Cross-cutting themes in the framework for the 5-19 biology curricula

The Royal Society of Biology framework for the 5-19 biology curricula has three dimensions sub-divided into 23 themes. Each of these is a different way of viewing the biological world. Underpinning these views are 'cross-cutting themes' that draw together common ideas across the themes, integrating them into three keystone ideas. Students' appreciation and understanding of these ideas will grow and develop throughout their study of biology.

The three cross-cutting themes are:

- Flows of energy and cycles of matter
- Forms of organisation
- Stability and change

Detailed exemplification of the statements is given below. It is important to realise these statements represent core principles, that will need to be re-interpreted to become relevant to students at their particular stage of learning.

Crosscutting Themes

1. Flows of energy and cycles of matter

Living organisms require continual inputs of energy to stay alive, to grow and reproduce. Energy flows from the Sun through feeding webs in ecosystems. At each stage, some energy is dissipated to the thermal store of energy in the environment. The availability and supply of energy regulates the distribution of living organisms in ecosystems.

Living organisms require continual inputs of matter, as nutrients, to maintain their systems, to grow and reproduce. Living organisms coexist in feeding webs in ecosystems and may become nutrients for other organisms. Matter is conserved in the biosphere as matter cycles around ecosystems.

Cell membranes are integral to the survival of living organisms. Surface membranes control the flow of energy and matter into and out of cells; internal membranes help to maintain the highly organised internal structure of the eukaryotic cell.

Tracking fluxes of energy and matter through living organisms allows their potential for growth and reproduction to be assessed.

2. Forms of organisation

Living organisms have characteristic forms with stable patterns that can be observed and measured. The forms are used to classify living organisms into groups based on common similarities. Often these groups reflect evolutionary relationships of descent from common ancestors. Analysis of similarities in the organisation of the genome provides powerful confirmatory evidence of these evolutionary relationships.

Biology is the study of the relationships between living organisms and with key factors in their environment, both now and in past times.

The living world consists of networks of systems within systems. A system is an integrated whole, whose essential properties arise from the relationships between its parts. Living organisms form multilevel networks of systems, nested within other systems:

molecules>cells>tissues>organs>organ systems>organisms>social systems>ecosystems>biosphere

At each level of organisation, *new properties* emerge that do not exist at lower levels. Life is a property that emerges when all of the systems within an organism integrate and function together.

Biologists define a level of organisation under study—specifying its boundaries and describing in detail the objects in the system and their structural and functional relations to other objects. They also predict the impacts of changes in this level on other levels of organisation. In this way, biologists make models of living systems. These provide tools for testing hypotheses, leading to greater understanding the living organisms and their relationships within the biosphere. Biologists frequently work concurrently at several different levels of organisation with different scales, from the microscopic through to the macroscopic.

3. Stability and change

At all times, living organisms are in the process of "being and becoming". They are stable structures, *maintaining* their bodies with high levels of functional organisation. At the same time, organisms are changing, becoming different through *growth* and *development*. They may also *reproduce,* which is another dimension of change.

The relationship between an organism and its ancestors can be traced back to a last common universal ancestor that lived about 3.7 billion years ago. The diversity of life that exists (or has ever existed) on Earth, has arisen through evolution by natural selection from the last universal common ancestor. The potential to generate new forms of life is a property of organisms' *genomes*. This potential is realised through the interaction of organisms with their social systems and with biotic and abiotic factors in their environments.

Stability and change reflect an organism's relationship with *time*. Time can be measured in terms of instantaneous moments, durations across an organism's life or across the aeons of historical time.

For living organisms, internal stability is maintained by regulation and control of negative feedback loops. This is *homeostasis*. Negative feedback loops can operate at any level of organisation, or between levels of organisation. Determining the processes of change or evolution of living systems are critical to the full understanding of living organisms and their relationships to each other.

All biological events have causes: occasionally a single factor can cause an effect. Usually multiple factors interact, and the final effects are indeterminate and probabilistic. Biological interactions often involve factors in the external environment interacting with the internal chemical environment of the organism. These may also involve further interactions with the organism's genome.

Biologists investigate and explain causal relationships and the mechanisms by which they are mediated. These causal relationships can operate within a single level of organisation, or between different levels. They can act upwards from lower levels to the higher levels or downwards from the higher levels to the lower levels. Such mechanisms can then be generalised to other related organisms and used to predict and explain events in these organisms.

Understanding the causal relationships between within the biosphere facilitate the production of novel interventions, to promote human welfare and to conserve the relationships between organisms in the biosphere. Agriculture, medicine, veterinary science and biotechnology are examples of such interventions.