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

Key concept (age 11-14)
BCL2.3: The human skeleton and muscles

What's the big idea?

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

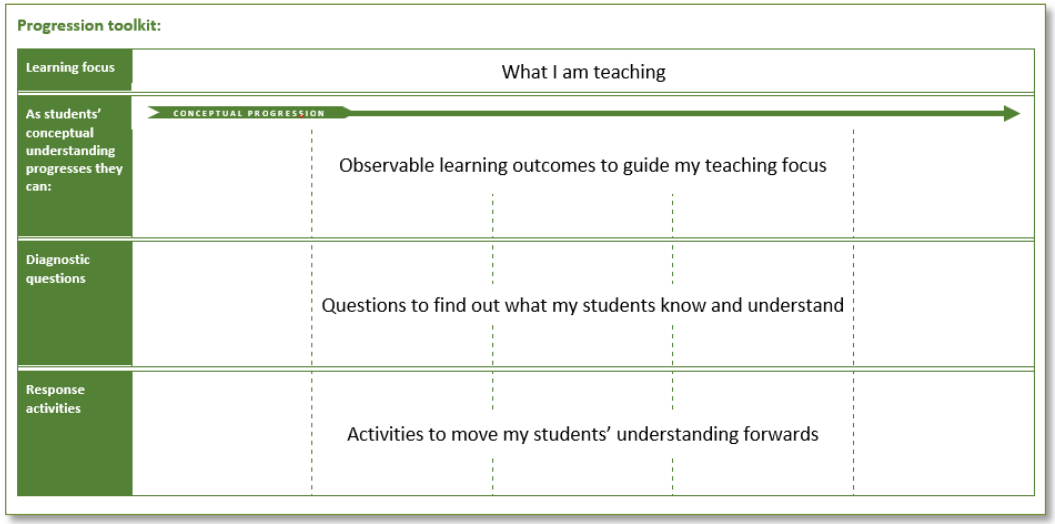
How does this key concept develop understanding of the big idea?

This key concept helps to develop the big idea by building understanding that bones and muscles are important tissues that work together with organs in organ systems to support the life processes of cells to keep us alive.

The conceptual progression starts by checking understanding of the presence and functions of the skeleton and muscles in humans. It then supports the development of understanding of how muscles work, and of the presence and roles of muscles in interacting organ systems that keep us 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: The human skeleton and muscles

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.				
As students' conceptual understanding progresses they can:	CONCEPTUAL PROGRESSION →				
	Recall that the human body contains a skeleton and muscles for support, protection and movement. **P**	Recall that bones and muscles are living tissues made up of cells.	Describe how muscles work to move bones, including antagonistic muscles.	Describe the presence and roles of muscles in organs and organ systems.	Explain why heart rate increases when we exercise.
Diagnostic questions	Without bones	Are muscles and bones alive?	Biceps and triceps	Moving through the digestive system Breathing	Exercise
Response activities	Standing up		PEOE – Muscle fuel Visualising muscles and joints	Muscles in organ systems	

Key:

P Prior understanding from earlier stages of learning

B Bridge to later stages of learning

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.

Humans and other animals have a skeleton and muscles, which are types of tissue made up of cells. Bones provide support and protection for organs. Bones and muscles work together to enable humans to move around, and muscles have vital roles in organs and organ systems.

What does the research say?

By age 11, students should know from science lessons that the bodies of humans and other animals have different parts with specific functions, including bones and muscles (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). 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).

Several studies have found that children up to age 20 struggle to appreciate that individual bones are not isolated but are connected to make a functional skeleton (Guichard, 1995; Tunnicliffe and Reiss, 1999). While young children only recognise the supportive and protective (static) functions of the skeleton, older children understand that the skeleton is necessary for movement; however, only one fifth of the older children in one study could draw muscles correctly across a joint (Caravita et al., 1988). Use of real muscles and bones, e.g. raw chicken legs, and models can help children to understand this more effectively, including the idea that muscles can only pull (Haddad, 1995; Goodwyn and Salm, 2007; Fullick, 2011).

It is a common misunderstanding amongst people of all ages that bone (even when it is inside a living organism) is dead, perhaps because bones and skeletons are often associated with imagery of death and with specimens in museums etc.; this misunderstanding is reinforced by the fact that bones are usually only seen when they are outside the body, and are usually only alive when they are inside it (Caravita and Falchetti, 2005; Fullick, 2011). Caravita and Falchetti found that growth and movement were the criteria most commonly applied by students to decide whether bones were alive, as well as phenomenological criteria drawn from personal experience such as that bones hurt when injured and repair when broken; few 8-9 years olds mentioned that bones are made of cells, but it was more common in 12-13 year olds.

A number of studies have used students' drawings to probe their understanding of what is inside the human body. 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; Bartoszeck, Machado and Amann-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; AHİ, 2017).

Some children believe that muscles need 'air' (rather than oxygen) to work; related misconceptions are that the heart pumps air around the body instead of or in addition to blood, and that the heart rate increases during exercise so that the heart can pump more air to the muscles (Allen, 2014).

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