Doing retrieval practice better

Kendra McMahon explains how rehearsing knowledge through retrieval practice helps to consolidate it; as we consolidate knowledge, we can also help students to build up more complex schemas of science knowledge by comparing and contrasting, categorising and connecting, creating and questioning within and beyond the topic context

What is retrieval practice?

Retrieval practice (sometimes called the 'testing effect') is bringing information to mind from memory. For example, at the start of a science lesson a teacher might say: '*Let's recap from last week – in what different ways can seeds be dispersed?*' The effort involved in the retrieval process helps to consolidate it as a long-term memory. Cognitive neuroscientist Efrat Furst (2019) explains that in order to bring the information to mind we invest deliberate effort, reactivating a sequence of neural networks and reconstructing the pathway to the stored information (Figure 1).

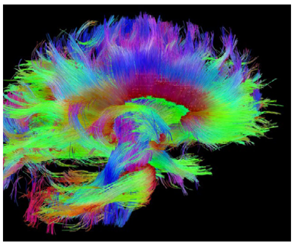

Figure 1 White matter pathways in the brain; image courtesy of the USC Mark and Mary Stevens Neuroimaging and Informatics Institute (www.ini.usc.edu) for the Human Connectome Project

The limitations of retrieval practice

At the moment, retrieval practice in many schools is usually in the form of low-stakes tests. These are good for supporting automaticity – quick and secure recall – but have limited potential for building more complex, interconnected knowledge, or 'schemas'. We can build on our current use of retrieval practice with a wider repertoire of strategies that challenge students to extend ideas as well as recall knowledge. This aim is consistent with Ofsted (2021), who advocate for an ambitious curriculum that '*not only identifies the most important concepts for pupils to learn*' but also teaches them '*how these concepts are related*'.

How can we do retrieval practice better?

We need to avoid thinking of memory as a limited region of the brain, a box in which we put facts. Neuroscientist Arthur Shimamura (2018) explains that knowledge is distributed widely across the cerebral cortex as a network of interconnected information. He sees forming memory as a process of 'generation' in which conceptual learning requires, firstly, the activation of pertinent information in working memory, then the 'binding' of that information and, thirdly, memory consolidation by '*reactivating and relating new information into existing knowledge networks stored in the cerebral cortex*' (Shimamura, 2018:22). Similarly, Furst (2019) argues that the value of retrieval '*stems from building new pathways of associations, closing gaps in knowledge and adjusting existing knowledge to current context*'.

Shimamura (2018: 27) recommends that we use techniques that simultaneously reactivate and elaborate

Primary example (ages 9–11)

Compare a real-life flower to a diagram.

Students could use the similarities that they find to help them to name the parts of the real-life flower (Figure 2).

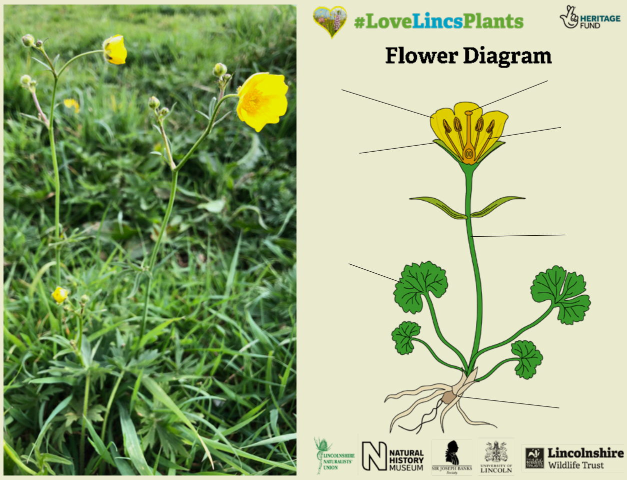

Figure 2 Photograph of real-life flower and a diagram for labelling; photo by Kendra McMahon and diagram from the free school resources at *LoveLincsPlants* (www.lincstrust.org.uk/what-we-do/love-lincs-plants/schools)

This task could be made more challenging by asking students to **compare** and **contrast** two flowers with very different-looking parts (Figure 3). Students could describe the similarities and differences using the correct scientific vocabulary for the parts of a flower.

Figure 3 Two contrasting flowers, camellia and narcissus; photos by Kendra McMahon

Secondary examples (ages 11–16)

Pollination

Students could be encouraged to retrieve primary learning about the parts of a flower and **connect** this to secondary learning about pollination by being asked to **compare** and **contrast** an insect-pollinated and a wind-pollinated plant. Students could comment on the location of the anthers, the position and type of stigma, the presence of nectaries and the type of pollen.

Cells

Compare and **contrast** a diagram and microscopic image of a plant cell (Figure 4).

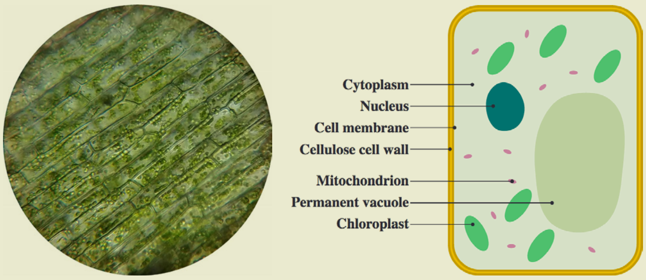

Figure 4 Microscope image of waterweed and a labelled plant cell (by domdomegg, https://commons.wikimedia.org/w/index.php?curid=46468379)

Students could use the similarities that they find to help label the parts of a cell on the microscope image. A key difference that students may observe is that not all the parts of the cell will be clearly visible in the microscope image. This type of activity could be used in different contexts at ages 11–14 and beyond, including during practical work using microscopy.

Another retrieval task with added challenge could be to ask students to use scientific vocabulary to **compare** and **contrast** a diagram of a specialised cell (for example, a ciliated cell or a root hair cell) with a basic cell diagram.

Digestive, respiratory and circulatory systems

A low-stakes retrieval quiz may ask students to recall parts of the digestive and respiratory systems or to write down the word equation for respiration. A more challenging type of retrieval question could encourage students to start connecting their knowledge from different topics. For example:

Name the process that requires substances that enter the body through the two systems in Figure 5.

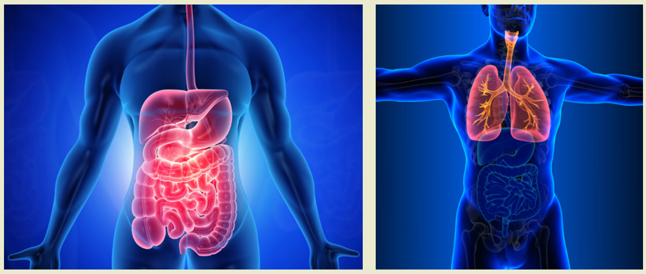

Figure 5 Photographs for body system questions (Shutterstock)

Describe how oxygen and glucose enter the bloodstream.

An even more challenging retrieval task could be to ask students to **compare** and **contrast** how oxygen and glucose enter the bloodstream.

This would require students not only to retrieve specific knowledge of parts of the respiratory and digestive system (alveoli and villi) but also to recognise similarities such as large surface area and thin membranes.

In Shimamura's model, and using the 5Cs and a question approach, it is the students who should generate the questions and do the thinking so this requires a more open-ended retrieval task. For example, the pictures in Figure 5 could be used to stimulate a discussion by asking students to '*Compare and contrast the digestive and respiratory systems*'. A teacher could provide some support to students if needed by suggesting some specific key words to include in their questions and discussion.

memories. Some techniques he lists are: connecting ideas, perhaps by visual mapping; the 3Cs – Categorise, Compare and Contrast; talking; creating stories; metaphors and analogies; explaining to others; and asking 'how' and 'why' questions.

What does this mean in practice? 5Cs and a Q!

In science education, we have long advocated activating student prior knowledge. Using 5Cs and a Q – Categorise, Compare, Contrast, Connect, Create and Question – builds on this constructivist approach, expanding retrieval practice with a wider repertoire of strategies that challenge students to extend their ideas as well as recall knowledge.

For example, developing a rich picture of knowledge of the life cycle of flowering plants would include comparing and contrasting different flowers and flower parts, categorising plants according to seed dispersal, and creating stories about the interdependence of living things (e.g. many flowering plants depend on animals for pollination and seed dispersal). This, in turn, connects to sustaining biodiverse environments that support pollinators, and ultimately the supply of food to humans.

Doing retrieval practice better by embedding a concept in additional networks, makes the concept more accessible and more useful.

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