AS Syllabus
2009 -2010

Strand 1

Content and Learning Outcomes
F211 Cell Structure 1.1.1
The cell is the basic unit of all living things. An understanding of how to use a light microscope is developed along with an understanding of why electron microscopes are so important in biology. Careful observation using microscopes reveals details of cell structure and ultrastructure and provides evidence to support hypotheses regarding the roles of cells and organelles. (a) state the resolution and magnification that can be achieved by a light microscope, a transmission electron microscope and a scanning electron microscope; (b) explain the difference between magnification and resolution; (c) explain the need for staining samples for use in light microscopy and electron microscopy; (d) calculate the linear magnification of an image (HSW3); (e) describe and interpret drawings and photographs of eukaryotic cells as seen under an electron microscope and be able to recognise the following structures: nucleus, nucleolus, nuclear envelope, rough and smooth endoplasmic reticulum (ER), Golgi apparatus, ribosomes, mitochondria, lysosomes, chloroplasts, plasma (cell surface) membrane, centrioles, flagella and cilia; (f) outline the functions of the structures listed in (e); (g) outline the interrelationship between the organelles involved in the production and secretion of proteins (no detail of protein synthesis is required); (h) explain the importance of the cytoskeleton in providing mechanical strength to cells, aiding transport within cells and enabling cell movement; (i) compare and contrast, with the aid of diagrams and electron micrographs, the structure of prokaryotic cells and eukaryotic cells; (j) compare and contrast, with the aid of diagrams and electron micrographs, the structure and ultrastructure of plant cells and animal cells.
F211 Cell Membranes 1.1.2

Membranes are a fundamental part of the cell.

The structure of the cell surface membrane allows cells to communicate with each other.

Understanding this ability to communicate is important as scientists increasingly make use of membrane-bound receptors as sites for the action of medicinal drugs.

Understanding how different substances enter cells is also crucial to the development of mechanisms for the administration of drugs.

(a) outline the roles of membranes within cells and at the surface of cells;
(b) state that plasma (cell surface) membranes are partially permeable barriers;
(c) describe, with the aid of diagrams, the fluid mosaic model of membrane structure (HSW1);
(d) describe the roles of the components of the cell membrane; phospholipids, cholesterol, glycolipids, proteins and glycoproteins;
(e) outline the effect of changing temperature on membrane structure and permeability;
(f) explain the term *cell signaling*;
(g) explain the role of membrane-bound receptors as sites where hormones and drugs can bind;
(h) explain what is meant by *passive transport* (diffusion and facilitated diffusion including the role of membrane proteins), *active transport*, *endocytosis* and *exocytosis;*
(i) explain what is meant by *osmosis*, in terms of water potential. (**No** calculations of water potential will be required);
(j) recognise and explain the effects that solutions of different water potentials can have upon plant and animal cells (HSW3).

F211 Cell Division, Cell Diversity and Organisation
1.1.3

During the cell cycle, genetic information is copied and passed to daughter cells. Microscopes can be used to view the different stages of the cycle.

In multicellular organisms, stem cells are modified to produce many different types of specialised cell. Understanding how stems cells can be modified has huge potential in medicine.

To understand how a whole organism functions, it is essential to understand the importance of cooperation between cells, tissues, organs and organ systems.

(a) state that mitosis occupies only a small percentage of the cell cycle and that the remaining percentage includes the copying and checking of genetic information;
(b) describe, with the aid of diagrams and photographs, the main stages of mitosis (behaviour of the chromosomes, nuclear envelope, cell membrane and centrioles);
(c) explain the meaning of the term *homologous pair of chromosomes*;

(d) explain the significance of mitosis for growth, repair and asexual reproduction in plants and animals;
(e) outline, with the aid of diagrams and photographs, the process of cell division by budding in yeast;
(f) state that cells produced as a result of meiosis are not genetically identical (details of meiosis are not required);
(g) define the term *stem cell*;
(h) define the term *differentiation*, with reference to the production of erythrocytes (red blood cells) and neutrophils derived from stem cells in bone marrow, and the production of xylem vessels and phloem sieve tubes from cambium;
(i) describe and explain, with the aid of diagrams and photographs, how cells of multicellular organisms are specialised for particular functions, with reference to erythrocytes (red blood cells), neutrophils, epithelial cells, sperm cells, palisade cells, root hair cells and guard cells;
(j) explain the meaning of the terms *tissue*, *organ* and *organ system*;
(k) explain, with the aid of diagrams and photographs, how cells are organised into tissues, using squamous and ciliated epithelia, xylem and phloem as examples;
(l) discuss the importance of cooperation between cells, tissues, organs and organ systems (HSW4).

F212 Biological Molecules
2.1.1

Proteins, carbohydrates and lipids are three of the key groups of macromolecules essential for life.
Understanding the structure of these macromolecules allows an understanding of their functions in living organisms.

(a) describe how hydrogen bonding occurs between water molecules, and relate this, and other properties of water, to the roles of water in living organisms (HSW1);
(b) describe, with the aid of diagrams, the structure of an amino acid;
(c) describe, with the aid of diagrams, the formation and breakage of peptide bonds in the synthesis and hydrolysis of dipeptides and polypeptides;
(d) explain, with the aid of diagrams, the term *primary structure;*
(e) explain, with the aid of diagrams, the term *secondary structure* with reference to hydrogen bonding;
(f) explain, with the aid of diagrams, the term *tertiary structure*, with reference to hydrophobic and hydrophilic interactions, disulfide bonds and ionic interactions;
(g) explain, with the aid of diagrams, the term *quaternary structure*, with reference to the structure of haemoglobin;
(h) describe, with the aid of diagrams, the structure of a collagen molecule;
(i) compare the structure and function of haemoglobin (as an example of a globular protein) and collagen (as an example of a fibrous protein);
(j) describe, with the aid of diagrams, the molecular structure of alpha-glucose as an example of a monosaccharide carbohydrate;
(k) state the structural difference between alpha- and beta-glucose;

(l) describe, with the aid of diagrams, the formation and breakage of glycosidic bonds in the synthesis and hydrolysis of a disaccharide (maltose) and a polysaccharide (amylose);
(m) compare and contrast the structure and functions of starch (amylose) and cellulose;
(n) describe, with the aid of diagrams, the structure of glycogen;
(o) explain how the structures of glucose, starch (amylose), glycogen and cellulose molecules relate to their functions in living organisms;
(p) compare, with the aid of diagrams, the structure of a triglyceride and a phospholipid;
(q) explain how the structures of triglyceride, phospholipid and cholesterol molecules relate to their functions in living organisms;
(r) describe how to carry out chemical tests to identify the presence of the following molecules: protein (biuret test), reducing and non-reducing sugars (Benedict's test), starch (iodine solution) and lipids (emulsion test);
(s) describe how the concentration of glucose in a solution may be determined using colorimetry.

F212 Nucleic Acids
2.1.2

Understanding the structure of nucleic acids allows an understanding of their role in the storage of genetic information and the functioning of the cell.

(a) state that deoxyribonucleic acid (DNA) is a polynucleotide, usually double stranded, made up of nucleotides containing the bases adenine (A), thymine (T), cytosine (C) and guanine (G);
(b) state that ribonucleic acid (RNA) is a polynucleotide, usually single stranded, made up of nucleotides containing the bases adenine (A), uracil (U), cytosine (C) and guanine (G);
(c) describe, with the aid of diagrams, how hydrogen bonding between complementary base pairs (A to T, G to C) on two antiparallel DNA polynucleotides leads to the formation of a DNA molecule, and how the twisting of DNA produces its 'double-helix' shape (HSW1);
(d) outline, with the aid of diagrams, how DNA replicates semi-conservatively, with reference to the role of DNA polymerase;
(e) state that a gene is a sequence of DNA nucleotides that codes for a polypeptide (HSW3);
(f) outline the roles of DNA and RNA in living organisms (the concept of protein synthesis must be considered in outline only).

F212 Enzymes
2.1.3

Cell function relies upon enzyme-controlled reactions.
Knowledge of how enzymes work allows an understanding of the action of metabolic poisons and some drugs.

(a) state that enzymes are globular proteins, with a specific tertiary structure, which catalyse metabolic reactions in living organisms;

(b) state that enzyme action may be intracellular or extracellular;
(c) describe, with the aid of diagrams, the mechanism of action of enzyme molecules, with reference to specificity, active site, lock and key hypothesis, induced-fit hypothesis, enzyme-substrate complex, enzyme-product complex and lowering of activation energy;
(d) describe and explain the effects of pH, temperature, enzyme concentration and substrate concentration on enzyme activity;
(e) describe how the effects of pH, temperature, enzyme concentration and substrate concentration on enzyme activity can be investigated experimentally;
(f) explain the effects of competitive and non-competitive inhibitors on the rate of enzyme-controlled reactions, with reference to both reversible and non-reversible inhibitors;
(g) explain the importance of cofactors and coenzymes in enzyme-controlled reactions;
(h) state that metabolic poisons may be enzyme inhibitors, and describe the action of one named poison;
(i) state that some medicinal drugs work by inhibiting the activity of enzymes (HSW6a).

F212 Maintaining Biodiversity
2.3.4

Maintaining biodiversity is important for many reasons.

Actions to maintain biodiversity must be taken at local, national and global levels.

(a) outline the reasons for the conservation of animal and plant species, with reference to economic, ecological, ethical and aesthetic reasons (HSW6b);
(b) discuss the consequences of global climate change on the biodiversity of plants and animals, with reference to changing patterns of agriculture and spread of disease (HSW6a, 6b, 7a, 7b, 7c);
(c) explain the benefits for agriculture of maintaining the biodiversity of animal and plant species (HSW6a, 6b, 7c);
(d) describe the conservation of endangered plant and animal species, both *in situ* and *ex situ*, with reference to the advantages and disadvantages of these two approaches (HSW4, 6a, 6b);
(e) discuss the role of botanic gardens in the *ex situ* conservation of rare plant species or plant species extinct in the wild, with reference to seed banks;
(f) discuss the importance of international co-operation in species conservation with reference to The Convention in International Trade in Endangered Species (CITES) and the Rio Convention on Biodiversity;
(g) discuss the significance of environmental impact assessments (including biodiversity estimates) for local authority planning decisions.

F212 Evolution
2.3.3

"*Nothing in biology makes sense except in the light of evolution*" Theodosius Dobzhansky, 1973.

(a) define the term *variation*;
(b) discuss the fact that variation occurs within as well as between species;
(c) describe the differences between continuous and discontinuous variation, using examples of a range of characteristics found in plants, animals and microorganisms;
(d) explain both genetic and environmental causes of variation;
(e) outline the behavioural, physiological and anatomical (structural) adaptations of organisms to their environments;
(f) explain the consequences of the four observations made by Darwin in proposing his theory of natural selection; (HSW1)
(g) define the term *speciation*;
(h) discuss the evidence supporting the theory of evolution, with reference to fossil, DNA and molecular evidence;
(i) outline how variation, adaptation and selection are major components of evolution;
(j) discuss why the evolution of pesticide resistance in insects and drug resistance in microorganisms has implications for humans.

Strand 2

Content and Learning Outcomes
F211 Exchange Surfaces and Breathing 1.2.1
The gas exchange surface in the lungs is used to exemplify the properties and functions of exchange surfaces in living things. (a) explain, in terms of surface area:volume ratio, why multicellular organisms need specialised exchange surfaces and single-celled organisms do not (HSW1); (b) describe the features of an efficient exchange surface, with reference to diffusion of oxygen and carbon dioxide across an alveolus; (c) describe the features of the mammalian lung that adapt it to efficient gaseous exchange; (d) describe, with the aid of diagrams and photographs, the distribution of cartilage, ciliated epithelium, goblet cells, smooth muscle and elastic fibres in the trachea, bronchi, bronchioles and alveoli of the mammalian gaseous exchange system; (e) describe the functions of cartilage, cilia, goblet cells, smooth muscle and elastic fibres in the mammalian gaseous exchange system; (f) outline the mechanism of breathing (inspiration and expiration) in mammals, with reference to the function of the rib cage,

intercostal muscles and diaphragm;
(g) explain the meanings of the terms *tidal volume* and *vital capacity;*
(h) describe how a spirometer can be used to measure vital capacity, tidal volume, breathing rate and oxygen uptake;
(i) analyse and interpret data from a spirometer.

F211 Transport in Animals
1.2.2

As animals become larger and more active, transport systems become essential to supply nutrients to and remove waste from individual cells.

Controlling supply of nutrients and removal of waste requires the co-ordinated activity of the heart and circulatory system.

(a) explain the need for transport systems in multicellular animals in terms of size, level of activity and surface area:volume ratio;
(b) explain the meaning of the terms *single circulatory system* and *double circulatory system*, with reference to the circulatory systems of fish and mammals;
(c) explain the meaning of the terms *open circulatory system* and *closed circulatory system*, with reference to the circulatory systems of insects and fish;
(d) describe, with the aid of diagrams and photographs, the external and internal structure of the mammalian heart;
(e) explain, with the aid of diagrams, the differences in the thickness of the walls of the different chambers of the heart in terms of their functions;
(f) describe the cardiac cycle, with reference to the action of the valves in the heart;
(g) describe how heart action is coordinated with reference to the sinoatrial node (SAN), the atrioventricular node (AVN) and the Purkyne tissue;
(h) interpret and explain electrocardiogram (ECG) traces, with reference to normal and abnormal heart activity;
(i) describe, with the aid of diagrams and photographs, the structures and functions of arteries, veins and capillaries;
(j) explain the differences between blood, tissue fluid and lymph;
(k) describe how tissue fluid is formed from plasma;
(l) describe the role of haemoglobin in carrying oxygen and carbon dioxide;
(m) describe and explain the significance of the dissociation curves of adult oxyhaemoglobin at different carbon dioxide levels (the Bohr effect);
(n) explain the significance of the different affinities of fetal haemoglobin and adult haemoglobin for oxygen.

F211 Transport in Plants
1.2.3

As plants become larger and more complex, transport systems become essential to supply nutrients to and remove waste from

individual cells.

The supply of nutrients from the soil relies upon the flow of water through a vascular system, as does the movement of the products of photosynthesis.

(a) explain the need for transport systems in multicellular plants in terms of size and surface area:volume ratio;
(b) describe, with the aid of diagrams and photographs, the distribution of xylem and phloem tissue in roots, stems and leaves of dicotyledonous plants.
(c) describe, with the aid of diagrams and photographs, the structure and function of xylem vessels, sieve tube elements and companion cells;
(d) define the term *transpiration*;
(e) explain why transpiration is a consequence of gaseous exchange;
(f) describe the factors that affect transpiration rate;
(g) describe, with the aid of diagrams, how a potometer is used to estimate transpiration rates (HSW3);
(h) explain, in terms of water potential, the movement of water between plant cells, and between plant cells and their environment. (**No** calculations involving water potential will be set);
(i) describe, with the aid of diagrams, the pathway by which water is transported from the root cortex to the air surrounding the leaves, with reference to the Casparian strip, apoplast pathway, symplast pathway, xylem and the stomata;
(j) explain the mechanism by which water is transported from the root cortex to the air surrounding the leaves, with reference to adhesion, cohesion and the transpiration stream;
(k) describe, with the aid of diagrams and photographs, how the leaves of some xerophytes are adapted to reduce water loss by transpiration;
(l) explain translocation as an energy-requiring process transporting assimilates, especially sucrose, between sources (eg leaves) and sinks (eg roots, meristem);
(m) describe, with the aid of diagrams, the mechanism of transport in phloem involving active loading at the source and removal at the sink, and the evidence for and against this mechanism.

F212 Diet and Food Production
2.2.1

A balanced diet is essential for good health.
Components of the human diet can be provided by plants, animals and microorganisms.
Ensuring the availability of food for human populations is problematic and has been, and continues to be, a key area for research and development.

(a) define the term *balanced diet*;

(b) explain how consumption of an unbalanced diet can lead to malnutrition, with reference to obesity (HSW4);
(c) discuss the possible links between diet and coronary heart disease (CHD);
(d) discuss the possible effects of a high blood cholesterol level on the heart and circulatory system, with reference to high-density lipoproteins (HDL) and low-density lipoprotein (LDL) (HSW1);
(e) explain that humans depend on plants for food as they are the basis of all food chains. (**No** details of food chains are required);
(f) outline how selective breeding is used to produce crop plants with high yields, disease resistance and pest resistance (HSW6a);
(g) outline how selective breeding is used to produce domestic animals with high productivity (HSW6a);
(h) describe how the use of fertilisers and pesticides with plants and the use of antibiotics with animals can increase food production (HSW6a, 6b);
(i) describe the advantages and disadvantages of using microorganisms to make food for human consumption;
(j) outline how salting, adding sugar, pickling, freezing, heat treatment and irradiation can be used to prevent food spoilage by microorganisms.

F212 Health and Disease
2.2.2

"Health is more than simply the absence of disease".

Health can be compromised in many ways. Humans are surrounded by parasites and pathogens and have evolved defences against them. Medical intervention can be used to support these natural defences.
Smoking is used as an example of a social/environmental factor that has an impact on health.

(a) discuss what is meant by the terms *health* and *disease*;
(b) define and discuss the meanings of the terms *parasite* and *pathogen*;
(c) describe the causes and means of transmission of malaria, AIDS/HIV and TB (knowledge of the symptoms of these diseases is not required);
(d) discuss the global impact of malaria, AIDS/HIV and TB;
(e) define the terms *immune response*, *antigen* and *antibody*;
(f) describe the primary defences against pathogens and parasites (including skin and mucus membranes) and outline their importance. (**No** details of skin structure are required);
(g) describe, with the aid of diagrams and photographs, the structure and mode of action of phagocytes;
(h) describe, with the aid of diagrams, the structure of antibodies;
(i) outline the mode of action of antibodies, with reference to the neutralisation and agglutination of pathogens;
(j) describe the structure and mode of action of T lymphocytes and B lymphocytes, including the significance of cell signalling and

the role of memory cells;
(k) compare and contrast the primary and secondary immune responses;
(l) compare and contrast active, passive, natural and artificial immunity;
(m) explain how vaccination can control disease (HSW6a, 7c);
(n) discuss the responses of governments and other organisations to the threat of new strains of influenza each year.
(o) outline possible new sources of medicines, with reference to microorganisms and plants and the need to maintain biodiversity.

F212 Biodiversity
2.3.1

Biodiversity is an important indicator in the study of habitats.

(a) define the terms *species*, *habitat* and *biodiversity*;
(b) explain how biodiversity may be considered at different levels; habitat, species and genetic;
© explain the importance of sampling in measuring the biodiversity of a habitat (HSW7a, 7b, 7c);
(d) describe how random samples can be taken when measuring biodiversity;
(e) describe how to measure species richness and species evenness in a habitat;
(f) use Simpson's Index of Diversity (D) to calculate the biodiversity of a habitat, using the formula $D = 1-(\Sigma(n/N)^2)$;
(g) outline the significance of both high and low values of Simpson's Index of Diversity (D);
(h) discuss current estimates of global biodiversity.

F212 Classification
2.3.2

Classification is an attempt to impose a hierarchy on the complex and dynamic variety of life on Earth.
Classification systems have changed and will continue to change as our knowledge of the biology of organisms develops.

(a) define the terms *classification*, *phylogeny* and *taxonomy*;
(b) explain the relationship between classification and phylogeny;
© describe the classification of species into the taxonomic hierarchy of domain, kingdom, phylum, class, order, family, genus and species;
(d) outline the characteristic features of the following five kingdoms: Prokaryotae (Monera), Protoctista, Fungi, Plantae, Animalia;
(e) outline the binomial system of nomenclature and the use of scientific (Latin) names for species;
(f) use a dichotomous key to identify a group of at least six plants, animals or microorganisms;
(g) discuss the fact that classification systems were based originally on observable features but more recent approaches draw on

a wider range of evidence to clarify relationships between organisms, including molecular evidence (HSW1, 7a);
(h) compare and contrast the five kingdom and three domain classification systems.

Ecosystems
5.3.1

Organisms do not work in isolation but form complex interactions, not just with other organisms but also with their physical environment.

The efficiency of energy transfer limits the number of organisms in a particular ecosystem.

Ecosystems are dynamic entities tending towards some form of climax community.

(a) define the term *ecosystem*;
(b) state that ecosystems are dynamic systems;
(c) define the terms *biotic factor* and *abiotic factor*, using named examples;
(d) define the terms *producer, consumer decomposer* and *trophic level*;
(e) describe how energy is transferred though ecosystems;
(f) outline how energy transfers between trophic levels can be measured;
(g) discuss the efficiency of energy transfers between trophic levels;
(h) explain how human activities can manipulate the flow of energy through ecosystems (HSW6b);
(i) describe one example of primary succession resulting in a climax community;
(j) describe how the distribution and abundance of organisms can be measured, using line transects, belt transects, quadrats and point quadrats (HSW3);
(k) describe the role of decomposers in the decomposition of organic material;
(l) describe how microorganisms recycle nitrogen within ecosystems. (Only *Nitrosomonas, Nitrobacter* and *Rhizobium* need to be identified by name).

Populations and Sustainability
5.3.2

There are many factors that determine the size of a population.

For economic, social and ethical reasons ecosystems may need to be carefully managed.

To support an increasing human population, we must try to use biological resources in a sustainable way.

(a) explain the significance of limiting factors in determining the final size of a population;
(b) explain the meaning of the term *carrying capacity*;

(c) describe predator–prey relationships and their possible effects on the population sizes of both the predator and the prey;
(d) explain, with examples, the terms *interspecific* and *intraspecific* competition;
(e) distinguish between the terms *conservation* and *preservation* (HSW6a, 6b);
(f) explain how the management of an ecosystem can provide resources in a sustainable way, with reference to timber production in a temperate country;
(g) explain that conservation is a dynamic process involving management and reclamation;
(h) discuss the economic, social and ethical reasons for conservation of biological resources (HSW6b, 7c);
(i) outline, with examples, the effects of human activities on the animal and plant populations in the Galapagos Islands.

A2 Syllabus
2009 – 2010
OCR GCE Biology

Strand 1

Content and Learning Outcomes
F214 – Photosynthesis 4.3.1
Photosynthesis is the process whereby light energy from the Sun is transformed into chemical energy and used to synthesise large organic molecules from inorganic substances. Photosynthesis forms the basis of most food chains: (a) define the terms *autotroph* and *heterotroph*; (b) state that light energy is used during photosynthesis to produce complex organic molecules; (c) explain how respiration in plants and animals depends upon the products of photosynthesis; (d) state that in plants photosynthesis is a two-stage process taking place in chloroplasts; (e) explain, with the aid of diagrams and electron micrographs, how the structure of chloroplasts enables them to carry out their functions; (f) define the term *photosynthetic pigment*; (g) explain the importance of photosynthetic pigments in photosynthesis; (h) state that the light-dependent stage takes place in thylakoid membranes and that the light-independent stage takes place in the

stroma;
(i) outline how light energy is converted to chemical energy (ATP and reduced NADP) in the light-dependent stage (reference should be made to cyclic and non-cyclic photophosphorylation, but **no** biochemical detail is required);
(j) explain the role of water in the light-dependent stage;
(k) outline how the products of the light-dependent stage are used in the light-independent stage (Calvin cycle) to produce triose phosphate (TP) (reference should be made to ribulose bisphosphate (RuBP), ribulose bisphosphate carboxylase (rubisco) and glycerate 3-phosphate (GP), but **no** other biochemical detail is required);
(l) explain the role of carbon dioxide in the light-independent stage (Calvin cycle);
(m) state that TP can be used to make carbohydrates, lipids and amino acids;
(n) state that most TP is recycled to RuBP;
(o) describe the effect on the rate of photosynthesis, and on levels of GP, RuBP and TP, of changing carbon dioxide concentration, light intensity and temperature;
(p) discuss limiting factors in photosynthesis with reference to carbon dioxide concentration, light intensity and temperature;
(q) describe how to investigate experimentally the factors that affect the rate of photosynthesis.
End of Unit Test – Photosynthesis

F214 Respiration
4.4.1

Respiration is the process whereby energy stored in complex organic molecules is transferred to ATP.
ATP provides the immediate source of energy for biological processes:

(a) outline why plants, animals and microorganisms need to respire, with reference to active transport and metabolic reactions;
(b) describe, with the aid of diagrams, the structure of ATP;
(c) state that ATP provides the immediate source of energy for biological processes;
(d) explain the importance of coenzymes in respiration, with reference to NAD and coenzyme A;
(e) state that glycolysis takes place in the cytoplasm;
(f) outline the process of glycolysis beginning with the phosphorylation of glucose to hexose bisphosphate, splitting of hexose bisphosphate into two triose phosphate molecules and further oxidation to pyruvate, producing a small yield of ATP and reduced NAD;
(g) state that, during aerobic respiration in animals, pyruvate is actively transported into mitochondria;
(h) explain, with the aid of diagrams and electron micrographs, how the structure of mitochondria enables them to carry out their functions;
(i) state that the link reaction takes place in the mitochondrial matrix;
(j) outline the link reaction, with reference to decarboxylation of pyruvate to acetate and the reduction of NAD.

(k) explain that acetate is combined with coenzyme A to be carried to the next stage;
(l) state that the Krebs cycle takes place in the mitochondrial matrix;
(m) outline the Krebs cycle, with reference to the formation of citrate from acetate and oxaloacetate and the reconversion of citrate to oxaloacetate (names of intermediate compounds are **not** required);
(n) explain that during the Krebs cycle, decarboxylation and dehydrogenation occur, NAD and FAD are reduced and substrate level phosphorylation occurs;
(o) outline the process of oxidative phosphorylation, with reference to the roles of electron carriers, oxygen and the mitochondrial cristae;
(p) outline the process of chemiosmosis, with reference to the electron transport chain, proton gradients and ATPsynthase (HSW7a);
(q) state that oxygen is the final electron acceptor in aerobic respiration;
(r) evaluate the experimental evidence for the theory of chemiosmosis (HSW1);
(s) explain why the theoretical maximum yield of ATP per molecule of glucose is rarely, if ever, achieved in aerobic respiration;
(t) explain why anaerobic respiration produces a much lower yield of ATP than aerobic respiration;
(u) compare and contrast anaerobic respiration in mammals and in yeast;
(v) define the term *respiratory substrate*;
(w) explain the difference in relative energy values of carbohydrate, lipid and protein respiratory substrates.
End of Unit test – Respiration

F214 Excretion
4.2.1

The kidneys, liver and lungs are all involved in the removal of toxic products of metabolism from the blood. The liver also metabolises toxins that have been ingested.

The kidneys also play a major role in the control of the water potential of the blood:

(a) define the term *excretion*;
(b) explain the importance of removing metabolic wastes, including carbon dioxide and nitrogenous waste, from the body;
(c) describe, with the aid of diagrams and photographs, the histology and gross structure of the liver;
(d) describe the formation of urea in the liver, including an outline of the ornithine cycle;
(e) describe the roles of the liver in detoxification;
(f) describe, with the aid of diagrams and photographs, the histology and gross structure of the kidney;

(g) describe, with the aid of diagrams and photographs, the detailed structure of a nephron and its associated blood vessels;
(h) describe and explain the production of urine, with reference to the processes of ultrafiltration and selective reabsorption;
(i) explain, using water potential terminology, the control of the water content of the blood, with reference to the roles of the kidney, osmoreceptors in the hypothalamus and the posterior pituitary gland;
(j) outline the problems that arise from kidney failure and discuss the use of renal dialysis and transplants for the treatment of kidney failure (HSW6a, 6b, 7c);
(k) describe how urine samples can be used to test for pregnancy and detect misuse of anabolic steroids (HSW6a, 6b).
End of Unit test – Excretion

F215 Cellular Control
5.1.1

The way that DNA codes for proteins is central to our understanding of how cells and organisms function.
The way in which cells control chemical reactions determines the ways in which organisms, grow, develop and function:

(a) state that genes code for polypeptides, including enzymes;
(b) explain the meaning of the term *genetic code*;
(c) describe, with the aid of diagrams, the way in which a nucleotide sequence codes for the amino acid sequence in a polypeptide;
(d) describe, with the aid of diagrams, how the sequence of nucleotides within a gene is used to construct a polypeptide, including the roles of messenger RNA, transfer RNA and ribosomes;
(e) state that mutations cause changes to the sequence of nucleotides in DNA molecules;
(f) explain how mutations can have beneficial, neutral or harmful effects on the way a protein functions;
(g) state that cyclic AMP activates proteins by altering their three-dimensional structure;
(h) explain genetic control of protein production in a prokaryote using the *lac* operon;
(i) explain that the genes that control development of body plans are similar in plants, animals and fungi, with reference to homeobox sequences (HSW1);
(j) outline how apoptosis (programmed cell death) can act as a mechanism to change body plans.
End of Unit tests – Cellular Control

F215 Biotechnology
5.2.2

Biotechnology uses microorganisms and enzymes to make useful products:

(a) state that biotechnology is the industrial use of living organisms (or parts of living organisms) to produce food, drugs or other products (HSW6a);

(b) explain why microorganisms are often used in biotechnological processes;
(c) describe, with the aid of diagrams, and explain the standard growth curve of a microorganism in a closed culture;
(d) describe how enzymes can be immobilised;
(e) explain why immobilised enzymes are used in large-scale production;
(f) compare and contrast the processes of continuous culture and batch culture;
(g) describe the differences between primary and secondary metabolites;
(h) explain the importance of manipulating the growing conditions in a fermentation vessel in order to maximise the yield of product required;
(i) explain the importance of asepsis in the manipulation of microorganisms.
End of Unit test – Biotechnology

F 215 Cloning in Plants and Animals
5.2.1

Farmers and growers exploit "natural" vegetative propagation in the production of uniform crops.

Artificial clones of plants and animals can now be produced:

(a) outline the differences between reproductive and non-reproductive cloning;
(b) describe the production of natural clones in plants using the example of vegetative propagation in elm trees;
(c) describe the production of artificial clones of plants from tissue culture;
(d) discuss the advantages and disadvantages of plant cloning in agriculture (HSW6a, 6b, 7c);
(e) describe how artificial clones of animals can be produced;
(f) discuss the advantages and disadvantages of cloning animals
End of Unit test – Cloning Plants and Animals

F215 Genomes and Gene Technologies
5.2.3

Genome sequencing gives information about the location of genes and provides evidence for the evolutionary links between organisms.

Genetic engineering involves the manipulation of naturally occurring processes and enzymes.

The capacity to manipulate genes has many potential benefits, but the implications of genetic techniques are subject to much public debate:

(a) outline the steps involved in sequencing the genome of an organism;
(b) outline how gene sequencing allows for genome-wide comparisons between individuals and between species (HSW7b);
(c) define the term *recombinant DNA*;

(d) explain that genetic engineering involves the extraction of genes from one organism, or the manufacture of genes, in order to place them in another organism (often of a different species) such that the receiving organism expresses the gene product (HSW6a);
(e) describe how sections of DNA containing a desired gene can be extracted from a donor organism using restriction enzymes;
(f) outline how DNA fragments can be separated by size using electrophoresis (HSW3);
(g) describe how DNA probes can be used to identify fragments containing specific sequences;
(h) outline how the polymerase chain reaction (PCR) can be used to make multiple copies of DNA fragments;
(i) explain how isolated DNA fragments can be placed in plasmids, with reference to the role of ligase;
(j) state other vectors into which fragments of DNA may be incorporated;
(k) explain how plasmids may be taken up by bacterial cells in order to produce a transgenic microorganism that can express a desired gene product;
(l) describe the advantage to microorganisms of the capacity to take up plasmid DNA from the environment;
(m) outline how genetic markers in plasmids can be used to identify the bacteria that have taken up a recombinant plasmid;
(n) outline the process involved in the genetic engineering of bacteria to produce human insulin;
(o) outline the process involved in the genetic engineering of 'Golden Rice™' (HSW6a);
(p) outline how animals can be genetically engineered for xenotransplantation (HSW6a, 6b);
(q) explain the term *gene therapy;*
(r) explain the differences between somatic cell gene therapy and germ line cell gene therapy;
(s) discuss the ethical concerns raised by the genetic manipulation of animals (including humans), plants and microorganisms.
End of Unit test – Genomes and Gene technologies

Strand 2

Content and Learning Outcomes
Ecology
Follow up from Dale Fort and L6th: 2.3.1 Biodiversity 2.3.2 Classification 2.3.3 Evolution 2.3.4 Maintaining Biodiversity 5.3.1 Ecosystems 5.3.2 Populations and Sustainability

(e) distinguish between the terms *conservation* and *preservation* (HSW6a, 6b);
(f) explain how the management of an ecosystem can provide resources in a sustainable way, with reference to timber production in a temperate country;
(g) explain that conservation is a dynamic process involving management and reclamation;
(h) discuss the economic, social and ethical reasons for conservation of biological resources (HSW6b, 7c);
(i) outline, with examples, the effects of human activities on the animal and plant populations in the Galapagos Islands
End of Unit test – Ecology

F214 Communication
4.1.1

Organisms use chemical and electrical systems to monitor and respond to any deviation from the body's steady state.

(a) outline the need for communication systems within multicellular organisms, with reference to the need to respond to changes in the internal and external environment and to co-ordinate the activities of different organs;

(b) state that cells need to communicate with each other by a process called cell signalling;

(c) state that neuronal and hormonal systems are examples of cell signalling;

(d) define the terms negative feedback, positive feedback and homeostasis;

(e) explain the principles of homeostasis in terms of receptors, effectors and negative feedback;

(f) describe the physiological and behavioural responses that maintain a constant core body temperature in ectotherms and endotherms, with reference to peripheral temperature receptors, the hypothalamus and effectors in skin and muscles.
End of Unit test – Communication

F214 Nerves
4.1.2

In receptors, the energy of a stimulus is transferred into energy in an action potential in a neurone.

Transmission between neurones takes place at synapses:

(a) outline the roles of sensory receptors in mammals in converting different forms of energy into nerve impulses;
(b) describe, with the aid of diagrams, the structure and functions of sensory and motor neurones;
(c) describe and explain how the resting potential is established and maintained;
(d) describe and explain how an action potential is generated;
(e) describe and explain how an action potential is transmitted in a myelinated neurone, with reference to the roles of voltage-gated sodium ion and potassium ion channels;
(f) interpret graphs of the voltage changes taking place during the generation and transmission of an action potential;

(g) outline the significance of the frequency of impulse transmission;
(h) compare and contrast the structure and function of myelinated and non-myelinated neurones;
(i) describe, with the aid of diagrams, the structure of a cholinergic synapse;
(j) outline the role of neurotransmitters in the transmission of action potentials;
(k) outline the roles of synapses in the nervous system.
End of Unit test –Nerves

F214 Hormones
4.1.3

The ways in which specific hormones bring about their effects are used to explain the action of hormones.

Treatment of diabetes is used as an example of the use of medical technology in overcoming defects in hormonal control systems.

The control of heart rate is used as an example of the integration of nervous and hormonal control:

(a) define the terms *endocrine gland*, *exocrine gland, hormone* and *target tissue*;
(b) explain the meaning of the terms *first messenger* and *second messenger*, with reference to adrenaline and cyclic AMP (cAMP);
(c) describe the functions of the adrenal glands;
(d) describe, with the aid of diagrams and photographs, the histology of the pancreas, and outline its role as an endocrine and exocrine gland;
(e) explain how blood glucose concentration is regulated, with reference to insulin, glucagon and the liver;
(f) outline how insulin secretion is controlled, with reference to potassium channels and calcium channels in beta cells;
(g) compare and contrast the causes of Type 1 (insulin-dependent) and Type 2 (non-insulin-dependent) diabetes mellitus;
(h) discuss the use of insulin produced by genetically modified bacteria, and the potential use of stem cells, to treat diabetes mellitus (HSW6a, 7b);
(i) outline the hormonal and nervous mechanisms involved in the control of heart rate in humans.
End of Unit test – Hormones

F215 Meiosis and Variation
5.1.2

Variation generated by meiosis and mutation provides the raw material for natural selection.

Isolating mechanisms can lead to the accumulation of different genetic information in populations, potentially leading to new species.

Over a prolonged period of time, organisms have changed and become extinct. The theory of evolution explains these changes.
Humans use artificial selection to produce similar changes in plants and animals:

(a) describe, with the aid of diagrams and photographs, the behaviour of chromosomes during meiosis, and the associated behaviour of the nuclear envelope, cell membrane and centrioles. (Names of the main stages are expected, but **not** the subdivisions of prophase);
(b) explain the terms *allele, locus, phenotype, genotype, dominant, codominant and recessive*;
(c) explain the terms *linkage* and *crossing-over*;
(d) explain how meiosis and fertilisation can lead to variation through the independent assortment of alleles;
(e) use genetic diagrams to solve problems involving sex linkage and codominance;
(f) describe the interactions between loci (epistasis). (Production of genetic diagrams is **not** required);
(g) predict phenotypic ratios in problems involving epistasis;
(h) use the chi-squared (χ^2) test to test the significance of the difference between observed and expected results. (The formula for the chi-squared test will be provided);
(i) describe the differences between continuous and discontinuous variation;
(j) explain the basis of continuous and discontinuous variation by reference to the number of genes which influence the variation;
(k) explain that both genotype and environment contribute to phenotypic variation. (**No** calculations of heritability will be expected);
(l) explain why variation is essential in selection;
(m) use the Hardy–Weinberg principle to calculate allele frequencies in populations (HSW1);
(n) explain, with examples, how environmental factors can act as stabilising or evolutionary forces of natural selection;
(o) explain how genetic drift can cause large changes in small populations;
(p) explain the role of isolating mechanisms in the evolution of new species, with reference to ecological (geographic), seasonal (temporal) and reproductive mechanisms;
(q) explain the significance of the various concepts of the species, with reference to the biological species concept and the phylogenetic (cladistic/evolutionary) species concept (HSW1);
(r) compare and contrast natural selection and artificial selection;
(s) describe how artificial selection has been used to produce the modern dairy cow and to produce bread wheat (*Triticum aestivum*).
End of Unit test – Meiosis and Variation

F215 Plant Responses
5.4.1

Plant responses to environmental changes are co-ordinated by hormones, some of which are commercially important:

(a) explain why plants need to respond to their environment in terms of the need to avoid predation and abiotic stress;

(b) define the term *tropism*;
(c) explain how plant responses to environmental changes are co-ordinated by hormones, with reference to responding to changes in light direction;
(d) evaluate the experimental evidence for the role of auxins in the control of apical dominance and gibberellin in the control of stem elongation;
(e) outline the role of hormones in leaf loss in deciduous plants
(f) describe how plant hormones are used commercially.

F215 Animal Responses
5.4.2

In animals, responding to changes in the environment is a complex and continuous process, involving nervous, hormonal and muscular coordination:
(a) discuss why animals need to respond to their environment;
(b) outline the organisation of the nervous system in terms of central and peripheral systems in humans;
(c) outline the organisation and roles of the autonomic nervous system;
(d) describe, with the aid of diagrams, the gross structure of the human brain, and outline the functions of the cerebrum, cerebellum, medulla oblongata and hypothalamus;
(e) describe the role of the brain and nervous system in the co-ordination of muscular movement;
(f) describe how co-ordinated movement requires the action of skeletal muscles about joints, with reference to the movement of the elbow joint;
(g) explain, with the aid of diagrams and photographs, the sliding filament model of muscular contraction;
(h) outline the role of ATP in muscular contraction, and how the supply of ATP is maintained in muscles;
(i) compare and contrast the action of synapses and neuromuscular junctions;
(j) outline the structural and functional differences between voluntary, involuntary and cardiac muscle.
(k) state that responses to environmental stimuli in mammals are co-ordinated by nervous and endocrine systems;
(l) explain how, in mammals, the 'fight or flight' response to environmental stimuli is co-ordinated by the nervous and endocrine systems.
End of Unit test – Plant and Animal Responses

F215 Animal Behaviour
5.4.3

Animals behave in ways that enhance their survival and reproductive capacity. Behaviour patterns can be simple or complex, and can range from genetically programmed behaviour to learned behaviour that is significantly influenced by the environment:
(a) explain the advantages to organisms of innate behaviour;
(b) describe escape reflexes, taxes and kineses as examples of genetically-determined innate behaviours;

(c) explain the meaning of the term *learned behaviour*;
(d) describe habituation, imprinting, classical and operant conditioning, latent and insight learning as examples of learned behaviours;
(e) describe, using one example, the advantages of social behaviour in primates;
(f) discuss how the links between a range of human behaviours and the dopamine receptor DRD4 may contribute to the understanding of human behaviour.
End of Unit test – Animal Behaviour