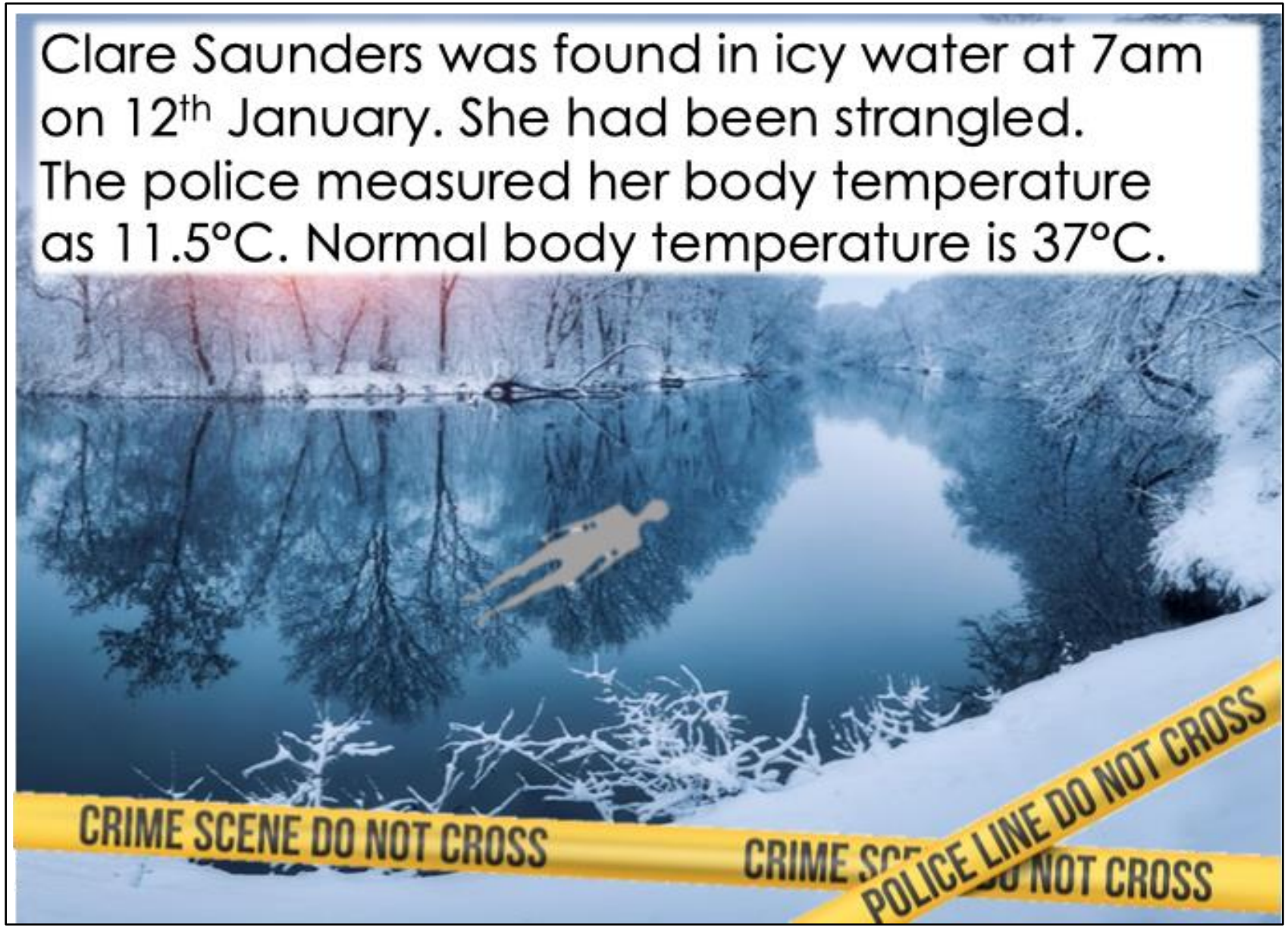
Energy and temperature: Show the image of the volcano on the lesson presentation. Ask ‘why do rocks melt. Students should suggest that rocks get very hot.

Hook

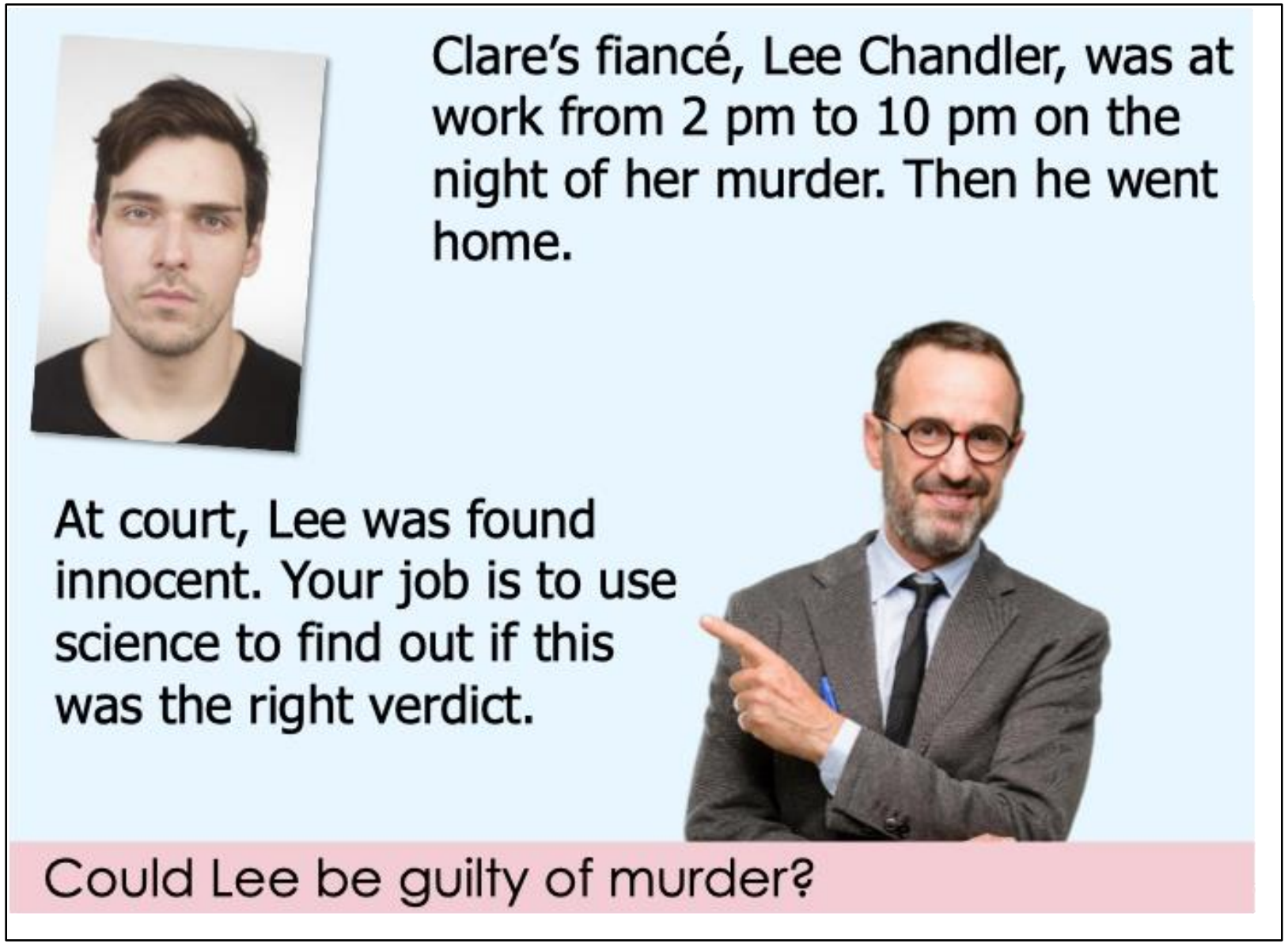
You're training to be a forensic scientist.

Class, I've found this interesting case for you.

Hook


Clare Saunders was found in icy water at 7am on 12th January. She had been strangled. The police measured her body temperature as 11.5°C. Normal body temperature is 37°C.
CRIME SCENE DO NOT CROSS
POLICE LINE DO NOT CROSS

Engage question




2. Build models

Are these surface or deep learning goals?

Energy transfer

Transfer of energy: An animation is available to explain energy stores, the transfer of energy between stores, and the law of conservation of energy.

Conservation of energy: Students then carry out a circus activity to identify energy stores before and after an energy transfer.

enable

explain

Facts
Basic ideas
Procedures

Key concepts
- Complex ideas
- AO2 application
- AO3 analysis

enable

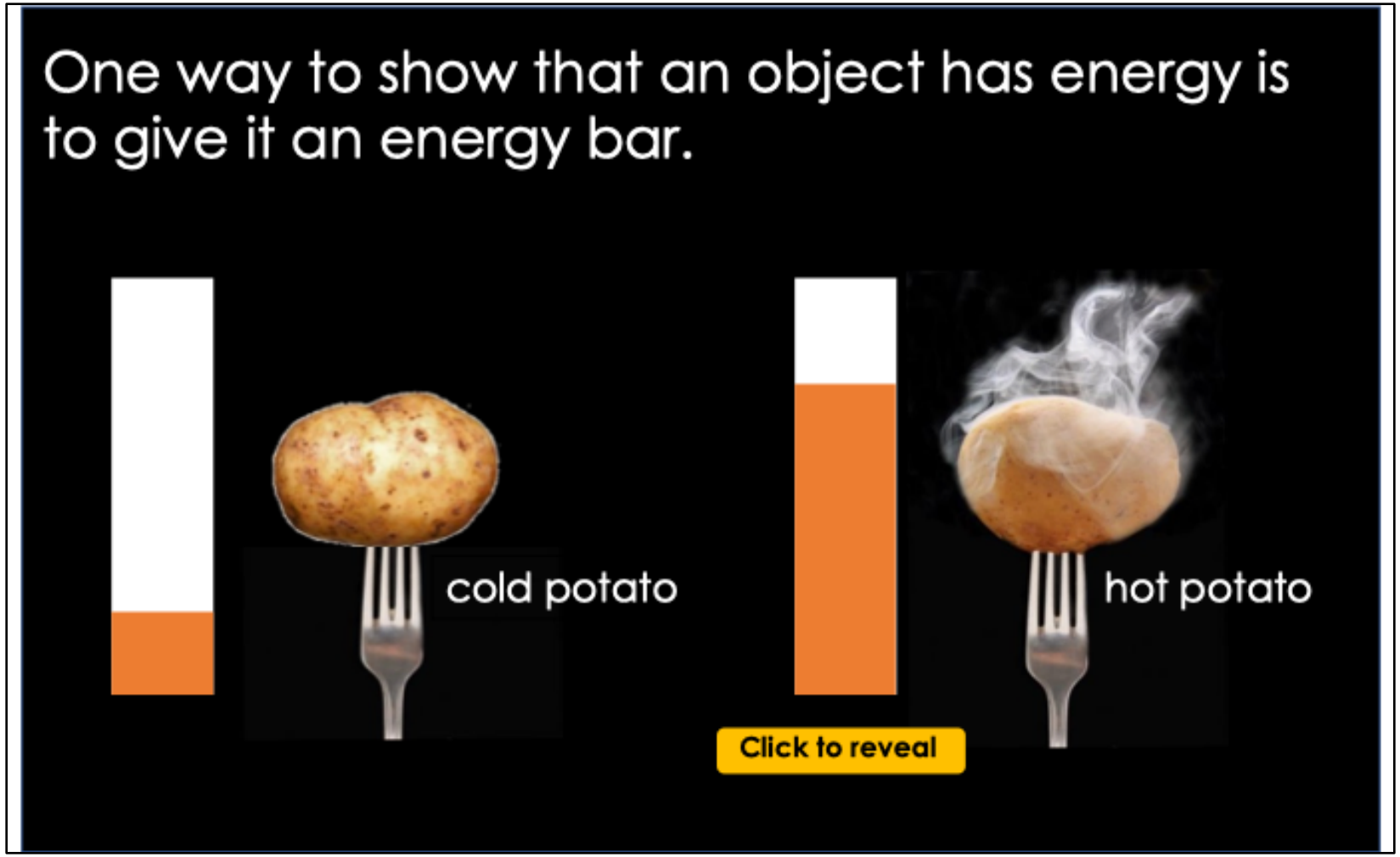
explain

Energy can be modelled as an imaginary substance that is stored in an object.

Stores include kinetic, gravitational, thermal, elastic and chemical.

Energy can be quantified. The energy of a moving object depends on mass and speed.

enable


One way to show that an object has energy is to give it an energy bar.
cold potato
hot potato
Click to reveal

enable

Objects store energy for different reasons.

A hot object has energy. We say it's in a **thermal store.**

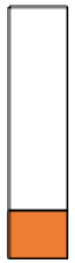
A moving object has energy. We say it's in a **kinetic store.**

explain

EXPLAIN

Speed affects kinetic energy (energy in the kinetic store).

Click to animate



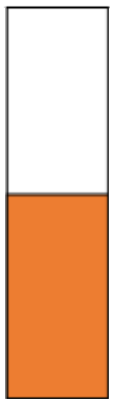
slow ball,
low energy

Click to animate

fast ball,
higher energy

explain

The car and motorbike are travelling at the same speed. The car has a greater mass.



Is there less, the same or more energy in the bike's kinetic store? Click to reveal

3. Concrete preparation

Will this help students to understand?

Natural selection

Evolutionary family tree

Think about how organisms may evolve and change over time.

Construct an evolutionary family tree from the organisms shown.

Try to use every organism in your family tree.

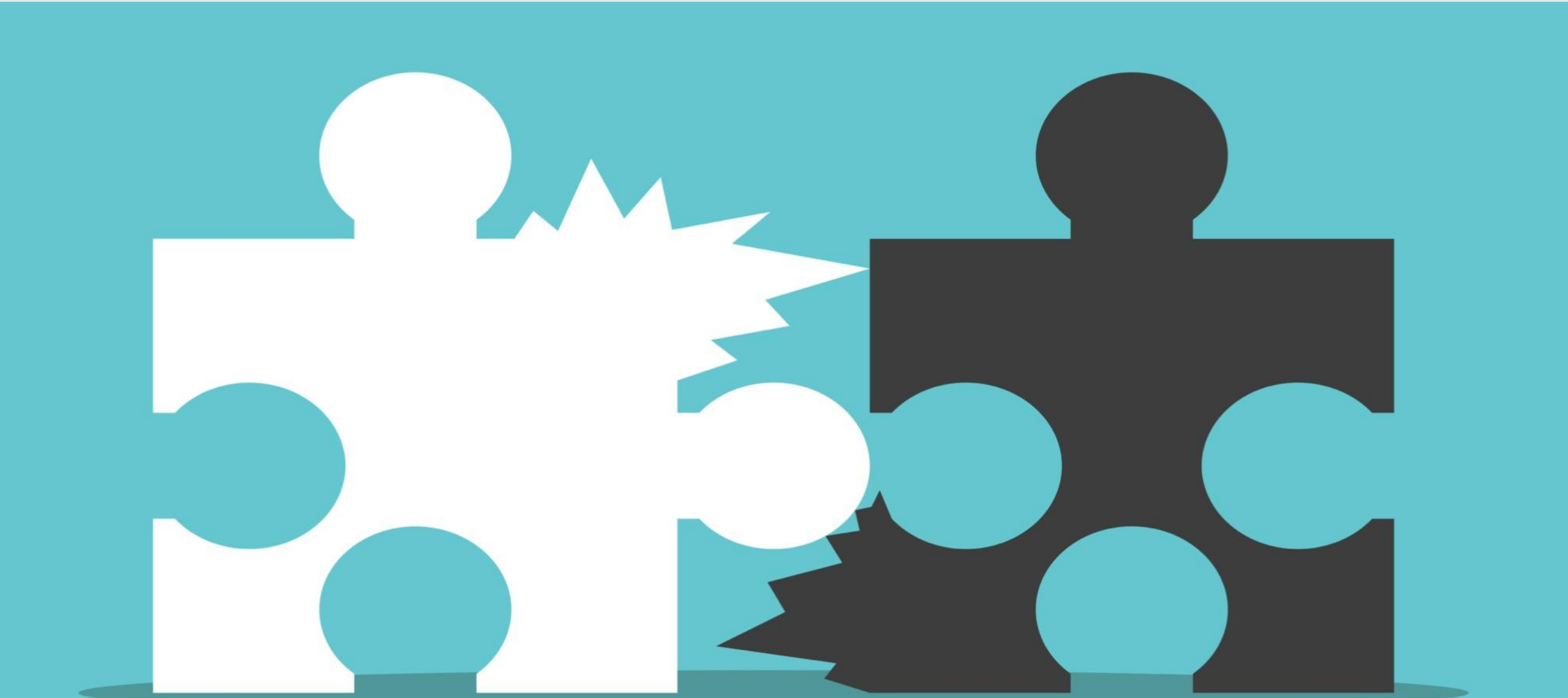
Then prepare a presentation on your family tree.

Many lines of evidence for ‘Explore’

- **Time for telling:** after students build ‘differentiated knowledge’ to make sense of the explanation
- **Multiple representations:** help understanding
- **Concrete**, **Pictorial**, **Abstract:** Singapore Maths
- **Cognitive Acceleration** (CASE)

Like a detective, students start putting pieces of the puzzle together

Your explanation helps them fit the pieces correctly



explore

Students build a **concrete** representation

explore

You can simulate how evolution works with these imaginary creatures.


hoppers


jumpers


walkers

Activity: Use a simulation to show evolution **SS1**

- Use a simulation to model how species evolve.
- Use what you found out to improve the hypothesis.

explore

1. Variation

Students vary in their movement

2. Competition

Students compete for 'food' placed around the room. Walkers get more food

3. Survival

Only those with enough food 'survive' and stay in the game

4. Reproduction

Surviving students recruit more onto their team, who move the same way

Over several rounds, students see which team wins

explain

They form a **pictorial** representation

1. Individuals in a population vary.
In the simulation, creatures varied on how they moved. There were:


hoppers


jumpers

walkers

What did the creatures compete for?

explain

They form an **abstract** representation

The 4-stage process you have seen in the simulation is called **natural selection.**

1.Variation → 2. Competition → 3. Survival → 4. Reproduction

Natural selection is the cause of evolution.

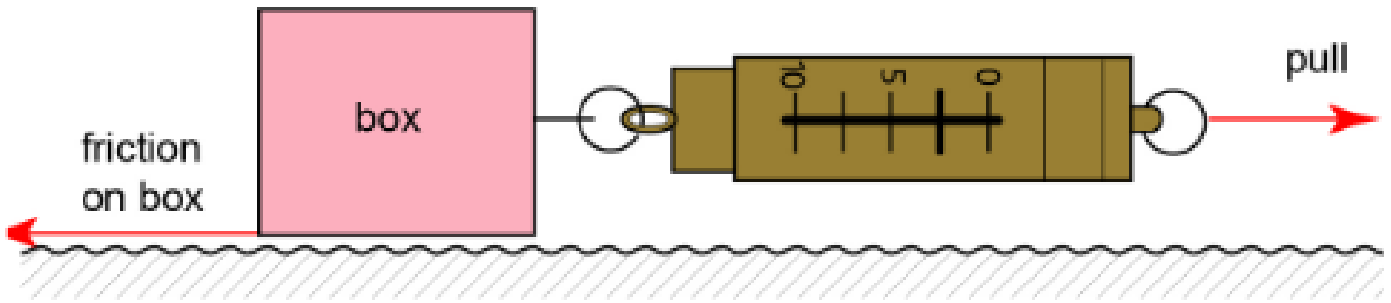

4. Just-in-time skills

Is this teaching enquiry or just practising skills?

Friction

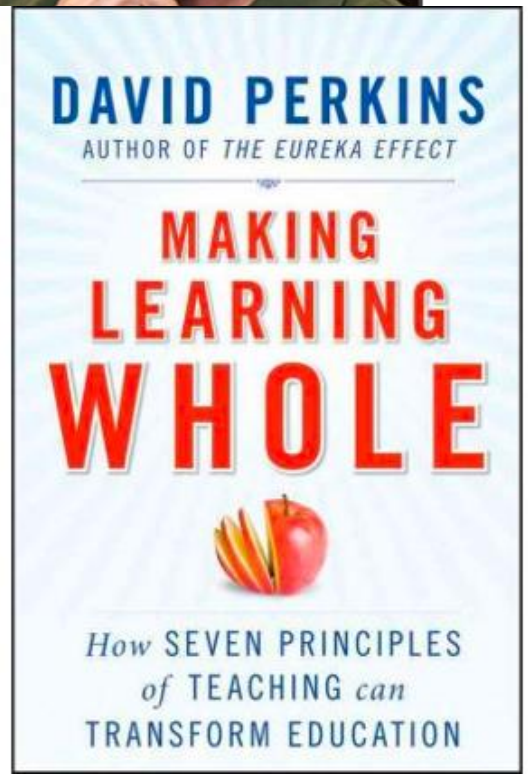
I will be using **enquiry processes** to:

- plan an investigation, test my prediction, and identify the independent, dependent, and control variables.



Why balance content with Working Scientifically:

- The science needed for STEM/ life is mostly procedural
- Ofsted expect it to be integrated and taught
- Challenging GCSE AO3 questions require it



".. When I was playing baseball … I was **playing a junior version of the game**.

".. But when studying those shards of math and history, I wasn't playing a junior version of anything.

".. It was like batting practice without knowing the whole game. Why would anyone want to do that."

3-dimensional objectives

Key concept

How the force of friction works

Working Scientifically

To collect accurate data in an investigation

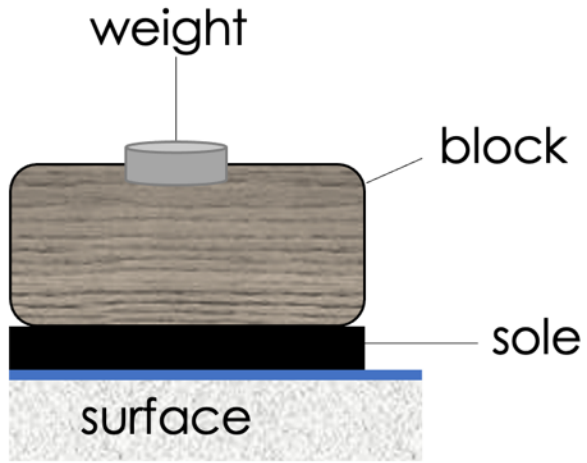
21st century skill

To work as a team, with each person taking a different role

Junior version of scientific investigation

What affects the force of friction?

Let's use a simplified shoe to test different variables.



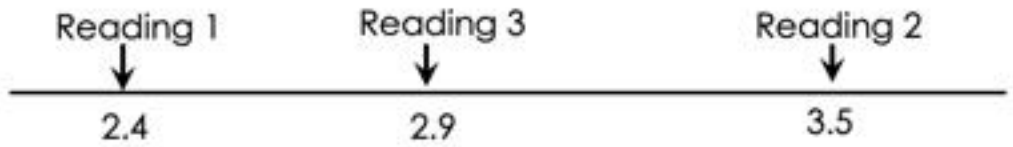
Activity: Test variables Click for sheet SS1

- Vary the sole material, weight, and wet or dry surface
- Do a trial run
- Review your method Click to review trial run
- Improve your method

explore explain

Create need for one skill

Review your trial run. Were your results like this?



With such a big **range**, we don't know the real value.
Our results are not **accurate**.

The **range** is the difference between the highest and lowest value.

What could have caused the big range?

explore explain

Teach the skill

Possible reasons for a big range:

1. You used the measuring instrument incorrectly
2. You used the wrong measuring instrument
3. The instrument is not working
4. You did not control all the variables
5. The environment changed (e.g. temperature, sudden movement)

What will you improve?

Click to return

explore explain

Practise it in context

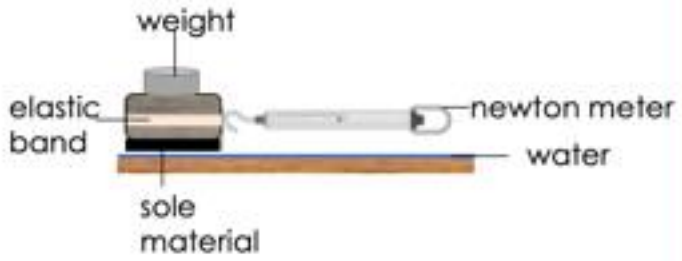
Collect friction data

SS1

What to do:

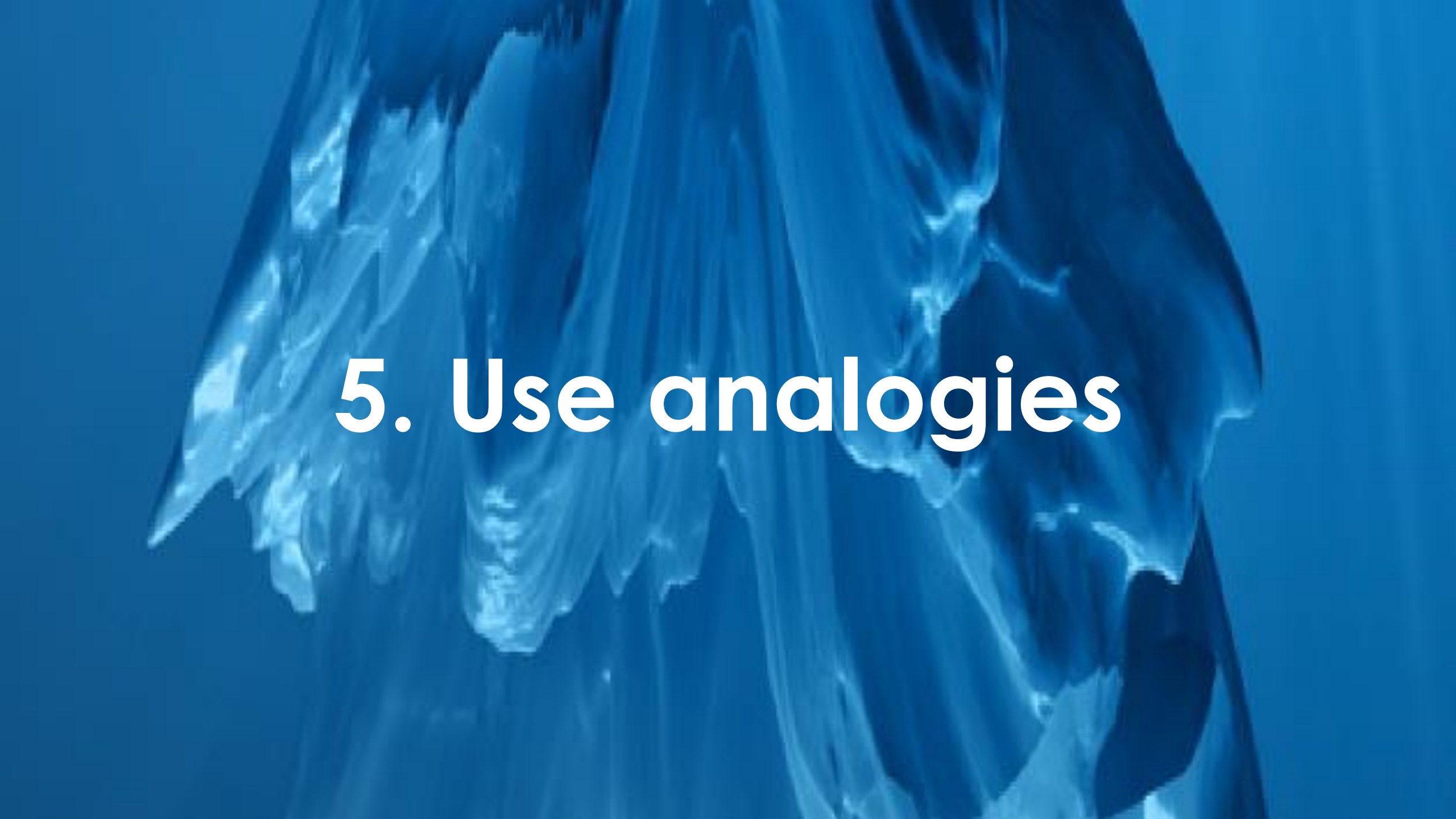
- Copy the table. Add your independent variable.
- Do a trial run and take three readings
- Review the method with your teacher
- If needed, make changes to your method
- Collect the rest of the results

Pull the newton meter until the block just moves. Read the force.



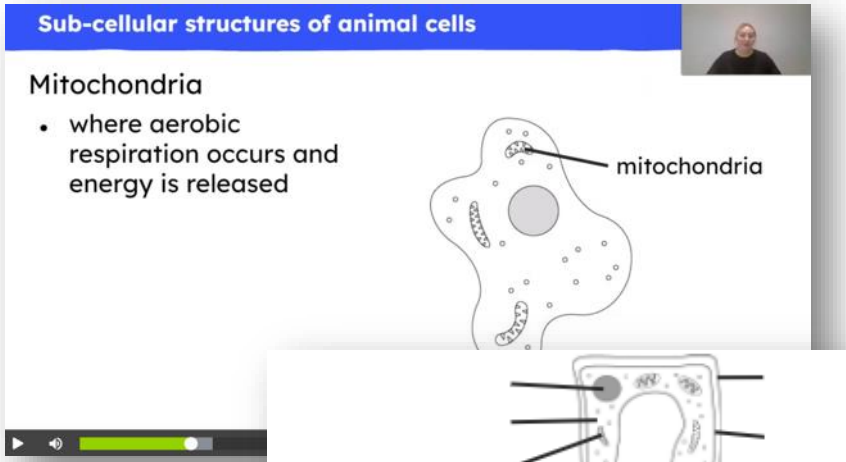
independent variable

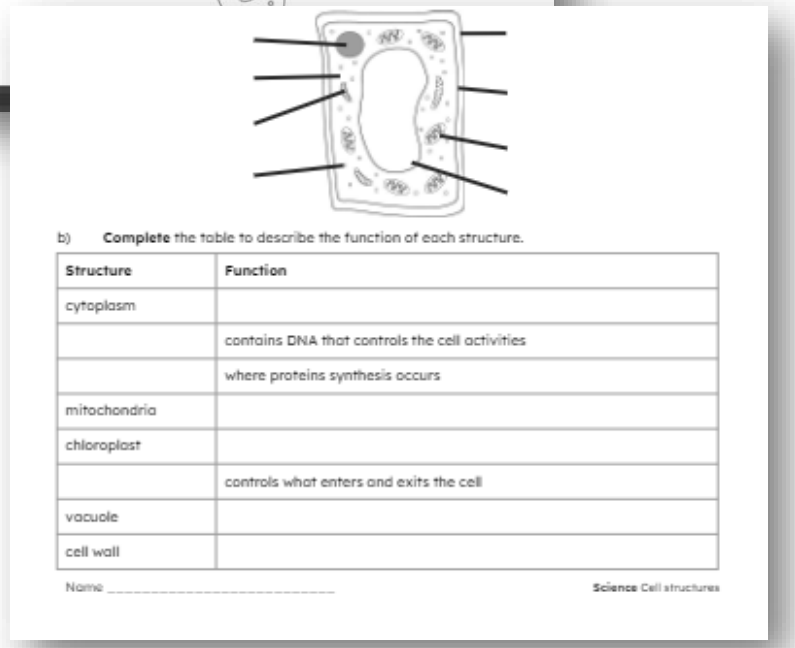
	Maximum force of friction (N)		
	Reading 1	Reading 2	Reading 3


5. Use analogies

Do these activities lead to deep learning?

Cell structure





X

Q: What would happen to a cell is its mitochondria stopped working?

explain

Students need scaffolding to construct a complex idea

Analogical reasoning: finding the underlying similarity between instances

We use this to explain a difficult new idea using a simpler, more familiar one.

In a classic experiment, students solve problems best after learning an analogy AND being told the principle (Duncker 1945)

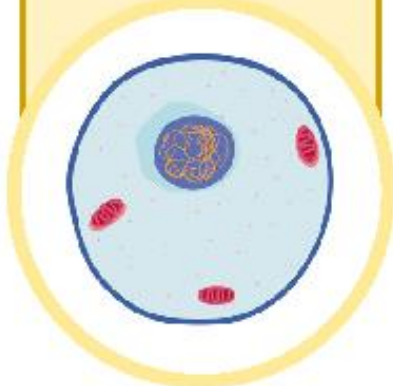
It works because students are processing deep structure.

FOCUS ON

imagining what's going on inside a cell, like playing a movie in your mind.

A cell is like a factory

CELL — is like → **FACTORY**



A drawing like this gives the idea there's not much happening in a cell. But it's quite the opposite. The parts of a cell are always busy making new proteins.

Instead, imagine the cell as a car factory. Inside, hundreds of robots are joining together the bits of a car.

MITOCHONDRION

is like

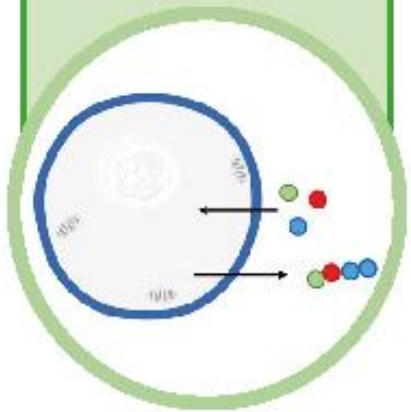
A mitochondrion releases energy from food for other cell parts to use.

GENERATOR

A generator releases energy from fuel for other factory parts to use.

Imagine things entering and leaving all over the cell membrane.

CELL MEMBRANE



The cell membrane is full of tiny holes to let food enter…

…and finished proteins leave.

is like

WALLS

The factory walls are full of gates that let raw materials enter…

…and finished cars leave.

NUCLEUS

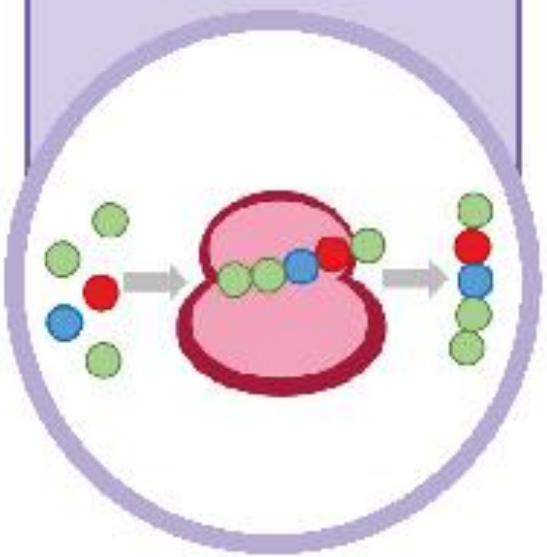
is like

Inside the nucleus is DNA. It gives instructions to the ribosomes to make proteins.

MANAGER

The manager gives instructions to the robots to make cars.

RIBOSOME

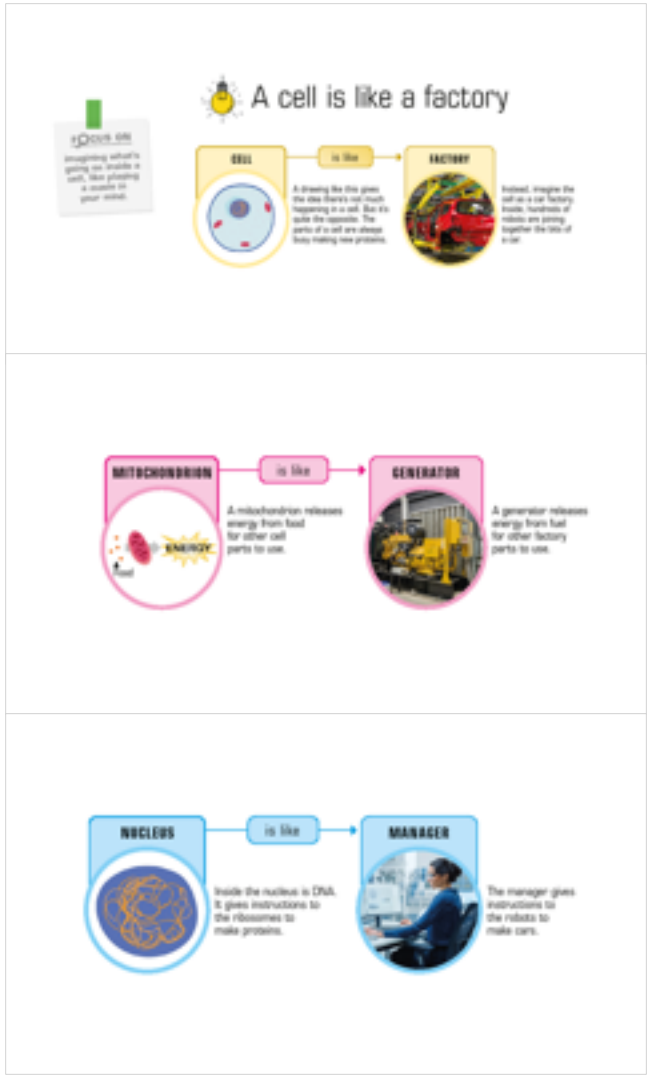


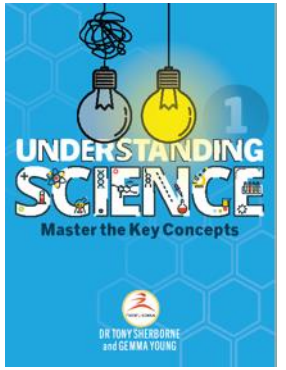
is like

A ribosome puts together all the bits of a protein.

ROBOT

A robot puts together all the bits of a car.

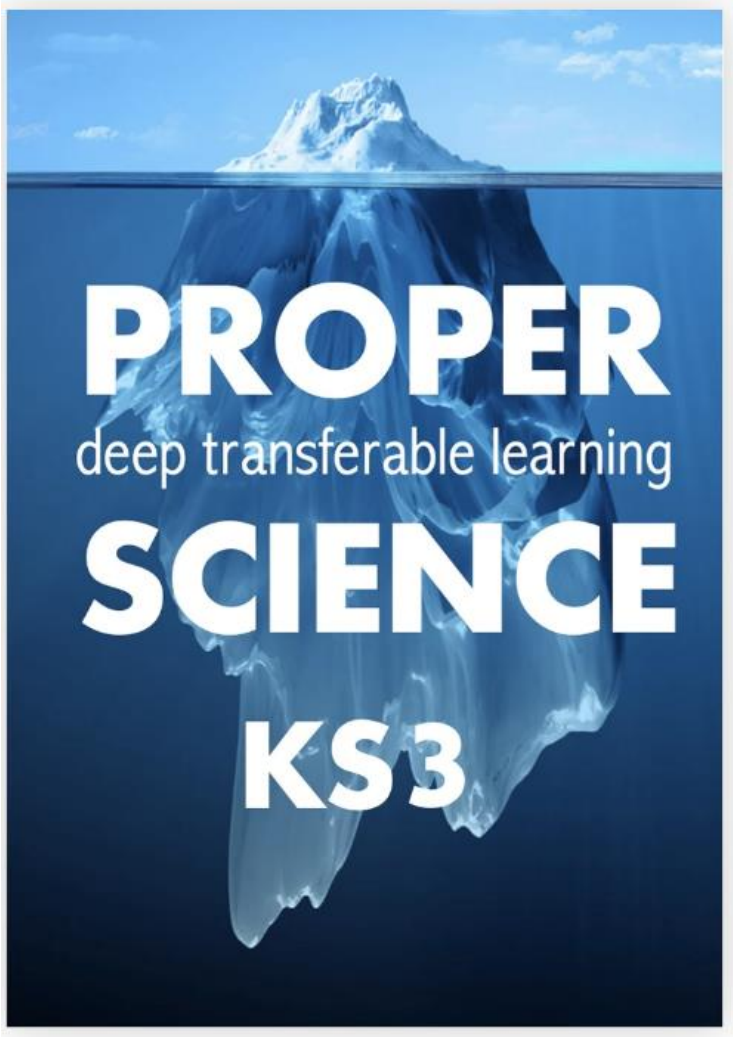




✓

Q: What would happen to a cell is its mitochondria stopped working?

Get Proper Science 1/2 price as a case study school



In 23-24, we're researching obstacles and effective strategies for switching to a 'deep, transferable learning' approach.

Become a case study school and provide information before, during and after a year.

Get Year 7/8 course at ~~£399~~ £199.

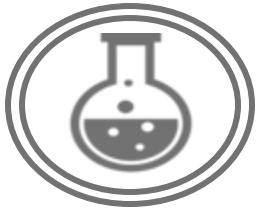
Offer ends 1st September.

RESERVE

In this lesson you will learn:

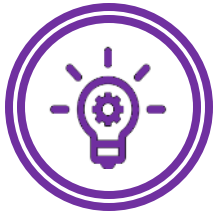
Key concept

How the force of friction works



Working Scientifically

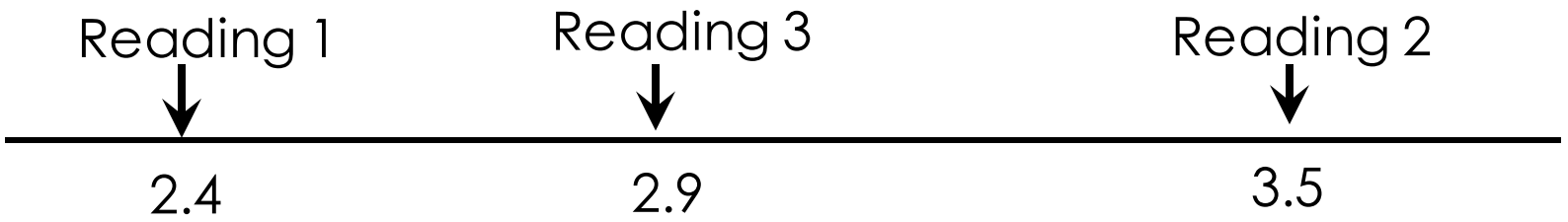
To collect accurate data in an investigation



21st century skill

To work as a team, with each person taking a different role

Review your trial run. Were your results like this?



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Possible reasons for a big range:

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2. You used the wrong measuring instrument
3. The instrument is not working
4. You did not control all the variables
5. The environment changed (e.g. temperature, sudden movement)

What will you improve?

Click to return

DO

To collect accurate data in an investigation

Maisie used a newton meter to measure the friction of some shoe soles. Which of these would make the measurements inaccurate?

A She repeated her results

B She did not control the type of shoe

C The newton meter measured 2 N before she pulled.

The newton meter was not working properly. This meant she was not measuring the real value of friction – her measurement was inaccurate.

Collect friction data

SS1

What to do:

- Copy the table. Add your independent variable.
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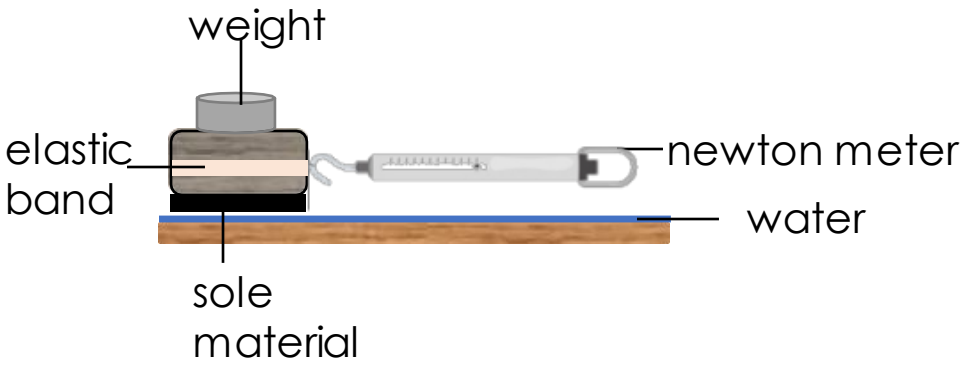


independent variable

	Maximum force of friction (N)		
	Reading 1	Reading 2	Reading 3

EXPLAIN

In the simulation, the population of creatures evolved in 4 stages.

1. Individuals in a population vary.

In the simulation, creatures varied on how they moved. There were:

hoppers

jumpers

walkers

What did the creatures compete for?

EXPLAIN

2. Individuals compete for limited resources.
Creatures competed for food. Walkers could get more food than jumpers and hoppers.




What happened to the creatures that did not get enough food?

EXPLAIN

3. Individuals with better adaptations survive.

Creatures that got enough food survived.

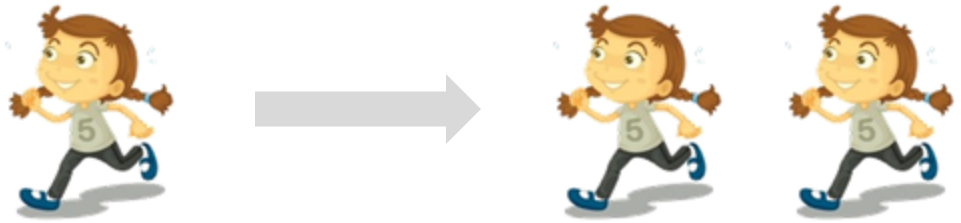
Creatures that didn't get enough food died.

Why did the number of walkers increase?

EXPLAIN

4. Individuals that survive and thrive reproduce.

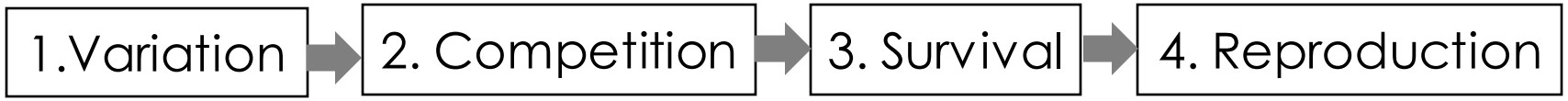
Creatures that survived reproduced.
Their offspring inherited their useful characteristics.



What happened to the numbers of the different creatures in the population?

EXPLAIN

The 4-stage process you have seen in the simulation is called **natural selection.**



EXPLAIN

1. Individuals in a population vary.

Elephants on the island show variation in size.

Most elephants are large

A few elephants are small

What causes this variation?

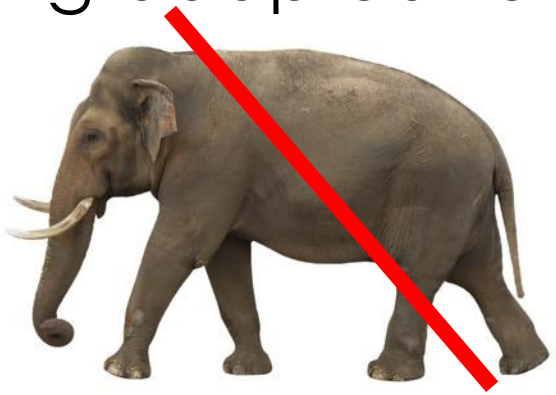
EXPLAIN

2. Individuals compete for limited resources. Elephants eat plants. They have to compete with each other for food.

Why do the smaller elephants have an advantage on the island?

EXPLAIN

3. Individuals with better adaptations survive.
This is called 'survival of the fittest'. It includes being adapted to avoid predators.



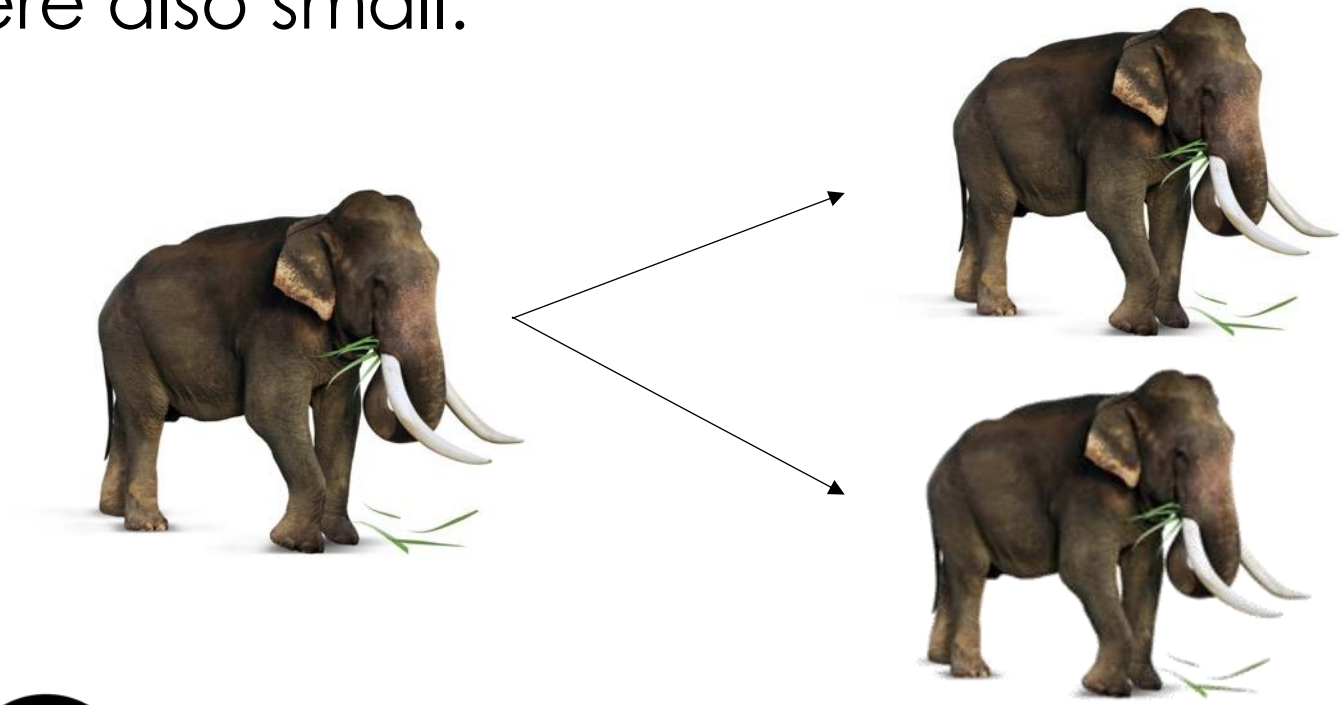
The island has fewer plants. Larger elephants need more food. If they don't get enough, they die.

Smaller elephants need less food. They get enough and survive.

Why will the population of small elephants increase?

EXPLAIN

4. Individuals that survive can reproduce.
The small elephants reproduced. Their offspring were also small.

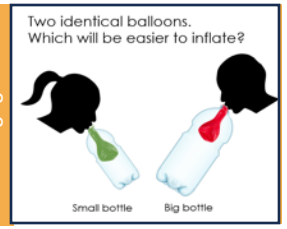


What will happen to the population of large elephants?

Learning efficiency

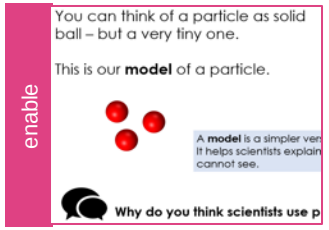
↑ **Curriculum efficiency** = ↑ **deep learning** + surface learning / teaching

engage



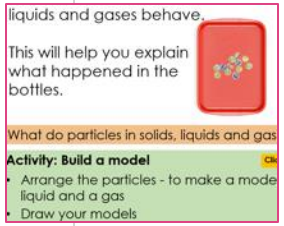
Direct instruction

enable



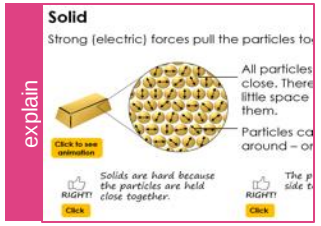
Guided enquiry? Problem-solving

explore

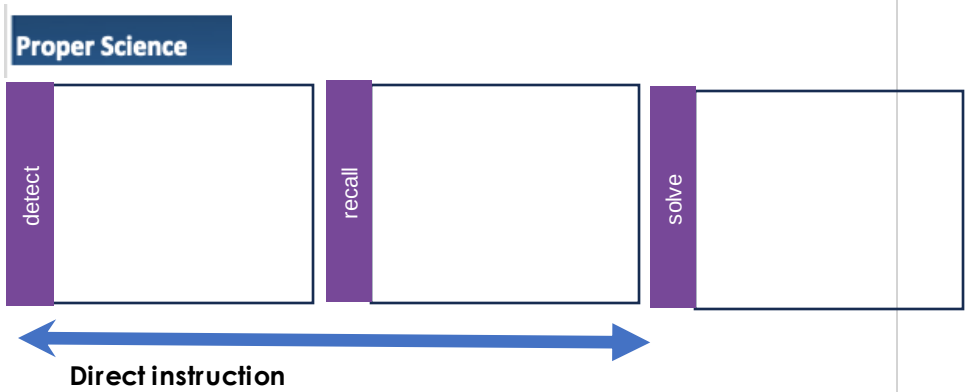


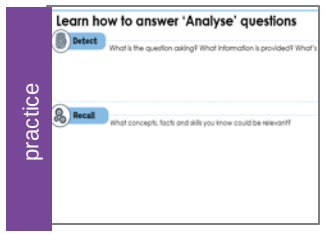
Direct instruction

explain



Deep, transferable learning model





Surface curriculum

Test questions

Information transfer with direct
To apply (AO2) and analyse (AO3

In Real Mastery we've develope
process.