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

Key concept (age 11-14)
BCL1.3: Cell shape and size

What's the big idea?

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

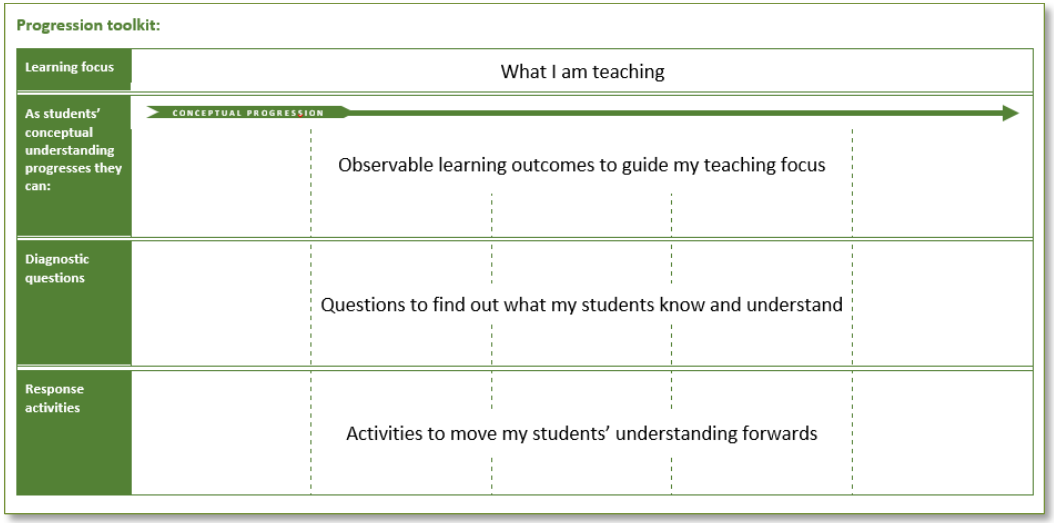
How does this key concept develop understanding of the big idea?

This key concept helps to develop the big idea by developing students' understanding that cells are usually too small to be seen without a microscope, but have a range of three-dimensional shapes and sizes.

The conceptual progression starts by checking understanding of the need for light microscopy to observe most cells due to their relatively small size. It then supports development of an appreciation of the variety of shapes and numbers of cells that make up organisms, as a foundation for progression onto later teaching about the hierarchical organisation of multicellular organisms from cells to organ systems.

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: Cell shape and size

<table>
<tr><th>Learning focus</th><td colspan="5">Cells are usually too small to be seen without a microscope, but have a range of three-dimensional shapes and sizes.</td></tr>
<tr><th rowspan="2">As students' conceptual understanding progresses they can:</th><td colspan="5">CONCEPTUAL PROGRESSION</td></tr>
<tr><td>Recall that most (but not all) cells are too small to be seen without a microscope.</td><td>Apply the idea that cells have a three-dimensional shape.</td><td>Link the shapes and sizes of different cells to their functions.</td><td>Estimate the numbers of cells that make up different organisms.</td><td>Describe the interacting levels of organisation within a cell (atoms, molecules, subcellular structures and whole cells) that make life possible.</td></tr>
<tr><th rowspan="6">Diagnostic questions</th><td rowspan="2">Seeing cells</td><td rowspan="6">A good cell model?</td><td rowspan="6">The size and shape of cells</td><td rowspan="6">How many cells?</td><td rowspan="3">Atoms, biological molecules and organelles</td></tr>
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<tr><td rowspan="2">What's the magnification?</td></tr>
<tr><td rowspan="3">The unit of life</td></tr>
<tr><td rowspan="2">Too small to see?</td></tr>
<tr></tr>
<tr><th rowspan="3">Response activities</th><td>Blood analysis</td><td rowspan="3">Build a cell model</td><td rowspan="3">The right cell for the job</td><td colspan="2" rowspan="3">Zooming in</td></tr>
<tr><td>Zooming in</td></tr>
<tr><td>Giant cells</td></tr>
</table>

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.

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?

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 build their own understanding of the size of cells and what they look like (AAAS Project 2061, 2009; Skinner, 2011).

Research has shown that students at age 11-14 resist accepting that cells are three-dimensional object, believe instead that they are flat (Vijapurkar, Kawalkar and Nambiar, 2014). This misunderstanding may be related to the prevalence of textbook line diagrams and photomicrographs that show cells only in two-dimensional cross-section, lacking depth or surface features. Several studies have advocated the building and use of three-dimensional models of cells during teaching to help overcome this (e.g. Tregidgo and Ratcliffe, 2000; Lazarowitz and Naim, 2014).

Clément (2007) notes that "the cell concept is generally introduced by two juxtaposed drawings, a plant cell and an animal cell", and that the plant cell is generally polygonal and adjacent to other cells while the animal cell is more rounded in shape and isolated. Clément has dubbed the common depiction of an animal cell as two concentric circles (cell membrane and nucleus, lacking other organelles or internal structures) the "fried-egg model", and has shown that it can block subsequent development of understanding (e.g. about cell differentiation). If students are not presented with a greater variety of images of cells they may come to think that all animals cells and all plants cells have the same shape and structures as these two archetypal depictions; Clément found exactly this misunderstanding persisting in students up to undergraduate level.

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. This conflation has been dubbed "the molecell" (Arnold, 1983). A related misunderstanding is that everything studied in biology lessons, including biological molecules such as proteins and carbohydrates, is made of cells and is alive; some children would only apply the term "molecule" to things they had studied in chemistry and physics (Dreyfus and Jungwirth, 1988).

The American Association for the Advancement of Science (AAAS) has reported that almost half of the students in a large sample of aged 11-18 year olds had misunderstandings about the number of cells from which organisms could be made up, with over a third believing there were no single-celled organisms and almost a quarter thinking that "about 1000" was the largest number of cells in an organism (AAAS Project 2061).

Cartoon-like depictions of cells and cell organelles 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.

References

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