Edexcel Additional Science
Biology B2

Topic 1 — Inside Living Cells
DNA in the nucleus controls the whole cell and therefore the whole organism.
Students will appreciate that our understanding of how cells work owes a lot to our search for cures for cancer. Energy for the cell is provided by the chemical reaction called respiration, which is driven by proteins. Proteins are important components of the cell and their production is determined by the genes: genes contain codes that determine the sequence of amino acids in proteins.
In this topic, there are opportunities to measure body functions and investigate how they are affected by physical activities. The data can be interpreted in relation to theories about respiration and oxygen debt. Students can practise measuring accurately and understand that they need to consider safety when collecting data.
There is an opportunity to consider the industrial use and benefits of technological developments, including the cultivation of microorganisms in fermenters. How scientific ideas develop can be demonstrated by the DNA story, from data collection to the leap of imagination.

Have you ever wondered?
- What processes in cells keep you alive?
- Why are plants and animals so different?
- How does my body know which enzymes to produce?
- Why does my heart beat faster when I exercise?
- Why do I get cramp?

Learning objectives
- The chemical reactions essential for life take place inside cells.
- Respiring cells require a supply of glucose and oxygen, producing carbon dioxide as a waste product.
- Genes are the template for protein synthesis inside cells.
- The digestive, circulatory and respiratory systems provide cells with the basic materials they need to carry out their functions.

Glossary
adenine cytosine microorganism strand
aerobic diffusion mRNA (messenger RNA) thymine
amino acid DNA organelle transcription
anaerobic double helix plasmid translation
aseptic fermentation polypeptide tRNA (transfer RNA)
bases fermenter protein triplet code
capillary glucose respiration ventilation
coding guanine ribosome
cramp insulin RNA
cultivated lactic acid rRNA (ribosomal RNA)

Students will be assessed on their ability to:
- describe a DNA molecule as two strands coiled to form a double helix, the strands linked by a series of paired bases (adenine with thymine and cytosine with guanine)
- explain that DNA controls the joining together of amino acids to make a specific protein in a cell and that the order of bases in a section of DNA decides the order of amino acids in the protein
- explain that sections of DNA coding for specific proteins can be transferred into microorganisms which are then cultivated in fermenters to produce useful substances, including human insulin

- explain that microorganisms use an external food source to obtain energy, changing some substances in the medium and recall that this process is fermentation
- **describe a fermenter as a vessel used to cultivate microorganisms and explain the need to supply suitable conditions in fermenters, including aseptic precautions, nutrients, optimum temperature and pH, oxygenation and agitation**
- explain the advantages of using microorganisms for food production
    - rapid population growth; ease of manipulation
    - production independent of climate
    - use of waste products from other industrial processes
- demonstrate an understanding of the emerging role of genetically modified bacteria in the production of useful substances
- **describe organelles in the cell that are involved with making protein**
- **describe the stages of protein synthesis**
    - **the coding by triplets of bases in the DNA to produce mRNA**
    - **the attachement of the ribosome to the mRNA**
    - **the linking of amino acids to form polypeptides**
- explain how ventilation provides oxygen for aerobic respiration which releases energy for work
- explain how glucose and oxygen diffuse from capillaries into respiring cells, and how carbon dioxide diffuses from respiring cells into capillaries
- explain why heart rate and breathing rate increase with exercise and interpret data on these measurements
- **explain why respiration is increased in exercising muscles and why diffusion of oxygen and carbon dioxide at the lung surface and muscle cells is increased**
- explain why during vigorous exercise, muscle cells may not receive sufficient oxygen for their energy requirements
- demonstrate an understanding of how digital thermometers, and breathing rate and heart rate monitors, can provide more reliable data than traditional methods
- describe that glucose is changed to lactic acid and energy is released, during anaerobic respiration
- **explain why extra oxygen is needed to remove the lactic acid that causes cramp (oxygen debt)**
- discuss why official advice on diet and exercise change over time and consider the scientific basis of current fashionable diets and advice.

Topic 2 — Divide and Develop

Understanding how living things grow helps us to understand and treat medical problems arising at birth or later in life. Cells replicate by mitosis and gametes are produced by meiosis. Cells are differentiated to specific functions. In animals this differentiation arises from stem cells, but this ability is lost at an early stage. Scientists are beginning to understand the medical potential of stem cells. This can be compared with plant growth, where regeneration and virtually continual growth is common. The more we can understand plant growth the more we will be able to produce the quantity of food the world requires. Consideration is given to the limiting factors affecting plant growth and
distribution, which can be investigated practically.
There is ample opportunity to discuss ethical issues associated with growth and development and genetic modification, as well as giving consideration to the potential of gene therapy.

Have you ever wondered?

- Why don't I keep on growing forever?
- Why do scientists want to modify cows?
- What is a stem cell and why do scientists think it is so valuable?
- Why do plants need hormones?
- Why have the International Olympics Committee (IOC) banned certain chemicals?
- How does scientific knowledge contribute to decisions regarding the termination of pregnancies?
- How can gene therapy help treat cancer sufferers?
- Why do 'weeds' always grow in the most awkward places?

Learning objectives

- Organisms grow by cell division, elongation and differentiation of cells.
- Plants and animals are different and this results in different patterns of growth and development.
- There is a variety of environmental factors that will influence the growth and distribution of plants.
- Human intervention can manipulate the outcome of reproduction.

Glossary

auxins embryo meiosis selective breeding
cancer cell fetus mitosis species
cell division gametes nuclear transfer sperm
chromosomes genes nucleus stem cell
continuous variation genetic modification nutrient steroids
differentiation growth ovum termination
diploid haploid pedigree analysis
discontinuous variation hormones phototropism
elongation inheritance regeneration

Students will be assessed on their ability to:

- describe mitosis as the division of a cell to produce two nuclei with identical sets of chromosomes, for growth or replacement
- **describe meiosis as the division of a cell to produce four haploid gametes with sets of chromosomes that are not genetically identical to produce gametes**
- **explain the differences between mitosis and meiosis**
- discuss the meaning of growth, in terms of increase in size; length; wet mass; dry mass
- demonstrate understanding of how cell division, elongation and differentiation contribute to the growth and development of an organism
- explore the scientific evidence for the potential of stem cell research

- **demonstrate understanding that cells have a limit to the number of divisions they undergo, the Hayflick limit; stem cells and cancer cells have no Hayflick limit**
- demonstrate understanding that stem cells in the embryo can differentiate into all other types of cells, but that cells lose this ability as the animal matures
- explore the scientific evidence that contributes to the decision regarding the legality and age of termination of a fetus
- explore the phenomenon that organisms have a size range for that particular species: height in humans is a continuous variable, influenced by a number of genes, hormones and nutrition
- discuss the factors affecting the growth and distribution of plants, including:
    - nutrients
    - light
    - temperature
    - carbon dioxide
    - oxygen
    - plant 'hormones'
- interpret data on how environmental factors affect the distribution of plants
- **discuss fruit initiation in plants and how it can be manipulated with artificial hormones**
- discuss regeneration in animals (including spiders, worms and reptiles) and why it is relatively rare
- explore the evidence that selective breeding (artificial selection) can be used to:
    - improve the quality of milk from cattle
    - increase the number of offspring in sheep
    - increase the yield from dwarf wheat and other cereal crops
- discuss the ethics and health concerns of using growth factors to enhance performance in sport
- **demonstrate an understanding of the stages in the production of cloned mammals, including Dolly the sheep:**
- **the replacement of the nucleus in an egg cell with a diploid nucleus from a mature cell (nuclear transfer)**
- **stimulation of the diploid nucleus to divide**
- discuss the potential benefits and ethical dilemmas posed by advances in genetic modification in plants and animals

Topic 3 — Energy Flow

Understanding energy flow is the key to sustainable food production in both developed and developing nations. This topic offers students opportunities to prepare and observe animal and plant tissue under the microscope and to design and evaluate experiments on production factors. Consideration of the carbon and nitrogen cycle leads to investigations on the use of fertilisers and farming methods to maximise energy transfer in food production methods.
Students will discuss maximising food production and understand that the world already produces sufficient amounts of food to feed the whole population. How human activities affect the environment will also be explored, including global warming, deforestation and the use of fertilisers.

Have you ever wondered?

- We can feed the world's population, but how exactly?
- What happens if we remove all of one kind of animal — will we ever be able to put them back again?
- Should I travel on buses rather than take the car?
- Why do some hospitals not allow plants in the hospital wards?
- Why do some people put lights in greenhouses?
- Why is there a global ban on whaling?
- How do fertilisers harm the environment?
- Can we set up a biosphere on Mars?

Learning objectives

- Plants provide energy for all other organisms.
- Plants and animals are interdependent due to their use and production of oxygen and carbon dioxide.
- Energy flows through the biosphere and elements are recycled within it.
- Human activities are often unsustainable and there are many associated ethical considerations.

Glossary

active transport denitrifying
bacteria
membrane photosynthesis
animal cell decomposer microorganism plant cell
biosphere deforestation mineral salt predator
carbon cycle disease nitrifying bacteria respiration
cellulose cell wall eutrophication nitrogen cycle root
chlorophyll fertiliser nitrogen fixing
bacteria
sustainability
chloroplast food production nucleus transpiration
combustion global warming osmosis vacuole
cytoplasm glucose phloem xylem

Students will be assessed on their ability to:

- recall that plant and animal cells are similar because they contain nuclei, cytoplasm and membranes and that plant cells also have cellulose cell walls, chloroplasts containing chlorophyll and vacuoles
- recall the reactants (carbon dioxide, water) for and products (glucose, oxygen) of photosynthesis
- explore human exploitation of plants, including their use as a food source B2 3.3
- analyse data on the effects of limiting factors on the rate of photosynthesis and draw conclusions
- **appreciate the role of mineral salts, such as magnesium, nitrogen, phosphorus and potassium, in the growth of plants**
- **demonstrate an understanding of now the mineral salts are taken up in the roots by active transport using energy from respiration**

- demonstrate an understanding of and interpret data on the carbon cycle as representing the flow of carbon in nature, including the roles of:
    - microorganisms
    - photosynthesis
    - respiration
    - combustion
- describe the importance of nitrogen in the environment, including the roles of:
    - nitrogen fixing bacteria
    - decomposers
    - nitrifying bacteria
    - denitrifying bacteria

  as shown and interpreted in nitrogen cycle diagrams (specific names of bacteria not required)
- explore the evidence that a biosphere could be used to colonise Mars
- describe how the indiscriminate use of nitrogenous fertilisers leads to environmental damage by eutrophication
- **appreciate that human populations are increasing and are using resources unsustainably which can lead to massive environmental change, eg deforestation**
- discuss the social and ethical considerations of the unequal distribution of food
- explain that energy transfer can be maximised in food production by the use of:
- optimum feeding/growing conditions
- disease and predator control
- using the examples of fish farms and greenhouses

Topic 4 — Interdependence

Understanding the principles of interdependence is the key to managing the Earth's resources successfully and sustainably. Television and newspapers often have stories about damage to the environment, but how can we put right the damage?

This topic explores how competition and predation affect the distribution and numbers of organisms in selected environments. The impact of human activity is then considered with the opportunity for students to interpret data on living and nonliving indicators. This leads to the need for responsible recycling and conservation and consideration of the effects on biodiversity.

Have you ever wondered?

- Why are rabbits such a pest in Australia?
- Why is territory so important for animals?
- If animals fight over land and mating partners, what do plants fight over?
- Why is there a variety of birds in the park and not just one species?
- Why did dinosaurs become extinct?
- Why do deep-sea fish have cylindrical eyes and not eyeballs?
- Why are all conservation initiatives not equally successful?
- Why is recycling of materials encouraged?

Learning objectives

- Organisms compete with each other for resources.
- Organisms are interdependent which affects their distribution and population size.
- Organisms have evolved to survive in extreme environments.
- Human impacts on the environment and conservation measures need management.

Glossary

adaptation environment organism replacement
planting
aquatic extreme environment ozone resource
biodegradable global temperature phosphates sewage
biodiversity greenhouse gases pollution skin cancer
chloroflurocarbons
CFCs
hydrothermal vents population terrestrial
competition indicators predation waste disposal
conservation interdependence recycling
coppicing nitrate reforestation

Students will be assessed on their ability to:

- explore the principles of interdependence, adaptation, competition and predation and explain how these factors influence the distribution and population sizes of organisms in a given terrestrial or aquatic environment
- **use primary and secondary data to consider how human activity, including differing economical and industrial conditions, can affect the environment and cause changes in sizes of population**
- investigate, using primary and secondary data, the impact of human activity on the environment, including the pollution of air and of water; and the effects of air pollutants (including carbon dioxide, sulphur dioxide, carbon monoxide) and of water pollutants (including sewage, nitrates and phosphates)
- interpret data on environmental change
- explain the importance of protecting natural populations
- describe the special nature of some extreme environments, notably deep sea volcanic vents, the Antarctic and high altitudes
- interpret data to show the impact of human activity on the environment to include:

    - living indicators, eg lichen distribution; incidence of skin cancer
    - non-living indicators, eg global temperature and ozone depletion
- explore whether recycling reduces the demand for resources and the problem of waste disposal, including paper, plastics and metals

consider conservation management techniques, including reforestation, coppicing, replacement planting and discuss how conservation can lead to greater biodiversity.