Biology

Big idea (age 11-16)
BCL: The cellular basis of life

What's the big idea?

Organisms are made of one or more cells. Multicellular organisms have a hierarchical organisation of cells, tissues, organs and organ systems that work together to keep the cells alive. Cells need a supply of energy and molecules to carry out life processes.

Key concepts

The big idea is developed through a series of **key concepts** at age 11-16, which have been organised into teaching topics as follows.

The numbering gives some guidance about teaching order based on research evidence on learning pathways and on effective sequencing of ideas. However, the teaching order can be tailored for different classes as appropriate.

11-14:

Topic BCL1
Cells

Key concepts:

BCL1.1	Living, dead and never been alive
BCL1.2	Cells and cell structures
BCL1.3	Cell shape and size
BCL1.4	Diffusion and the cell membrane

Topic BCL2
From cells to organ systems

Key concepts:

BCL2.1	Working together – cells, tissues and organ systems
BCL2.2	Supplying cells – the human circulatory, digestive and gas exchange systems
BCL2.3	The human skeleton and muscles

Topic BCL3
Biochemistry

Key concepts:

BCL3.1	Plant nutrition and photosynthesis
BCL3.2	Cellular respiration

14-16:

Topic BCL4
Cell structure

Key concepts:

BCL4.1 Eukaryotic and prokaryotic cells

Topic BCL5
Exchange and transport

Key concepts:

BCL5.1 Diffusion, osmosis and active transport

BCL5.2 Supplying cells – exchange surfaces and transport systems in humans

BCL5.3 Supplying cells – exchange surfaces and transport systems in plants

Topic BCL6
Coordination and control

Key concepts:

BCL6.1 The human nervous system

BCL6.2 The human endocrine system

BCL6.3 Homeostasis

Topic BCL7
Biochemistry

Key concepts:

BCL7.1 Biological molecules and enzymes

BCL7.2 Photosynthesis and limiting factors

BCL7.3 Cellular respiration and ATP

This document last updated: November 2020

Learning progression

The science story associated with the big idea develops from age 5 to age 16, and could be summarised as follows:

Science story at age 5-11

Requirements for life

Living organisms depend on their environment to survive. Animals, including humans, need a plentiful supply of air, water, nutrients from food, and a suitable temperature to survive. Plants need air, light, water, a suitable temperature, nutrients from soil, and room to grow.

All living organisms carry out some characteristic processes that distinguish them from non-living things. Living organisms can move, can respond to the world around them, use food as a source of energy and materials, get rid of waste, grow and can reproduce – though something that is alive will not show all of these life processes all of the time, and in some cases may not show them in an obvious way. All living organisms eventually die.

Tissues, organs and systems

The bodies of humans and other animals are divided into different parts with different functions, including senses. Humans and some other animals have skeletons and muscles for support, protection and movement. The human digestive system includes the mouth, stomach and intestines. In the human circulatory system the heart pumps blood around the body through blood vessels.

Flowering plants are also divided into parts with different functions. The roots absorb water, which is transported up the stem or trunk to the leaves and flowers.

Science story at age 11-14

Cells

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 DNA 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. Molecules move through the cytoplasm by diffusion, and some molecules can enter and leave a cell by diffusing through the cell membrane.

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.

Tissues, organs and systems

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.

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.

Biochemistry

Chemical reactions that make and break down substances take place all the time in living cells. Photosynthesis and cellular respiration are important chemical processes in living cells.

Plants do not take in food. Instead, they make carbohydrate inside their cells, which is their only source of food. Plants are called producers because they make their own food. A chemical process called photosynthesis in plant cells makes the carbohydrate food, and also makes oxygen as a waste product. Photosynthesis requires light, water and carbon dioxide. Photosynthesis can be modelled very simply using a summary of the inputs and outputs. Photosynthesis takes place in chloroplasts inside cells in parts of a plant such as the leaves. Plants use the carbohydrate food made by photosynthesis to make other substances for growth and they also use it as a fuel. Although plants do not take in food, they do take in non-food substances, such as water and carbon dioxide for photosynthesis, and minerals that the plant cannot make. Plants are the source of the food that is transferred through food chains.

All living organisms require energy for life processes. The energy is provided by a chemical process called cellular respiration that takes place in cells. One type of cellular respiration is aerobic – it uses oxygen and glucose from carbohydrate food as fuel. This process breaks down the glucose, and makes carbon dioxide and water as waste products. It takes place in the cytoplasm and mitochondria inside plant and animal cells. Cellular respiration can be modelled very simply using a summary of the inputs and outputs of the process.

Science story at age 14-16

Cells

Our understanding of cell structures and their functions has been developed from observations made using light and electron microscopes.

Cells have different shapes and sizes, but all cells are made up of common parts: all cells have a genome, ribosomes and cytoplasm contained by a cell membrane. There are differences in the sub-cellular structures of eukaryotic cells (all the cells that make up animals, plants, fungi and protists) and prokaryotic cells (bacteria and archea). All eukaryotic cells store their DNA in a membrane-bound nucleus, and they also have mitochondria; some eukaryotic cells additionally have a cell wall and can have chloroplasts and a vacuole. Prokaryotic cells are smaller than eukaryotic cells, and do not have a membrane-bound nucleus or organelles such as mitochondria and chloroplasts; their DNA is stored in the cell cytoplasm.

Tissues, organs and systems: exchange and transport

The heart, red blood cells, white blood cells, platelets and plasma of the circulatory system are adapted to transport molecules in humans. The circulatory system interacts with other organ systems to support life processes.

The roots, xylem, phloem and stomata are adapted for the transport and exchange of molecules in plants. Environmental factors affect the rate of water uptake by a plant, including light intensity, air movement, and temperature.

Tissues, organs and systems: coordination and control

The brain, spinal cord, neurones, synapses, receptors and effectors of the nervous system are adapted to enable humans to respond to internal and external stimuli. The structures of the eye are adapted to its function as a sense organ.

The human endocrine system is adapted for coordination and control, including through negative feedback.

Maintaining a constant internal environment in response to internal and external change is essential for survival. In humans this is achieved through detection, processing and antagonistic responses by the nervous and endocrine systems, to control blood sugar levels, body temperature and water balance.

Biochemistry

The variety of life is extensive, but all life depends on common biological molecules including carbohydrates, lipids and proteins, and the smaller molecules and elements from which they are made. Biological molecules and reactions can be represented using chemical formulae. Many biological processes require energy, which is provided by the breakdown of ATP.

Many chemical reactions in organisms depend on enzymes, which are biological molecules that act as catalysts. They help to break down and build up other molecules without being used up themselves. Enzyme action and specificity depends on the shape of the enzyme's active site, and the rate of enzyme-controlled reactions is affected by temperature, substrate concentration and pH.

A two-stage model can be used to describe the process of photosynthesis in the chloroplasts of plants and algae. The first stage requires light and water; the second stage does not need light but uses carbon dioxide to make glucose (a carbohydrate) and oxygen as a waste product. The rate of photosynthesis is affected by, and can be limited by, temperature, light intensity and carbon dioxide concentration. The structure of a leaf is adapted to maximise the rate of photosynthesis.

Cellular respiration is an exothermic process that occurs continuously in living cells. ATP is made during cellular respiration as molecules of glucose are broken down. There are differences between aerobic and anaerobic cellular respiration in humans and in microorganisms, in terms of the reactants, products and the implications for the organism.