*Biology> Big idea BCL: The cellular basis of life > Topic BCL2: From cells to organ systems*

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| **Key concept (age 11-14)** |
| **BCL2.1: Working together – cells, tissues and organ systems** |

**What’s the big idea?**

A big idea in biology is that organisms are made of one or more cells, which need a supply of energy and molecules to carry out life processes.

**How does this key concept develop understanding of the big idea?**

This key concept helps to develop the big idea by building understanding that multicellular organisms have a hierarchical organisation of cells, tissues, organs and organ systems that work together to keep the cells alive.

The conceptual progression starts by checking understanding of the different parts of the human body. It then supports the development of ideas about cells, tissues and organs in order to build understanding of how organ systems work together to keep cells alive.

**Using the progression toolkit to support student learning**

Use diagnostic questions to identify quickly where your students are in their conceptual progression. Then decide how to best focus and sequence your teaching. Use further diagnostic questions and response activities to move student understanding forwards.

**Progression toolkit: Working together – cells, tissues and organ systems**

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| **Learning focus** | The cells of multicellular organisms are organised into tissues, organs  and organ systems that work together to keep the cells alive. | | | | |
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| **As students’ conceptual understanding progresses they can:** | **C o n c e p t u a l p r o g r e s s I o n** | | | | |
| Recall that multicellular organisms have different parts with different functions.  **P** | Recall that the parts of a multicellular organism are made up of cells. | Explain what cells must be supplied with in order to stay alive. | Distinguish between cells, tissues, organs and organ systems. | Apply the idea that life in multicellular organisms depends upon tissues, organs and organ systems working together to keep the cells alive. |
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| **Diagnostic questions** | Body parts | Body cells | Animal cell needs | Cells, tissues and organs | Brain cell |
| Where is it? |
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| **Response**  **activities** | Draw what’s inside you |  | What do cells need? | Talking about cells, tissues and organs |  |

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

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| **Body parts** | **Where is it?** | **Body cells** | **Animal cell needs** | **Cells, tissues and organs** |
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| Two-tier multiple choice | Simple multiple choice | Simple multiple choice | Linking ideas | Confidence grid |
| **Brain cell** | **Draw what’s inside you** | **What do cells need?** | **Talking about cells, tissues and organs** |  |
|  |  |  |  |  |
| Two-tier multiple choice | Drawing, discussion | Discussion, card-sort | Talking heads, discussion |  |

**What’s the science story?**

To stay alive, cells need a constant supply of energy and molecules for chemical reactions, and they need to get rid of waste. In a multicellular organism the cells are organised into tissues, organs and organ systems that work together to support the life processes of cells to keep the organism alive.

**What does the research say?**

*The biological concept of ‘alive’*

It is still common for science teaching up to around age 11 to define life using a set of characteristic processes of living organisms: movement, growth, nutrition, excretion, respiration, reproduction, sensitivity and sometimes also control (maintaining a constant internal environment). From the age of 11 this definition of life (which comprises criteria based only on processes) can be supplemented with an additional (structural) criterion – that organisms are made up of cells.

Children at this age could also begin to explore some basic ideas that introduce a systems view of life (Capra and Luisi, 2014), including the idea that living systems are organised at different levels (molecules, cells, tissues, organs, organs systems and whole organisms) and that life is a property that emerges from the interactions between the parts that make up these different levels (Skinner, 2011).

*Body parts*

By age 11, students should know from science lessons that the bodies of humans, other animals and flowering plants have different parts with specific functions (AAAS Project 2061, 2009; Department for Education, 2013). Young children may think of the human body holistically as a single entity, but by age 10 they more commonly understand that it has different functional parts that work together to maintain life (Carey, 1985; Driver et al., 1994). Older research found that while young children thought of the human body as a hollow skin bag in which food, blood and waste are all contained, by age 11 most children had a reasonable understanding of human anatomy and the functions of the parts (Fraiberg, 1959; Gellert, 1962).

*Cells and organs*

Researchers have reported the common misunderstanding in children that the bodies of humans and other animals *contain* cells, perhaps floating in a ‘soup’ of body fluids, rather than being *made up of* cells; typical textbook depictions of animal cells as round and isolated (in contrast to plant cells, which are usually depicted as polygonal and adjacent to other cells) may introduce or reinforce this misunderstanding (Clément, 2007). Several studies have reported that children aged 11-16 lack an appreciation of size and scale, manifested in their assumption that atoms, molecules and cells are all the same size – a conflation dubbed “the molecell” (Arnold, 1983). Cartoon-like depictions of cells with faces, limbs or speech bubbles implying that they are able to speak may introduce or reinforce misunderstandings about the size and scale of cells and organs. Dreyfus and Jungwirth (1988) found that many 16-year-olds struggled to explain how cells carry out life processes, with many students thinking that cells contain macroscopic organs such as a digestive tract (e.g. for nutrition) or lungs (e.g. for respiration).

A number of studies have used drawings to probe understanding of what is inside the human body. Young children tend to draw randomly-placed internal organs, but by age 10 or 11 it is more common to see drawings of organs in approximately correct positions; however, even by age 15 only a minority of children drew organs connected in such a way that they could be considered to represent organ systems (Reiss et al., 2002; Bartoszeck, Machado and Amann-Gainotti, 2011). Misunderstandings about the size, positions and connections between human internal organs can persist in older students aged 19-23 (Çakici, 2018).

**Guidance notes**

It is assumed that, before exploring the ideas covered in this key concept, students will have been taught the requirements of living organisms for life processes and the waste products they produce (key concept BCL1.1 *Living, dead and never been alive*), that organisms are made up of cells (key concept BCL1.2 *Cells and cell structures*), and the principles of diffusion (key concept BCL1.4 *Diffusion and the cell membrane*).

Deeper understanding of human organ systems that work together to keep cells alive is developed in key concept BCL2.2 *Supplying cells – the human circulatory, digestive and gas exchange systems*.

**References**

AAAS Project 2061. (2009). *Benchmarks for Science Literacy* [Online]. Available at: <http://www.project2061.org/publications/bsl/online/index.php>.

Arnold, B. (1983). Beware the molecell! *Biology Newsletter,* 42**,** 2-6.

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.

Çakici, Y. (2018). An investigation of primary student teachers' drawings of the human internal organs. *International Journal of Higher Education,* 7(3)**,** 107-123.

Capra, F. and Luisi, P. L. (2014). *The Systems View of Life,* Cambridge, UK: Cambridge University Press.

Carey, S. (1985). *Conceptual change in childhood,* Cambridge, Massachusetts: Massachusetts Institute of Technology Press.

Clément, P. (2007). Introducing the cell concept with both animal and plant cells: a historical and didactic approach. *Science & Education,* 16(3-5)**,** 423-440.

Department for Education (2013). *Science programmes of study: key stages 1 and 2 - National curriculum in England (DFE-00182-2013),* London, UK.

Dreyfus, A. and Jungwirth, E. (1988). The cell concept of 10th graders: curricular expectations and reality. *International Journal of Science Education,* 10(2)**,** 221-229.

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

Fraiberg, S. (1959). *The Magic Years,* New York, NY: Scribners.

Gellert, E. (1962). Children's conceptions of the content and functions of the human body. *Genetic Psychology Monographs,* 65**,** 293-405.

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.

Skinner, N. (2011). Cells and life processes. In Reiss, M. (ed.) *ASE Science Practice: Teaching Secondary Biology.* London, UK: Hodder Education.