*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)** |
| **BCL2.2: Supplying cells – the human circulatory, digestive and gas exchange systems** |

**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 of how the human circulatory, digestive and gas exchange systems work together to support the life processes of cells to keep the whole organism alive.

The conceptual progression starts by checking understanding of the simple structures and functions of the human digestive, circulatory and gas exchange systems. It then supports the development of understanding that these systems work together to keep cells alive, and that substances are exchanged by diffusion.

**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: Supplying cells – the human circulatory, digestive and gas exchange systems**

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| **Learning focus** | Human life depends upon the tissues and organs of the circulatory, digestive and gas exchange systems working together to support the life processes of the cells from which we are made. | | | | |
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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** | | | | |
| Describe simply the structures and functions of the human digestive system.  **P** | Describe simply the structures and functions of the human circulatory system.  **P** | Describe simply the structures and functions of the human gas exchange system. | Explain how the human circulatory, digestive and gas exchange systems work together to keep cells alive. | Explain how substances move into and out of the blood.  **B** |
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| **Diagnostic questions** | The human digestive system | The human circulatory system | The human gas exchange system | Brain cell | Oxygen |
| What happens to the food we eat? | Arteries and veins | What’s in the air? | Circulation |
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| **Response**  **activities** | A model of digestion |  | PEOE – Flames | Circulatory system  role-play |  |

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| 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.

In humans, the circulatory system transports useful molecules and waste around the body. The blood transports useful molecules to cells from food that has been broken down by the digestive system. The blood also transports oxygen to cells from the gas exchange system, and transports waste carbon dioxide away from cells back to the gas exchange system to be removed from the body.

**What does the research say?**

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).

*The digestive system*

Older research found that young children thought of the human body as a hollow skin bag – like a large stomach – in which food, blood and waste are all contained (Fraiberg, 1959). Even when human internal anatomy is better understood, a common misconception is that the stomach is larger and lower in the body than it really is; specifically that it takes up most of the abdomen, with the centre of the stomach roughly where the navel is (perhaps because in everyday language this entire area can be referred to as the ‘stomach’ with the ‘belly button’ at its centre) (Mintzes, 1984; Allen, 2014). Some young children believe that there are separate ‘food’ and ‘drink’ tubes that run from the mouth to the anus and urinary organs, respectively, rather than a single digestive tract (Equit et al., 2013; Brinkman and Boschhuizen, 1989).

From an early age, children understand that ‘goodness’ is taken out of food after it is eaten, though there is little understanding of the chemical process of digestion even in older children (Driver et al., 1994; Millar, 2011; AHİ, 2017). Many students think that while food is broken down, its chemical composition remains unchanged (Teixeira, 2000; García-Barros, Martínez-Losada and Garrido, 2011). A common misconception held by school children is that digestion (rather than cellular respiration) is the process that releases useful energy from food, perhaps because students incorrectly link two ideas – i.e. that digestion breaks down food, and that organisms get energy from food (Simpson, 1984). Some children incorrectly describe digestion as ‘melting’ or ‘dissolving’ (Çakici and Yilmaz, 2005).

Studies have found that young children commonly recognise the mouth and stomach as part of the digestive system, but not the intestines (García-Barros et al., 2011; AHİ, 2017). The word ‘tummy’ is commonly used by children up to age 10 to refer in a non-organ-specific way to the abdominal area (Teixeira, 2000). The role of the stomach is often misunderstood as the main or only place where digestion occurs (food is mainly stored and churned in the stomach, while most of the digestion and absorption takes place in the intestines) (Millar, 2011).

*The circulatory system*

Various authors (e.g. Arnaudin and Mintzes, 1985; Schoon and Boone, 1998; Bartoszeck et al., 2011; Winterbottom, 2011; Özgür, 2013; Allen, 2014) have described misunderstandings about the human circulatory system that are commonly observed in school science classrooms (and can persist in students up to undergraduate level), including that:

* the heart is located on the left side of the chest (rather than in the centre);
* the heart has a cartoon-like or emoji-like shape (♥), and is the centre of feelings;
* the heart produces, stores, filters or cleans the blood;
* the heart pumps air around the body instead of, or in addition to, blood (perhaps because they believe air to be synonymous with oxygen, that muscles need ‘air’ to work, and have observed heart rate and breathing rate increasing when they exercise);
* the heart is a muscular bag without chambers (i.e. is a single pump);
* humans have a single (rather than double) circulatory system, in which blood is pumped from the heart to the lungs and then to the rest of the body before returning to the heart;
* arteries only carry oxygenated blood, while veins only carry deoxygenated blood (applying a ‘rule of thumb’ that ignores the direction of blood flow relative to the heart, and also ignores arteries and veins carrying blood to and from the lungs);
* arteries carry ‘clean’ blood, while veins carry ‘dirty’ blood;
* deoxygenated blood is blue in colour, while oxygenated blood is red (a misconception introduced or reinforced by the common depictions in textbooks).

*Breathing and gas exchange*

Unlike the digestive system and the circulatory system, students are less likely to have been formally taught about the gas exchange system before age 11; however, they should be familiar with the lungs as organs of the body (Department for Education, 2013). One study found that young children up to age 7 frequently included other organs in the gas exchange system, in particular the stomach and heart (García-Barros et al., 2011).

While most children at age 11 are aware that humans need air to survive, some think that air is breathed into the lungs (or, less commonly, just into the head) and is then breathed out unchanged; a related but contrasting misconception has also been reported, in which children think that inhaled air is all oxygen while exhaled air is all carbon dioxide (Yip, 1998; García-Barros et al., 2011; Allen, 2014).

Students at age 11 are usually aware that ‘air tubes’ link the mouth to the lungs, and that humans have two lungs located in the chest (Bartoszeck et al., 2011; Allen, 2014). However, some students also believe that similar ‘air tubes’ connect the lungs to the heart, and that this explains how oxygen from air enters the blood.

**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*).

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