

# Best Evidence Science Teaching (BEST)

## INTRODUCTION

All resources  
FREE to  
download

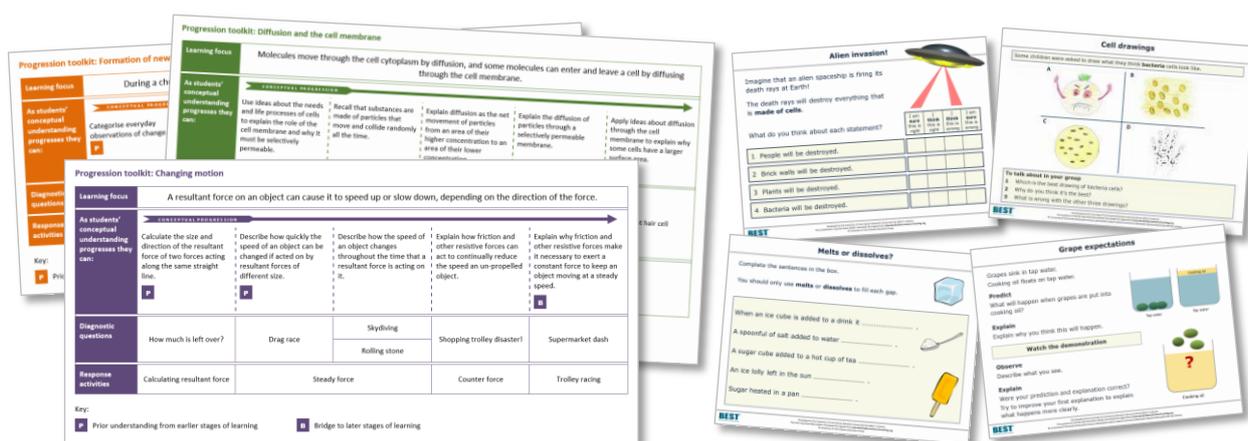
The best teaching draws on the best evidence.

**Best Evidence Science Teaching (BEST)** provides a large online collection of **FREE** resources for secondary school science. The resources help teachers to test and consolidate students' understanding of key concepts in science, to facilitate better progression. 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, and effective sequencing of key concepts.

The BEST project aims to transform science education research into practice by making research-informed resources freely available to science teachers. It is not a commercial venture. All of the resources are developed by the *University of York Science Education Group*. We've already published hundreds of resources for age 11-14, and will be publishing resources for age 14-16 throughout 2021 and 2022.

The project is funded by the *Salters' Institute*, a charitable body that works to support science education. All of the resources are free and open-access, and are hosted online by *STEM Learning* at [www.BestEvidenceScienceTeaching.org](http://www.BestEvidenceScienceTeaching.org).

## The BEST resources



Research-informed **progression toolkits** for key concepts in science provide:

- appropriately-sequenced steps for learning progression
- **diagnostic questions** to reveal preconceptions and common misunderstandings
- **response activities** to challenge misunderstandings and encourage conceptual development.

## Diagnose misunderstandings

Research-informed **diagnostic questions** help you to quickly and easily collect:

- evidence of preconceptions and misunderstandings, which may form barriers to developing scientific understanding
- evidence of what your students know, understand and can do
- evidence of where your students are in their conceptual progression.

Innovative formats such as confidence grids provide rich evidence about what your students are thinking. This evidence can be used formatively to decide what to do next.

**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.

**No friction**

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

**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
A The solution includes sugar in the liquid state.				
B You cannot see sugar in the solution, so it is not there.				
C You could taste the sugar in the solution, if it were safe to do so.				
D The sugar has reacted with the water.				

All resources are provided in **editable Word documents and PowerPoint presentations**

**What does C represent?**

Some children talk about the C in CO<sub>2</sub>.

Alex: C is short for the element name carbon.  
Arjun: C stands for the substance carbon.  
Zara: C means one atom of carbon.  
Kyle: C makes me picture a lump of black coal.  
Poppy: C is the symbol for the element carbon.

To talk about in your group:  
1 Who do you **agree** with?  
2 Who do you **disagree** with, and why?  
3 How would you explain the right ideas to these children?

**Particle model - melting**

This diagram from a textbook illustrates 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.

**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?

## Respond effectively to build understanding

Research-informed **response activities** challenge misunderstandings and help students to overcome barriers to conceptual development.

These activities facilitate metacognition and encourage meaning-making through:

- dialogue and group discussions
- using and critiquing models
- purposeful practical work.

Formats such as predict-explain-observe-explain help to challenge students' thinking.

**BEST** 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; Bartoszek, Machado and Anann-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; AHI, 2017).

**When to use this question**

Students should complete the question individually. This could be a pencil and paper exercise, or you could use the PowerPoint presentation with an electronic response 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.

Developed by the University of York Science Education Group and the Salters' Institute.  
This document may have been edited. Download the original from [www.BestEvidenceScienceTeaching.org](http://www.BestEvidenceScienceTeaching.org)  
© University of York Science Education Group. Distributed under a Creative Commons Attribution-NonCommercial (CC BY-NC) license.

**BEST** 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**

AHI, B. (2017). Thinking about digestive system in early childhood: a comparative study about biological knowledge. *Cogent Education*, 4(1).

Bartoszek, A. B., Machado, D. Z. and Anann-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.

## Bitesize CPD for evidence-based practice

Each resource in the **Best Evidence Science Teaching (BEST)** collection includes teacher notes that summarise the research evidence underpinning the item.

These provide bitesize CPD to help you develop your evidence-based practices.

## Plan a curriculum that builds the big ideas of science

The **Best Evidence Science Teaching (BEST)** resources are focussed on key concepts in science and can be incorporated into your 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.

**BIOLOGY (AGE 11-14)**

- BIG IDEA: THE CELLULAR BASIS OF LIFE**  
Organisms are made of one or more cells, which use a...
- BIG IDEA: HEREDITY AND LIFE CYCLES**  
Genetic information is...
- BIG IDEA: ORGANISMS AND THEIR ENVIRONMENTS**  
All organisms, including...
- BIG IDEA: VARIATION, ADAPTATION AND EVOLUTION**  
Differences between...
- BIG IDEA: HEALTH AND DISEASE**

**CHEMISTRY AND EARTH SCIENCE (AGE 11-14)**

- BIG IDEA: SUBSTANCES AND PROPERTIES**  
Materials are either made of a single chemical substance...
- BIG IDEA: PARTICLES AND STRUCTURE**  
All matter is made up of...
- BIG IDEA: CHEMICAL REACTIONS**  
During a chemical reaction...
- BIG IDEA: EARTH CHEMISTRY**
- BIG IDEA: DYNAMIC EARTH**

**PHYSICS (AGE 11-14)**

- BIG IDEA: MATTER**  
Objects are made of particles with mass. Understanding particles helps us to design our world.
- BIG IDEA: FORCES AND MOTION**  
Forces make things change. Understanding forces helps us to predict and control physical change.
- BIG IDEA: SOUND, LIGHT AND WAVES**  
Waves transfer information. Understanding waves helps us to communicate.
- BIG IDEA: ELECTRICITY AND MAGNETISM**  
The everyday world is largely a consequence of electrical charge. Understanding electricity and magnetism helps us develop technology to improve lives.
- BIG IDEA: EARTH IN SPACE**  
Understanding the uniqueness of the Earth and the nature of space gives us perspective and awe.

Topic PMA1: Heating and cooling  
Key concepts: PMA1.1 Temperature, PMA1.2 Heating and cooling, PMA1.3 Thermal conduction, PMA1.4 Thermal store of energy

Topic PML1: Forces  
Key concepts: PML1.1 What forces do, PML1.2 Describing forces, PML1.3 Balanced and unbalanced forces, PML1.4 Friction, PML1.5 Energy stores and transfers

Topic PSL1: Sound and light  
Key concepts: PSL1.1 Production and transmission of sound, PSL1.2 Characteristics of light

Topic PSL2: How we see  
Key concepts: PSL2.1 The 'passive eye' model of vision, PSL2.2 'Seeing' colour

Topic PESS: Solar system and beyond  
Key concepts: PESS.1 Planets and the solar system, PESS.2 Gravity, PESS.3 Thoughts sky, stars and galaxies

## Don't just take our word for it!

The UK-based **Education Endowment Foundation** published a guidance report in 2018 titled 'Improving Secondary Science'.

This report cites **Best Evidence Science Teaching (BEST)** as a good source of:

- diagnostic questions
- activities that promote metacognitive talk and dialogue.



To download our poster showing how **Best Evidence Science Teaching (BEST)** can help you work towards the seven main recommendations of the report, go to [www.BestEvidenceScienceTeaching.org](http://www.BestEvidenceScienceTeaching.org)

BEST is proving popular with teachers, too. Hundreds of schools across the UK have been using the resources, and the feedback has been overwhelmingly positive!



Follow us on Twitter for updates:

 [@BestEvSciTeach](https://twitter.com/BestEvSciTeach)

Download all BEST resources for FREE from:

[www.BestEvidenceScienceTeaching.org](http://www.BestEvidenceScienceTeaching.org)