Biology> Big idea BCL: The cellular basis of life > Topic BCL1: Cells

Key concept (age 11-14)
BCL1.2: Cells and cell structures

What's the big idea?

A big idea in biology is that organisms are made of one or more cells.

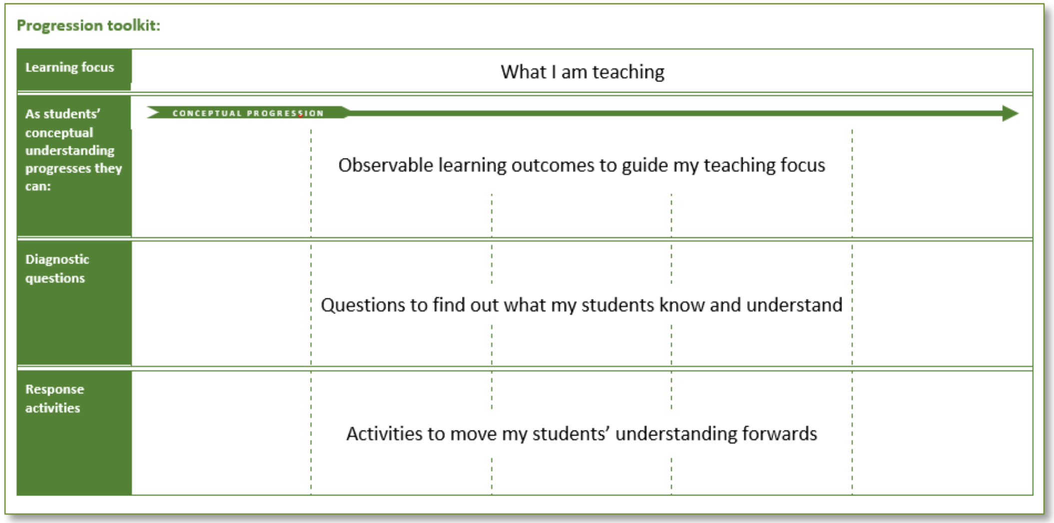
How does this key concept develop understanding of the big idea?

This key concept helps to develop the big idea by developing students' understanding of cells as the ubiquitous building blocks of life, with common structures that carry out life processes.

The conceptual progression starts by checking students' ability to use appropriate apparatus and techniques to observe cells from a range of tissues and organisms. It then supports the development of ideas about common cell structures and their functions, leading to understanding of the models that scientists use to describe the common features of animal and plant cells.

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: 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?

What's the science story?

Organisms, living and dead, are made up of cells. Cells are made of molecules organised into membranes and other structures.

Most cells are too small to be seen with the naked eye but can be seen using a light microscope. There are many different types of cells with different shapes and sizes, but all cells are made up of common parts: all cells have a genome and cytoplasm contained by a cell membrane; all animal and plant cells store their genome within a nucleus, and they also have mitochondria; plant cells additionally have a cell wall and can have chloroplasts and a vacuole. These parts have common functions in all cells.

A single cell can carry out all the processes of life. An organism may be made up of a single cell or many cells working together. This is why scientists think of cells as the basic units of life.

What does the research say?

Cell theory[1] is a fundamental concept in biology that underpins understanding of other biological concepts. It includes the ideas that organisms are made up of one or more cells; that life depends on the structure, functions and organisation of cells; and that all cells are made from existing cells.

It is unlikely that students will have developed a scientific understanding of cells from science lessons before the age of 11 (AAAS Project 2061, 2009; Department for Education, 2013), but they may have acquired their own ideas from hearing about cells in their everyday experiences and the media, e.g. cancer cells and stem cells.

Researchers have acknowledged that the cell is, when first introduced, an abstract concept (Dreyfus and Jungwirth, 1988; 1989). When introducing ideas about cells, several sources advocate starting with hands-on light microscopy of cells from a range of tissues and organisms, to enable students to discover for themselves that cells are the common building blocks of living things and what they look like (AAAS Project 2061, 2009; Skinner, 2011). Haşiloğlu and Eminoğlu (2017) found that light microscopy coupled with drawing cells was effective in helping students to overcome misunderstandings. Dreyfus and Jungwirth (1988) note that most children will never see cells functioning, so the *living* (functional) cell remains an abstract idea even if they have become familiar with the structures of cells through light microscopy and pictures; the US Benchmark for 11 year-olds recommends that students watch videos of "living cells growing and dividing, taking in substances, and changing direction when they run into things".

[1] It should be noted that the scientific use and meaning of the term "theory" is commonly misunderstood in classrooms, and differs from the everyday use and understanding of the term (Williams, 2013). In vernacular use, "a theory" often refers to something that is theoretical in the sense that it is unproven or untested and speculative. In scientific parlance, a scientific explanation of a phenomenon begins with a hypothesis – a tentative explanation that can be tested by collecting data; if a hypothesis is supported by data it may become a scientific theory. A scientific theory is often a general explanation that applies to a large number of situations or examples (perhaps to all possible ones), which has been extensively tested and evidenced. Cell theory is fully supported by evidence and is universally accepted by scientists.

Many authors have described ways of learning about cells and their structures, in addition to the use of microscopy and videos, that may help to develop students' understanding, including for example:

- building two- and three-dimensional models of cells (e.g. Tregidgo and Ratcliffe, 2000);
- role-playing as cell organelles (e.g. Cherif et al., 2016);
- using smartphones/tablets to create their own animations and videos of life processes in cells (Deaton et al., 2013).

Research (e.g. Dreyfus and Jungwirth, 1988; Clément, 2007) has identified a number of misunderstandings that students have about cells, and some common practices that may introduce or reinforce these misunderstandings, including for example:

Misunderstanding	Practices that can introduce or reinforce the misunderstanding
Cells are merely structural units, like 'bricks in a wall', but not functional units that carry out life processes.	Over-reliance on static imagery of cells, including textbook diagrams and photomicrographs that show only structural details of (apparently lifeless) cells.
There are only two kinds of cells, namely animal cells and plant cells (and hence that only animals and plants are made up of cells).	Limiting students' experience of cells (e.g. through microscopy and cellular imagery) to just animal and plant cells (e.g. onion cells and cheek cells).
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). Over-reliance on blood cells as examples of human cells.
Animistic and anthropomorphic views, such as believing that cells and cell organelles have desires and intentions (e.g. they 'know' or 'want' to take in and discard particular substances).	Use of cartoon-like depictions of cells and cell organelles with faces or with speech bubbles in which they describe their own functions.

Dreyfus and Jungwirth (1988) found that many 16-year-olds struggled to explain how cells carry out life processes. Many of the students thought that cells contain macroscopic organs such as a digestive tract (e.g. for nutrition) or lungs (e.g. for respiration). Even students who could identify the correct cell organelles could not explain how they carry out their functions, especially how the nucleus 'controls' the structure and functions of a cell.

Guidance notes

Ideas about the size and scale of cells are explored further in the next key concept, *BCL1.3: Cell shape and size*. Understanding of photosynthesis and respiration, as the functions of chloroplasts and mitochondria respectively, is developed in topic *BCL3: Cellular biochemistry*. Appreciation of what is stored in the nucleus and how it is affects the structure and function of living organisms is developed as part of the big idea *Growth, reproduction and inheritance*.

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