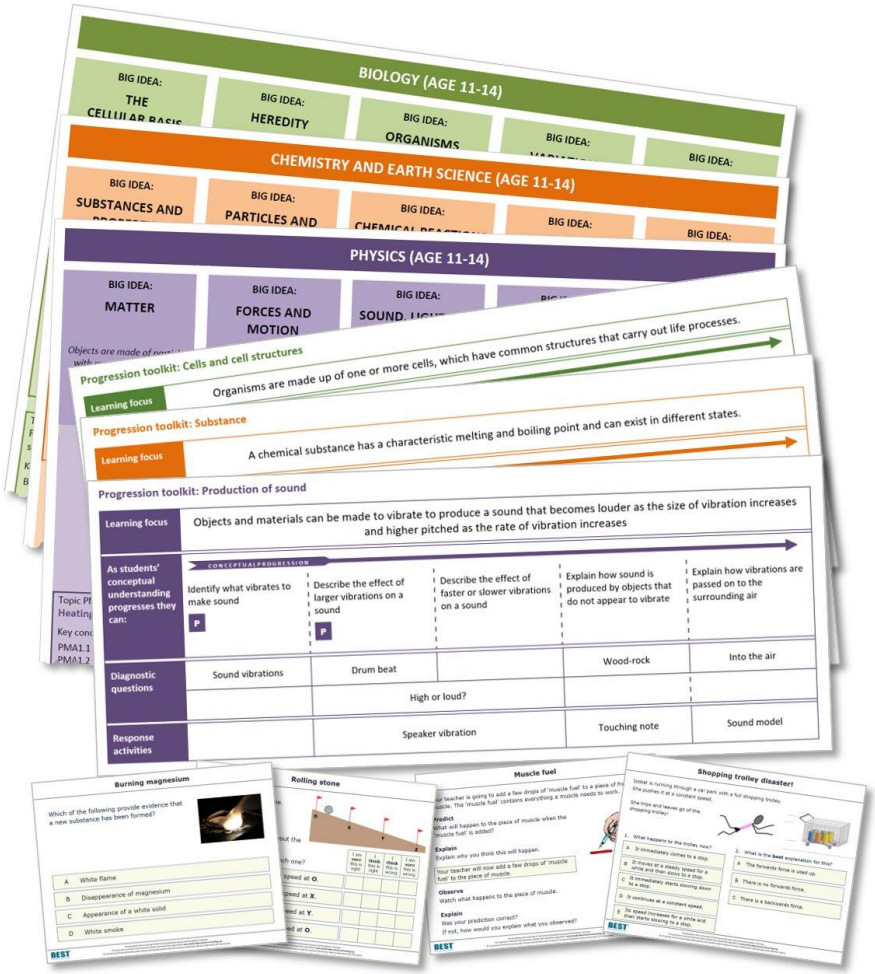

BEST™

Best Evidence Science Teaching

The best teaching draws on the best evidence

Brief introduction to resources

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STEM LEARNING

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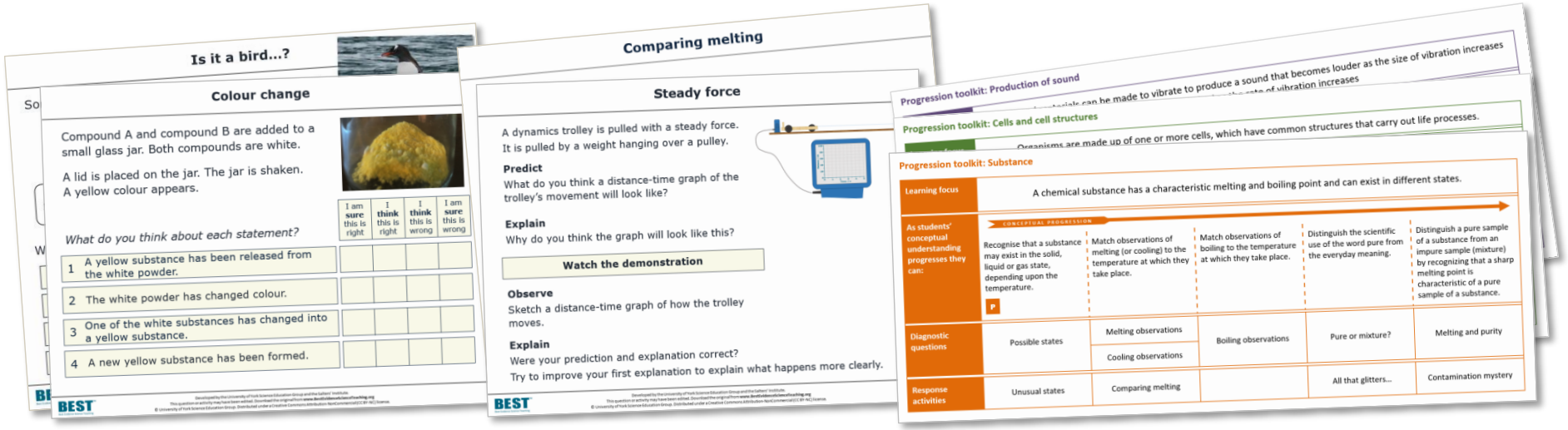
Hundreds of resources

All based on research evidence

ONLINE, OPEN-ACCESS & FREE!



DIAGNOSTIC QUESTIONS

RESPONSE ACTIVITIES

PROGRESSION TOOLKITS

…to help teachers develop **evidence-based practices**

…to test and consolidate students' understanding of **key concepts** in science.

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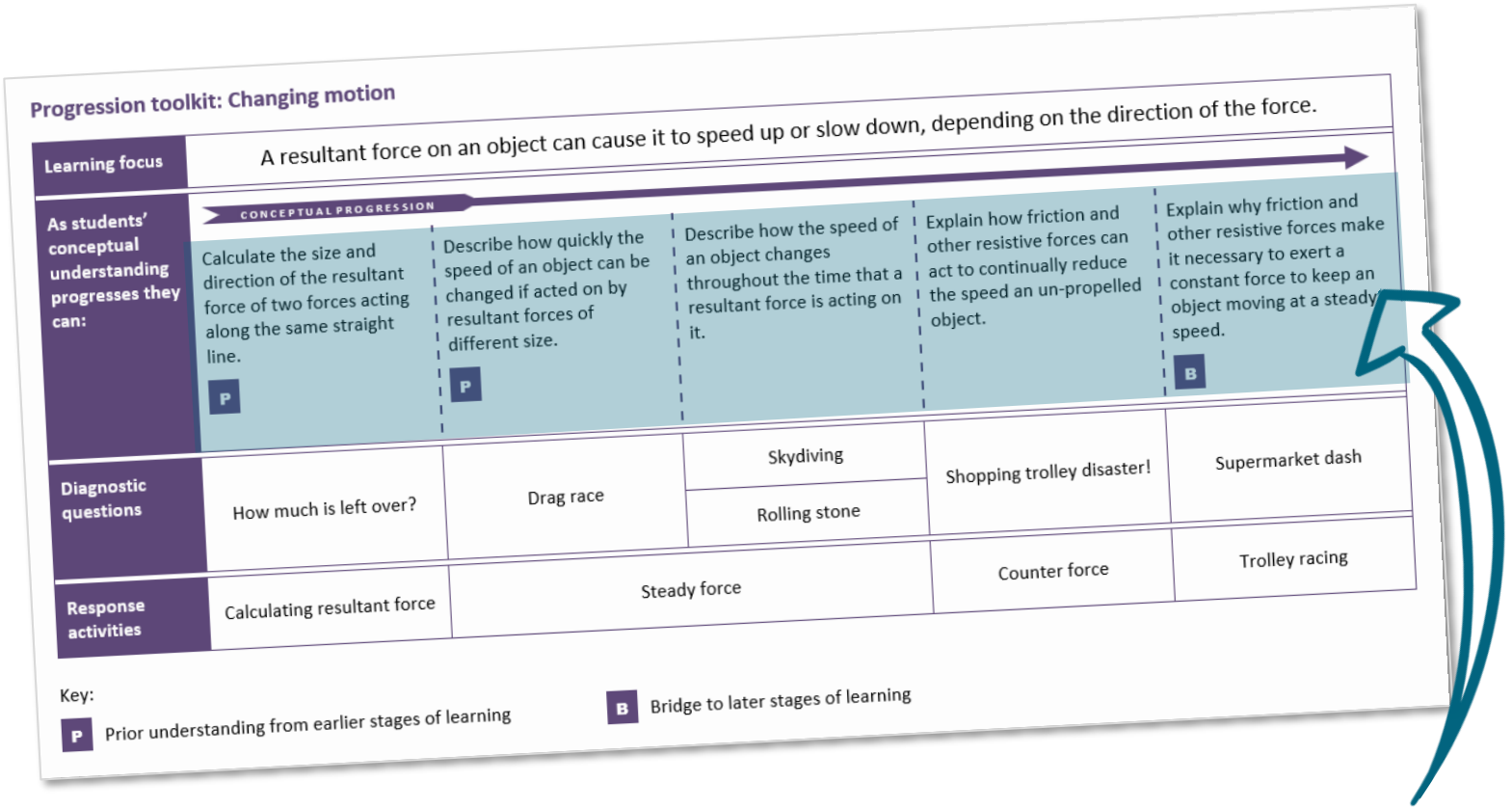
Evidence-informed progression

A **progression toolkit** helps you to test and consolidate understanding of a **key concept** in science.



Progression toolkit: Changing motion

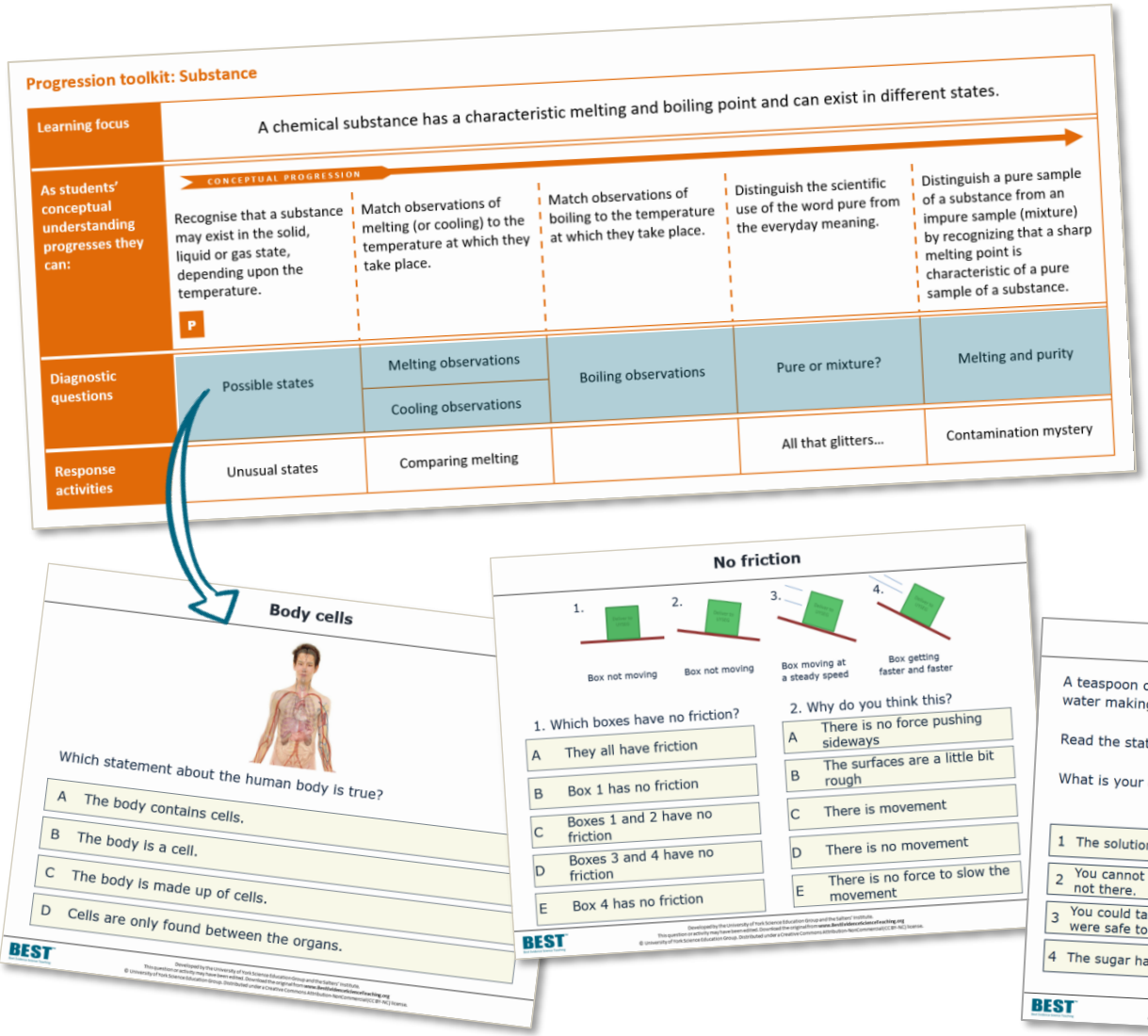
Learning focus	A resultant force on an object can cause it to speed up or slow down, depending on the direction of the force.

As students' conceptual understanding progresses they can: (CONCEPTUAL PROGRESSION)					
	Calculate the size and direction of the resultant force of two forces acting along the same straight line. **P**	Describe how quickly the speed of an object can be changed if acted on by resultant forces of different size. **P**	Describe how the speed of an object changes throughout the time that a resultant force is acting on it.	Explain how friction and other resistive forces can act to continually reduce the speed an un-propelled object.	Explain why friction and other resistive forces make it necessary to exert a constant force to keep an object moving at a steady speed. **B**
Diagnostic questions	How much is left over?	Drag race	Skydiving / Rolling stone	Shopping trolley disaster!	Supermarket dash
Response activities	Calculating resultant force	Steady force		Counter force	Trolley racing

Key:
P Prior understanding from earlier stages of learning
B Bridge to later stages of learning

A research-informed progression pathway describes what students should be able to do as their understanding of the concept develops.

Diagnose misunderstandings



Progression toolkit: Substance

Learning focus	A chemical substance has a characteristic melting and boiling point and can exist in different states.				
As students' conceptual understanding progresses they can:	CONCEPTUAL PROGRESSION Recognise that a substance may exist in the solid, liquid or gas state, depending upon the temperature. P	Match observations of melting (or cooling) to the temperature at which they take place.	Match observations of boiling to the temperature at which they take place.	Distinguish the scientific use of the word pure from the everyday meaning.	Distinguish a pure sample of a substance from an impure sample (mixture) by recognizing that a sharp melting point is characteristic of a pure sample of a substance.
Diagnostic questions	Possible states	Melting observations Cooling observations	Boiling observations	Pure or mixture?	Melting and purity
Response activities	Unusual states	Comparing melting		All that glitters...	Contamination mystery

Body cells

Which statement about the human body is true?

A The body contains cells.
B The body is a cell.
C The body is made up of cells.
D Cells are only found between the organs.

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No friction

1. Box not moving
2. Box not moving
3. Box moving at a steady speed
4. Box getting faster and faster

1. Which boxes have no friction?

A They all have friction
B Box 1 has no friction
C Boxes 1 and 2 have no friction
D Boxes 3 and 4 have no friction
E Box 4 has no friction

2. Why do you think this?

A There is no force pushing sideways
B The surfaces are a little bit rough
C There is movement
D There is no movement
E There is no force to slow the movement

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Sugar solution

A teaspoon of sugar is dissolved in a glass of water making a sugar solution.

Read the statements in the table.

What is your decision for each statement?

	I am **sure** this is right	I **think** this is right	I **think** this is wrong	I am **sure** this is wrong
1 The solution includes sugar in the liquid state.				
2 You cannot see sugar in the solution, so it is not there.				
3 You could taste the sugar in the solution, if it were safe to do so.				
4 The sugar has reacted with the water.				

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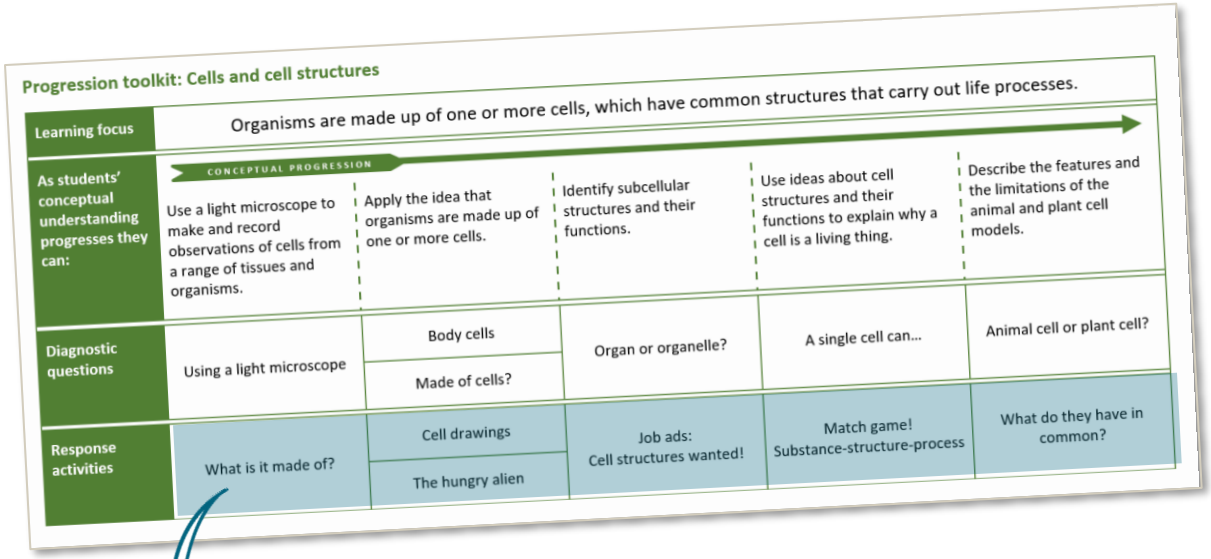
Diagnostic questions help you to collect:

- evidence of where your students are in their conceptual progression
- evidence of common misunderstandings and preconceptions.

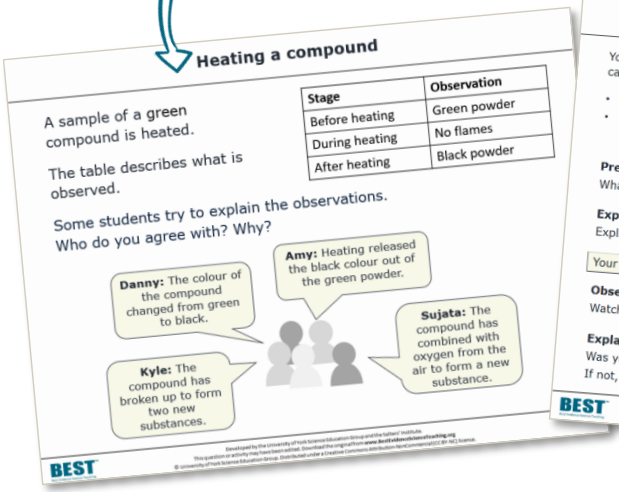
They can be used formatively to decide what to do next.

Respond effectively



Progression toolkit: Cells and cell structures

Learning focus	Organisms are made up of one or more cells, which have common structures that carry out life processes.				
As students' conceptual understanding progresses they can:	CONCEPTUAL PROGRESSION → Use a light microscope to make and record observations of cells from a range of tissues and organisms.	Apply the idea that organisms are made up of one or more cells.	Identify subcellular structures and their functions.	Use ideas about cell structures and their functions to explain why a cell is a living thing.	Describe the features and the limitations of the animal and plant cell models.
Diagnostic questions	Using a light microscope	Body cells / Made of cells?	Organ or organelle?	A single cell can...	Animal cell or plant cell?
Response activities	What is it made of?	Cell drawings / The hungry alien	Job ads: Cell structures wanted!	Match game! Substance-structure-process	What do they have in common?



Heating a compound

A sample of a green compound is heated.

The table describes what is observed.

Stage	Observation
Before heating	Green powder
During heating	No flames
After heating	Black powder

Some students try to explain the observations. Who do you agree with? Why?

Danny: The colour of the compound changed from green to black.

Amy: Heating released the black colour out of the green powder.

Sujata: The compound has combined with oxygen from the air to form a new substance.

Kyle: The compound has broken up to form two new substances.

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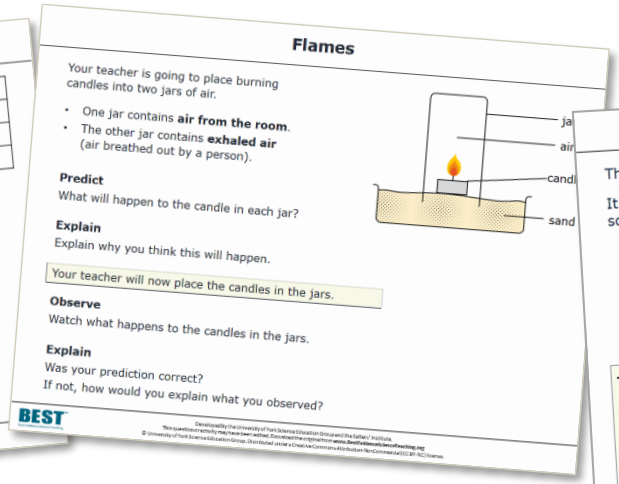

Flames

Your teacher is going to place burning candles into two jars of air.

- One jar contains **air from the room**.
- The other jar contains **exhaled air** (air breathed out by a person).

Predict
What will happen to the candle in each jar?

Explain
Explain why you think this will happen.

Your teacher will now place the candles in the jars.

Observe
Watch what happens to the candles in the jars.

Explain
Was your prediction correct?
If not, how would you explain what you observed?

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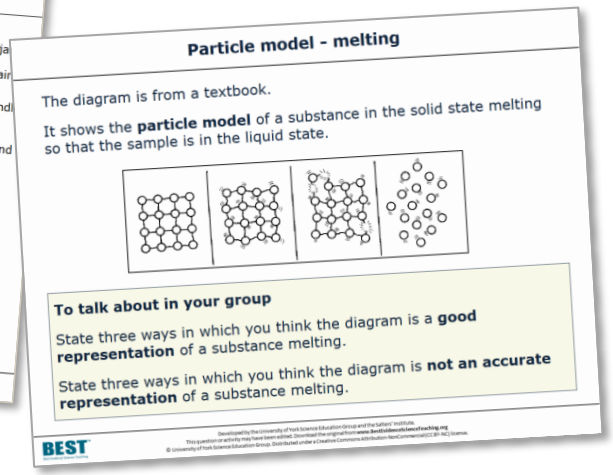

Particle model - melting

The diagram is from a textbook.

It shows the **particle model** of a substance in the solid state melting so that the sample is in the liquid state.

To talk about in your group

State three ways in which you think the diagram is a **good representation** of a substance melting.

State three ways in which you think the diagram is **not an accurate representation** of a substance melting.

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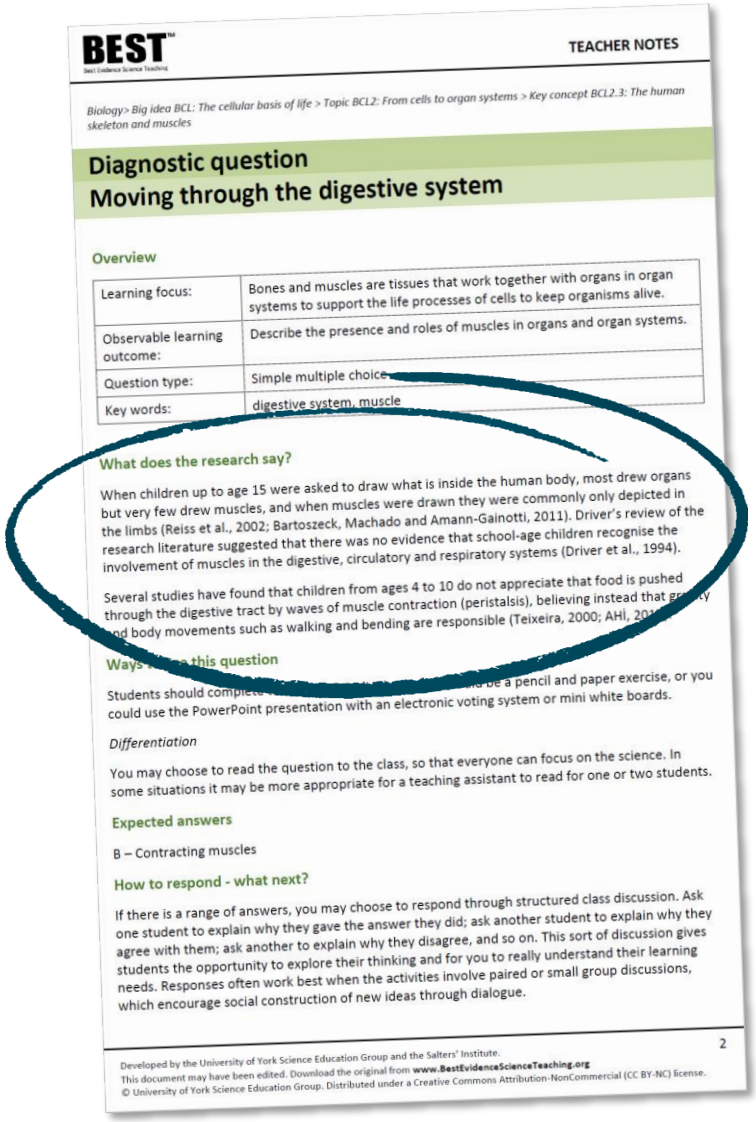
Response activities:

- encourage students to talk and think about what they're thinking (metacognition)
- facilitate purposeful practical work
- encourage meaning-making.

They help to challenge misunderstandings and overcome barriers to conceptual development.

Evidence-informed practice



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TEACHER NOTES

Biology > Big idea BCL: The cellular basis of life > Topic BCL2: From cells to organ systems > Key concept BCL2.3: The human skeleton and muscles

Diagnostic question
Moving through the digestive system

Overview

Learning focus:	Bones and muscles are tissues that work together with organs in organ systems to support the life processes of cells to keep organisms alive.
Observable learning outcome:	Describe the presence and roles of muscles in organs and organ systems.
Question type:	Simple multiple choice
Key words:	digestive system, muscle

What does the research say?

When children up to age 15 were asked to draw what is inside the human body, most drew organs but very few drew muscles, and when muscles were drawn they were commonly only depicted in the limbs (Reiss et al., 2002; Bartoszeck, Machado and Amann-Gainotti, 2011). Driver's review of the research literature suggested that there was no evidence that school-age children recognise the involvement of muscles in the digestive, circulatory and respiratory systems (Driver et al., 1994).

Several studies have found that children from ages 4 to 10 do not appreciate that food is pushed through the digestive tract by waves of muscle contraction (peristalsis), believing instead that gravity and body movements such as walking and bending are responsible (Teixeira, 2000; AHİ, 201

Ways to use this question

Students should complete [illegible] be a pencil and paper exercise, or you could use the PowerPoint presentation with an electronic voting system or mini white boards.

Differentiation

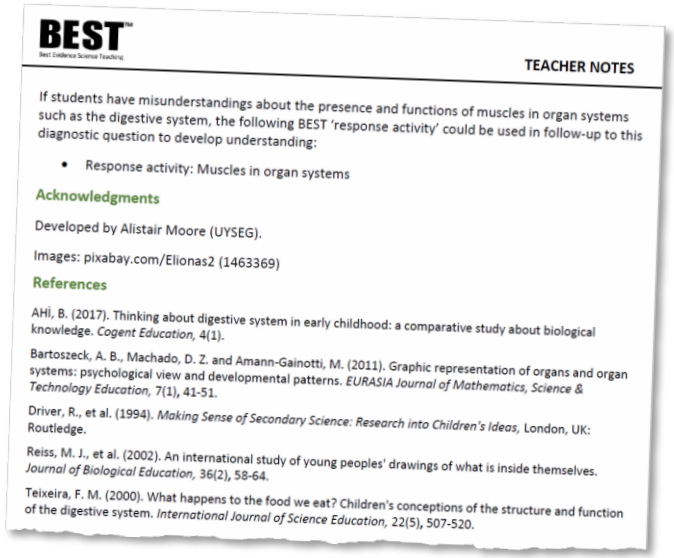
You may choose to read the question to the class, so that everyone can focus on the science. In some situations it may be more appropriate for a teaching assistant to read for one or two students.

Expected answers

B – Contracting muscles

How to respond - what next?

If there is a range of answers, you may choose to respond through structured class discussion. Ask one student to explain why they gave the answer they did; ask another student to explain why they agree with them; ask another to explain why they disagree, and so on. This sort of discussion gives students the opportunity to explore their thinking and for you to really understand their learning needs. Responses often work best when the activities involve paired or small group discussions, which encourage social construction of new ideas through dialogue.



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TEACHER NOTES

If students have misunderstandings about the presence and functions of muscles in organ systems such as the digestive system, the following BEST 'response activity' could be used in follow-up to this diagnostic question to develop understanding:

- Response activity: Muscles in organ systems

Acknowledgments

Developed by Alistair Moore (UYSEG).

Images: pixabay.com/Elionas2 (1463369)

References

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Bartoszeck, A. B., Machado, D. Z. and Amann-Gainotti, M. (2011). Graphic representation of organs and organ systems: psychological view and developmental patterns. *EURASIA Journal of Mathematics, Science & Technology Education,* 7(1), 41-51.

Driver, R., et al. (1994). *Making Sense of Secondary Science: Research into Children's Ideas,* London, UK: Routledge.

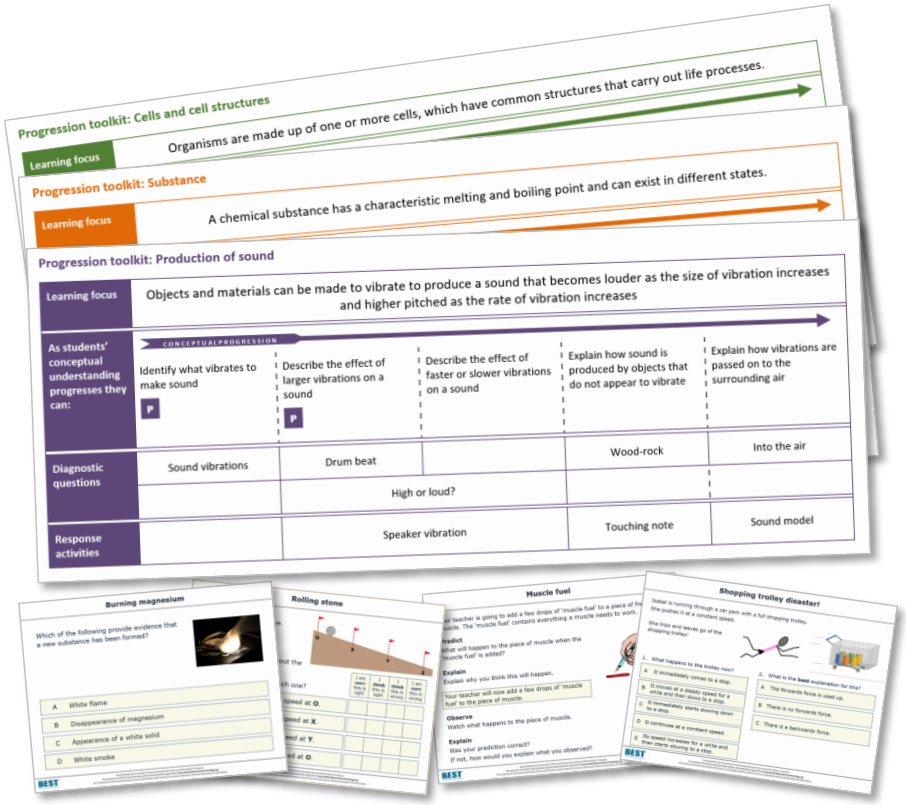
Reiss, M. J., et al. (2002). An international study of young peoples' drawings of what is inside themselves. *Journal of Biological Education,* 36(2), 58-64.

Teixeira, F. M. (2000). What happens to the food we eat? Children's conceptions of the structure and function of the digestive system. *International Journal of Science Education,* 22(5), 507-520.

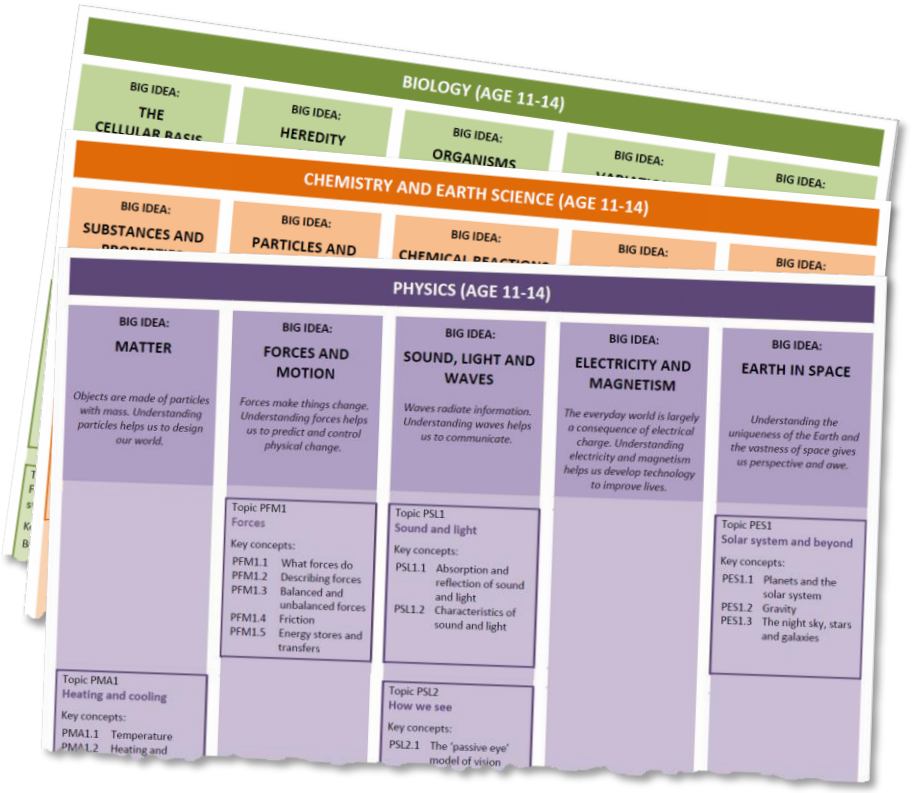
Teacher notes summarise the **research evidence** underpinning each resource.

This provides bitesize CPD to help you develop your evidence-informed practices.

Research-informed curriculum planning



The BEST resources can be incorporated into existing schemes of learning…



…or use our research-informed maps for curriculum planning. They suggest how key concepts can be sequenced to build understanding of **big ideas** of science.

Best Evidence Science Teaching (BEST)

The resources have been developed from the best available research evidence on:

- common misunderstandings in science
- effective diagnostic questioning and formative assessment
- constructivist approaches to building understanding
- sequencing of key concepts.

The resources are developed by the University of York Science Education Group.

The Salters' Institute has been proud to fully fund the BEST project since it began in 2016.

The Institute of Physics is now a co-funder of BEST, having supported the project since 2021.

We are providing FREE online access to the resources in collaboration with STEM Learning to support science teaching.

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