Pearson BTEC Levels 4 and 5 Higher Nationals specification in Applied Biology

Contents

Unit 1: Cell Biology

Unit code: T/601/0215

Level: 4

Credit value: 15

Aim

This unit provides an understanding of the structure of a cell and how the cell functions, divides, differentiates and adopts a position in order to perform a specialist role in the multicellular organism. Learners also develop skills necessary for growing cells in culture.

Unit abstract

Understanding the cell, and the role and function of the cell in the multicellular organism, are of fundamental importance in understanding biology and related disciplines.

This unit will enable learners to appreciate the cell as the basic unit of life. Learners will examine the structure and function of the organelles of the cell. Familiarity with the internal structure of the cell and the variety of cell types will be enhanced through the use of microscopy and electron micrographs. The importance of the cell membrane in controlling the internal environment of the cell and in communication will be emphasised. The process of internalisation into the cell and secretion from the cell will be explored.

The unit enables learners to understand how cells develop and arrange themselves in order to perform specialist roles in the multicellular organism. The different factors contributing to the developmental and differentiation of a cell into an overtly specialised cell type will be emphasised.

The unit also enables learners to examine the life cycle of a cell and how knowledge of the cell cycle can be utilised to grow cells in culture. The unit provides opportunities for learners to grow cells in culture and to appreciate the importance of cell culture as a valuable tool in diagnostic research. Integral to the practical investigations into cell culture is the need to work safely and accurately, adhering to laboratory safety guidelines and protocols.

Learning outcomes

On successful completion of this unit a learner will:

1 Understand the structural features of eukaryotic and prokaryotic cells

2 Understand cellular diversity

3 Understand the growth and development of cells

4 Be able to grow cells in culture.

Unit content

1 Understand the structural features of eukaryotic and prokaryotic cells

Structure and role: nucleus; mitochondria; chloroplasts; endoplasmic reticulum; Golgi body; peroxisomes; lysosomes; cilia; flagella; cytoskeleton; examination of electron and light micrographs

Membrane structure and function: Singer and Nicolson model; properties and composition of lipid bilayer; fluidity of lipid bilayer; membrane proteins; differential permeability; membrane transport; ion gradients

Interdependence: protein sorting; vesicular transport; secretory pathways; ingestion pathways; energy requirements

2 Understand cellular diversity

Cell types: differences in structure eg epithelial cells, secretory cells, nerve cells, muscle cells, specialised plant cells

Function of cells: tissue group eg protection, transport, secretion, excretion, absorption, electrochemical signalling, movement, transport

Observation: tissue sectioning and staining; use of the light microscope; examination of electron micrographs

Tissue types: epithelial; connective; muscular; nervous

3 Understand the growth and development of cells

Mitosis and meiosis: prophase; metaphase; anaphase; telophase; spindle formation; generation of genetic diversity

Cell division cycle: G_0; G_1; S; G_2; control points; cell size; apoptosis and tumour formation

Cell division cycle control: maturation promoting factor (MPF); protein kinases; cyclins; growth factors

Growth and differentiation: germ layers; cleavage; gastrulation; cell junctions; foetal tissue development; cell adhesion molecules; foetal tissue development; stem cells; pluripotent cells; differential gene expression

4 Be able to grow cells in culture

Culture methods: plant and animal cultures eg cell lines and cell strains, batch culture, continuous culture, primary tissue culture

Factors: pH; temperature; media type; oxygen tension; water potential; nutritional requirements

Preparation: selective cell culture media; sub-culture; aseptic techniques

Growth: experimental data eg mean generation time, growth rate constant, measurement of population growth by cell number, mass and optical density

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Learning outcomes and assessment criteria

Learning outcomes **On successful completion of this unit a learner will:**	Assessment criteria for pass **The learner can:**
LO1 Understand the structural features of eukaryotic and prokaryotic cells	1.1 discuss the structural features of prokaryotic and eukaryotic cells 1.2 explain the role of subcellular organelles in the cell 1.3 relate the structure of membranes to their function 1.4 explain the interdependence of subcellular organelles
LO2 Understand cellular diversity	2.1 examine a range of cell types to identify differences in structure 2.2 illustrate the function of cells belonging to specific tissue groups 2.3 undertake observation of different types of tissues
LO3 Understand the growth and development of cells	3.1 compare the processes of mitosis and meiosis 3.2 explain the events of the cell division cycle 3.3 explain the control of the cell division cycle 3.4 explain how multicellular organisms develop by a process of growth and differentiation
LO4 Be able to grow cells in culture	4.1 safely use methods for the growth of cell cultures 4.2 determine factors affecting growth of cells in culture 4.3 prepare and maintain cell cultures using appropriate techniques 4.4 estimate the growth of cells in culture using experimental data.

Guidance

Links

This unit has particular links with the following units within this qualification:

- Unit 2: Biochemistry of Macromolecules and Metabolic Pathways
- Unit 3: Physiology of Cellular Systems in Animals
- Unit 4: Laboratory Techniques for Applied Biology
- Unit 5: Analysis of Scientific Data and Information
- Unit 7: Laboratory Management
- Unit 9: Neurophysiology and Homeostatic Control of the Human Body
- Unit 10: Molecular Biology and Genetics
- Unit 12: Pharmacological Principles of Drug Actions
- Unit 13: The Immune Response
- Unit 14: Infectious Diseases.

Essential requirements

Delivery

Delivery must emphasise the relationship between the structure and function of a cell and its position and function in the whole organism. How a cell type or tissue obtains its final position in the whole organism must be demonstrated.

The development of appropriate laboratory skills, especially in the correct use of a microscope, must be encouraged whenever possible. Prepared slides and electron micrographs are required for delivery of learning outcomes 1 and 2. Prepared slides and digital presentations are needed to illustrate the processes of cleavage and gastrulation in learning outcome 3.

Tutors must emphasise the importance of health and safety throughout the delivery and assessment of learning outcome 4 (growth of cells in culture). Learners must understand the importance of adhering to laboratory health and safety guidelines when working with immortalised cells and live tissue. Practical tasks and activities relating to cell culture must include risk analyses consistent with COSHH guidelines.

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Assessment

Learning outcome 1 involves gaining knowledge of the structure and function of the cell and it is essential that learners demonstrate this knowledge. Learners must carry out, and provide evidence for, the microscopic examination of cells.

Learning outcome 2 involves understanding the variety of cell types and their functions and how cells arrange themselves into tissues. Evidence is likely to be in written form and will include laboratory studies such as a histological stain and the microscopic examination of tissues. General reviews can also be used in conjunction with laboratory studies as evidence.

Learning outcome 3 involves understanding the cell cycle and how cells obtain their final position and function in the complete adult multicellular organism. Evidence may be in written form and will include microscopic examination of cells undergoing mitosis, meiosis, cleavage and gastrulation. Evidence for cell division, the cell cycle and apoptosis can be integrated with evidence for learning outcome 4.

Learning outcome 4 involves learners carrying out laboratory investigations, selecting appropriate methods in a laboratory situation, growing and maintaining cells in culture and calculating the growth rate of a culture of cells. Techniques used will depend on the equipment available in the centre. Learners must provide evidence of preparing culture media, growing and maintaining cells in culture and measuring the growth of a population of cells.

Resources

Learners will require access to light microscopes. Prepared slides and electron micrographs are essential for the delivery of learning outcomes 1, 2 and 3. Biosets provide a cost effective alternative to glass slides. Each bioset normally contains a strip containing eight pre-prepared slide images and can be viewed under a bioviewer. Many biosets contain workbooks which may be used in the delivery and assessment of learning outcomes 1, 2 and 3. Biosets and bioviewers are available from a range of distributers.

Learners will also require access to immortalised cells. Ideally, a laminar flow hood should be available for cell culture. However, if this is not available, cell culture may be attempted in a suitable environment using good aseptic techniques in a fume cupboard or on a sterilised laboratory bench.

Learners will need access to appropriate laboratory facilities, tutorial support and library resources.

Employer engagement and vocational contexts

Understanding the cell and its function in the multicellular organism is of fundamental importance in understanding biology and related disciplines. Learners will have opportunities to grow cells in culture and to appreciate the importance of cell culture as a valuable tool in diagnostic research. Learners will benefit from visits to industrial cell culture facilities to observe the practical applications of cell culture in operation. Learners would also benefit from visits to centres with electron and confocal microscope facilities.

Industry links, work placements and visits from personnel with technical expertise in developmental biology and cell culture would enhance delivery of this unit.

Unit 2: Biochemistry of Macromolecules and Metabolic Pathways

Unit code: F/601/0217

Level: 5

Credit value: 15

Aim

This unit enables learners to develop practical skills and examine the chemical characteristics of amino acids, monosaccharides, nucleotides and fatty acids. These are used to develop an understanding of the structure and function of related biological macromolecules.

Unit abstract

Biochemistry deals with the chemistry of those molecular substances that occur in living organisms in terms of their structure and the processes in which they are involved. It is a key element in many scientific areas including medicine, pharmacology, genetics and biotechnology.

Learners will examine how biological systems comprise macromolecules which are derived from building block molecules such as amino acids, sugars, nucleosides and fatty acids. They will develop an appreciation of how the structure and properties of macromolecules are determined by the chemical structure and functional group chemistry of the building block molecules. The structure of macromolecules, including proteins, polysaccharides, nucleic acids and lipids, are examined with a view to relating them to key biological functions such as enzyme metabolism or protein biosynthesis.

The unit will also enable learners to understand the key features of principal metabolic pathways and their relationship to each other. For example, they will develop an appreciation of the role played by gluconeogenesis in overcoming irreversible steps in glycolysis.

Learners will have the opportunity to develop a range of basic practical skills by carrying out scientific investigations in the laboratory that involve measurement, separation and purification, as related to the above topics.

Learning outcomes

On successful completion of this unit a learner will:

1 Understand the chemical principles that apply to the structures of biological building block molecules

2 Understand the structures of biological macromolecules and the relationships to biological functions

3 Understand the features of and links between the major metabolic pathways

4 Be able to use biochemical practical skills and cognate techniques.

Unit content

1 Understand the chemical principles that apply to the structures of biological building block molecules

Amino acids: functional group chemistry, acidic and basic properties, isoelectric points; chemical structure; side chain types and classification; optical isomerism; D and L classification; essential amino acids

Monosaccharides, *aldoses and ketoses*: functional group chemistry; reducing properties; reactivity of glycosidic hydroxyl groups; chemical structure; cyclic structure formation; α and β terminology; optical isomerism

Nucleosides and nucleotides: nitrogen bases; sites of attachment of sugar residues

Fatty acids: saturated; unsaturated; essential fatty acids

2 Understand the structures of biological macromolecules and the relationships to biological functions

Protein structure: primary (planar nature of the peptide bond and dihedral angles); secondary (helix and β sheet as a consequence of dihedral angles and hydrogen bonding); tertiary (types of intramolecular stabilising bonds); structure and properties of globular and fibrous proteins; quaternary eg haemoglobin

Enzymes: relationship between structure and function; enzymes as biological catalysts (active site structure, substrate binding, strain and specificity); properties of enzymes (pH_{opt}, T_{opt}, V_{max}, K_m); denaturation; enzyme inhibition limited to competitive and non-competitive; allosteric enzymes; collagen as a structural protein (role of glycine and proline, triple helix structure, fibril formation)

Polysaccharides: glycogen; starch; cellulose; relationship between storage polysaccharides and shape due to α glycosidic links; importance of branching; structural polysaccharides as a result of glycosidic links; enzymic hydrolysis of polysaccharides as a result of β glycosidic links; enzymic hydrolysis of polysaccharides as a source of monosaccharides and energy

Nucleic acids: structure of a strand of deoxyribonucleic acid (DNA); double helix and the role of hydrogen bonding; types of ribonucleic acid (RNA); outline of protein biosynthesis

Phospholipids: lipids as exemplified by triglycerides and phospholipids; phospholipids in membrane formation; effect of saturated to unsaturated fatty acid ratio on membrane fluidity

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3 Understand the features of and links between the major metabolic pathways

Main metabolic pathways: glycolysis; fermentation; electron transport; fatty acid β oxidation; gluconeogenesis; fatty acid synthesis

Processes controlling metabolism: free energy change; relationship between metabolism and free energy change; equilibrium; metabolic flux

Irreversible steps: irreversibility in terms of free energy changes; reverse of pathways as different chemical steps

Control of glycolysis and gluconeogenesis: factors that control catabolic pathways; factors that control anabolic pathways; phosphofructokinase (PFK1)

4 Be able to use biochemical practical skills and cognate techniques

Protein separation: methods used to separate or purify proteins eg gel filtration chromatography, ion exchange chromatography, affinity chromatography, polyacrylamide gel electrophoresis (PAGE)

Determination of unknown concentrations: selected biological molecules eg determination of concentrations of glucose, an amino acid or bovine serum albumin by colorimetry

Determination of enzyme characteristics: characteristics eg specific activity, T_{opt}, pH_{opt}, V_{max}, K_m, type of inhibition

Learning outcomes and assessment criteria

Learning outcomes **On successful completion of this unit a learner will:**	Assessment criteria for pass **The learner can:**
LO1 Understand the chemical principles that apply to the structures of biological building block molecules	1.1 explain the principal properties and classification of amino acids 1.2 explain the principal properties and classification of monosaccharides, aldoses and ketoses 1.3 explain the principal properties and classification of nucleosides and nucleotides 1.4 explain the principal properties and classification of fatty acids
LO2 Understand the structures of biological macromolecules and the relationships to biological functions	2.1 discuss the differences in protein structure at primary, secondary and tertiary level between globular and fibrous proteins 2.2 explain the structure, catalytic function and characteristic properties of enzymes 2.3 review the major features of storage and structural polysaccharides 2.4 outline briefly the roles of the nucleic acids in protein biosynthesis with reference to the structural differences between DNA and different types of RNA 2.5 explain the structural features and properties of phospholipids that enable them to form membranes
LO3 Understand the features of and links between the major metabolic pathways	3.1 summarise the function of the main metabolic pathways and the relationships between them 3.2 review the processes that control metabolic pathways 3.3 explain the apparent irreversible steps in glycolysis and the role of gluconeogenesis in overcoming them 3.4 explain the control of glycolysis and gluconeogenesis exhibited by phosphofructokinase (PFK1)
LO4 Be able to use biochemical practical skills and cognate techniques	4.1 plan types of protein separation in terms of the theory and practice involved 4.2 carry out a separation and purification of protein from a simple mixture, using safe practices 4.3 determine experimentally the concentration of an unknown biological molecule, using safe practices 4.4 determine experimentally the characteristics of an enzyme, using safe practices.

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Guidance

Links

This unit has particular links with the following units within this qualification:

- Unit 1: Cell Biology
- Unit 4: Laboratory Techniques for Applied Biology
- Unit 5: Analysis of Scientific Data and Information
- Unit 9: Neurophysiology and Homeostatic Control of the Human Body
- Unit 10: Molecular Biology and Genetics
- Unit 12: Pharmacological Principles of Drug Actions
- Unit 13: The Immune Response System
- Unit 15: Medical Microbiology
- Unit 18: Food Molecules, Additives and their Roles
- Unit 22: Chemistry for Applied Biologists.

Essential requirements

Delivery

Throughout the unit, chemical structures must be used wherever possible. For learning outcome 1, learners must appreciate the differences between D and L isomers, as well as alpha and beta anomeric structures.

For learning outcome 2, for the structure of DNA, nitrogen bases should be represented by the letters ATCG.

For learning outcome 3, awareness of the links between pathways is essential.

For learning outcome 4, learners must cover three types of protein separation in terms of the theory and practice involved.

Assessment

For learning outcome 1, learners must demonstrate an ability to represent chemical structures of compounds with one chiral centre in 2D and 3D forms as well as their knowledge of the fundamental principles of building block molecules. There should be an appreciation of the biochemical significance relating to functional group(s) within these molecules.

For learning outcome 2, learners must be able to show how the structure of the biological macromolecules enables them to perform the functions they are involved in. Again, particular emphasis should be placed on the chemistry underlying functions such as the catalytic activity of enzymes or the role of nucleotides in protein synthesis.

Evidence for learning outcome 3 needs to detail the biochemical reactions involved in the major metabolic pathways and recognise the importance of free energy (G) changes in these reactions. The relationship between the different pathways, especially glycolysis and gluconeogenesis, should be emphasised.

Learning outcome 4 requires learners to demonstrate practical skills and cognate techniques.

Resources

Learners need access to well-equipped laboratory facilities to carry out practical investigations. Tutorial support, library and ICT resources are also required for learners to undertake independent research.

Employer engagement and vocational contexts

Learners will benefit from visits to laboratories that are in engaged in investigations or research into biochemical processes. For example, medical laboratories, agri-food research and/or veterinary science. These facilities would enable learners to observe the application of biochemistry and biochemical techniques within a particular context.

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Unit 3: Physiology of Cellular Systems in Animals

Unit code: J/601/0218

Level: 4

Credit value: 15

Aim

The unit provides learners with an understanding of the structure of the main physiological systems and how they function together to utilise nutrients and remove waste products effectively.

Unit abstract

It is essential that learners understand how differing body systems are structured and, in turn, are able to understand the associated physiology. This unit will enable learners to gain an understanding of a number of systems within the body, including the nervous, blood and cardiovascular, respiratory, digestive, renal and endocrine systems.

The unit also gives learners an opportunity to examine the importance of the interrelationship between these diverse systems in maintaining homeostasis within an organism.

This unit provides a general introduction to human physiology and learners will have the opportunity to examine the differences between mammalian, amphibian, bird and fish physiology.

Learners will use underpinning knowledge of cellular structure and its associated physiology by considering two specific processes, the assimilation of nutrients and removal of waste products.

Learning outcomes

On successful completion of this unit a learner will:

1 Understand the relationship between the structure of specialised cells and their functioning within tissues

2 Understand how different tissues communicate with each other

3 Understand how different systems assimilate nutrients and remove waste products.

Unit content

1 Understand the relationship between the structure of specialised cells and their functioning within tissues

Muscle cells: muscle anatomy (myofibrils, myofilaments, myosin, actin); differences in structure and function between smooth, cardiac and skeletal muscle; movement of myosin and actin during contraction

Neuronal cells: neuroglia (Schwann cells, astrocytes, microglia, oligodendrocytes); neuron structure (dendrites, axons); synapses; myelin sheath

Epithelial cells: tight junctions; membrane transport of ions, fluids and macromolecules; membrane transport of Na^+/K^+ pump; ion channels

Secretory cells: increased number of mitochondria for additional energy requirements for synthesis of material for release; packaging of secreted material into secretory granules; comparison of different secretory cells eg anterior pituitary, gastric cells, liver cells

2 Understand how different tissues communicate with each other

Endocrine system: intracellular triggers for release of stored peptides (second messenger systems); receptors and their regulation; different hormone structures and mechanisms of action (peptide, steroid, thyroid and neurotransmitters)

Nervous system: membrane potential and action potential; structure and function of the central, peripheral and autonomic nervous systems; signalling, the reflex arc; fibre tracts in the spinal cord; functional neuroanatomy of the brain

Homeostasis: maintenance of consistent cellular conditions for certain variables (pH, temperature, concentrations of dissolved gases, ions and organic nutrients); components of homeostatic control systems (receptor, sensory pathway, integration centre, motor pathway, effector); negative feedback mechanisms

Control of homeostasis: hypothalamic releasing and inhibitory hormones; the hormones of the anterior pituitary and their effects on their target organs; nervous control of the release of hormones from the posterior pituitary (antidiuretic hormone and oxytocin); nervous control of blood pressure

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3 Understand how different systems assimilate nutrients and remove waste products

Systems: mammalian; amphibian; bird; fish

Absorption of nutrients: morphological and functional relationships in the gastrointestinal tract; mechanisms and control of motility; neurohormonal control of gastric and pancreatic exocrine secretions; nature and function of bile; general anatomy and histology of the cardiovascular system; physiology and electro-physiology of the heart; blood pressure and its control; capillary blood flow and exchange of fluid

Waste product removal: structure and function of the renal system; counter current mechanisms; water and salt balance; regulation of pH of body fluids; structure of the respiratory system; mechanisms of ventilation; gaseous exchange; transport of respiratory gases; generation of rhythmic breathing; nervous and chemical control of breathing

Learning outcomes and assessment criteria

Learning outcomes **On successful completion of this unit a learner will:**	Assessment criteria for pass **The learner can:**
LO1 Understand the relationship between the structure of specialised cells and their functioning within tissues	1.1 explain the cellular structures of specialised muscle, neuronal, epithelial and secretory cells 1.2 assess how the properties of specialised cells enable them to perform their specialised functions
LO2 Understand how different tissues communicate with each other	2.1 explain the operation of the endocrine system with respect to its regulatory roles within an organism 2.2 evaluate the operation of the nervous system as a method of rapid signalling within an organism 2.3 explain the homeostatic control mechanisms necessary for effective functioning within an organism
LO3 Understand how different systems assimilate nutrients and remove waste products	3.1 explain the systems by which an organism absorbs nutrients to meet its need to maintain a constant internal environment 3.2 discuss the mechanisms by which an organism maintains a water and salt balance different to its external environment 3.3 discuss the processes by which gaseous exchange occurs between an organism and its external environment 3.4 evaluate the efficacy of the systems employed by organisms to rid themselves of solid and gaseous waste.

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Guidance

Links

This unit has particular links with the following units within this qualification:

- Unit 1: Cell Biology
- Unit 2: Biochemistry of Macromolecules and Metabolic Pathways
- Unit 4: Laboratory Techniques for Applied Biology
- Unit 5: Analysis of Scientific Data and Information
- Unit 9: Neurophysiology and Homeostatic Control of the Human Body
- Unit 10: Molecular Biology and Genetics
- Unit 12: Pharmacological Principles of Drug Actions
- Unit 25: Plant Physiology and Environmental Adaptation.

Essential requirements

Delivery

It is highly recommended that the unit is delivered using an integrated approach of theory, practical investigations and practical demonstrations. The theoretical element could be delivered using a variety of practical activities. Tutors should guide learners carefully towards understanding the link between the identified cell structures and their function.

Homeostatic functioning must be discussed in relation to nutrient assimilation and the process of gaseous exchange relating to the removal of waste products.

Assessment

For learning outcome 1, learners must assess how the properties of two specialised cells enable them to perform their specialised functions. The learning outcomes can be treated on an individual basis, concentrating on specific cells and body systems. Alternatively, a thematic approach covering several or all learning outcomes may be used, in which studies of communication between cells within tissues and different systems are used to illustrate the principles of homeostasis within an organism.

Resources

Learners require access to ICT and library resources and well-equipped laboratory facilities.

Employer engagement and vocational contexts

Learners would benefit from visits to industrial laboratories and research facilities.

Unit 4: Laboratory Techniques for Applied Biology

Unit code: L/601/0219

Level: 4

Credit value: 15

Aim

This unit gives learners the opportunity to practise and be able to use skills commonly used in practical biology. These include microscopy, titration, spectroscopy, chromatography and use of aseptic technique.

Unit abstract

Learners studying applied biology have a wide range of specialisms open to them, for example biochemistry, molecular biology, physiological measurement, haematology, histopathology, oncological research, microbiology and infection control, virology, environmental science, genetics and forensic science. In this unit learners will cover a range of techniques. They will become familiar with microscopy, titrimetric, spectroscopic and chromatographic techniques, serial dilution and aseptic techniques. Learners will develop the ability to present experimental results in a variety of formats and to produce different styles of report. Learners will also learn how to assess the risks associated with particular practical techniques.

On completion of the unit, learners should have developed the flexibility to use unfamiliar techniques, by following given instructions and be able to report on, and assess, the reliability of these techniques.

Learning outcomes

On successful completion of this unit a learner will:

1 Be able to use and calibrate a light microscope to differentiate between cell types

2 Be able to use titrimetric and spectroscopic quantitative techniques

3 Be able to use chromatographic techniques for qualitative and quantitative analyses

4 Be able to use aseptic technique in microbiological procedures.

Unit content

1 Be able to use and calibrate a light microscope to differentiate between cell types

Component parts of a microscope: eyepiece; body tube; coarse adjustment; fine adjustment; stage; condenser/diaphragm; mirror; foot; objective lenses on nosepiece; lamp

View prepared slides: slides from a library eg tissue slides; slides prepared by learners eg onion cells, pond water; mount slides appropriately using clip on stage; optimise light; optimise focus and magnification; calibrate; stage micrometer; reticule; eyepiece micrometer

Produce representations: labelled drawings; calculation of magnification; digital image capture

Slide preparation: slide; coverslip; dry mounting; wet mounting; staining eg iodine; microtome

2 Be able to use titrimetric and spectroscopic quantitative techniques

Assess the risks: chemical hazards eg toxic, harmful, teratogenic; non-chemical hazards eg broken glassware; risk assessment for a titrimetric procedure; risk assessment for a spectroscopic procedure; aspects of given procedures which minimise inherent risks

Weighing and measuring equipment: balances eg top pan, analytical; volumetric equipment eg automated pipettes, graduated pipettes, syringes, burettes, volumetric flasks

Analyses using titrimetric techniques: quantitative methodology eg weighing by difference, use of appropriate glassware, accurate reading of position of meniscus, appropriate mixing of solutions; different types of pipette eg bulb, graduated, automatic; calibration of pipettes; use of primary standard solutions; acid base titration including use of pH electrode; calibration of pH electrode; redox titration eg use of potassium manganate (VII), thiosulfate/iodine

Analyses using spectroscopic techniques: using the Beer-Lambert law eg use of ultraviolet/visible spectrometer at fixed wavelength, use of colorimeter techniques eg flame emission to determine potassium content of blood, atomic absorption (AA) to determine iron concentration; technique to involve serial dilution eg Beer-Lambert determination of potassium manganate (VII) concentration, potassium by flame emission

Appropriate degree of accuracy: in quantitative determinations eg comparison with reference value with given tolerance, use of class results/statistical treatments to establish appropriate tolerance

Report: methods of producing formal laboratory reports; use of additional methods of reporting eg completion of a pro forma, oral presentation, PowerPoint presentation, writing an article

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3 Be able to use chromatographic techniques for qualitative and quantitative analyses

Assess the risks: risk assessment eg for a paper or thin layer chromatography (TLC); risk assessment for an instrumental technique

Chromatographic separations: paper chromatography; TLC; other techniques as available eg gas chromatography (GC), high performance liquid chromatography (HPLC), electrophoresis, ion-exchange; use of locating agents eg iodine, ninhydrin, cerium sulfate

Quantitative techniques: interpretation of results from GC; HPLC; integration of peak area; composition of a mixture or concentration of a solution

Present: methods eg poster, report, written account, PowerPoint presentation slides, verbal presentation

Principles: mobile phase eg solvent, carrier gas; stationary phase eg water within paper, silica, viscous liquid on GC capillary/support; sorption mechanism eg adsorption, partition, ion-exchange; column eg GC, HPLC, ion-exchange; layer eg paper and thin layer; detection of components eg colour of components, locating agent, flame ionisation detector (FID), absorption of ultraviolet light; calculation of R_f values; retention time; features of specific techniques eg oven in GC, pump and degassing of solvents in HPLC; block diagrams of instrumental techniques

Report: formal laboratory report; other methods of reporting eg completion of a pro forma, oral presentation, PowerPoint presentation, writing an article

4 Be able to use aseptic technique in microbiological procedures

Guidelines: types eg instruction sheets, verbal instructions, instruction manuals

Prepare inoculated agar plates: sterile plates; pouring techniques; control plates; appropriate inoculation eg streak plates; lawn plates, environmental swabbing; incubation to determine extent of growth; appropriate labelling of plates

Minimal environmental contamination: wiping surfaces with disinfectant; use of alcohol and flaming as appropriate; pouring technique; protecting cultures from contamination

Decontamination techniques: sterilisation; use of an autoclave; disinfection; different types of disinfection; safe disposal of waste

Risks associated with microbiological experiments: hazards associated with various disinfectants eg toxicity, flammability; hazards associated with micro-organisms; aerosol formation; steps to minimise risk

Learning outcomes and assessment criteria

Learning outcomes **On successful completion of this unit a learner will:**	Assessment criteria for pass **The learner can:**
LO1 Be able to use and calibrate a light microscope to differentiate between cell types	1.1 explain the function of the component parts of a microscope 1.2 produce representations of views under different magnifications 1.3 prepare slides to meet given requirements
LO2 Be able to use titrimetric and spectroscopic quantitative techniques	2.1 assess risks inherent in quantitative procedures 2.2 routinely and accurately use weighing and measuring equipment 2.3 safely perform analyses using titrimetric techniques to an appropriate degree of accuracy 2.4 safely perform analyses using spectroscopic techniques to an appropriate degree of accuracy 2.5 report on the analyses conducted
LO3 Be able to use chromatographic techniques for qualitative and quantitative analyses	3.1 assess the risks associated with chromatographic procedures 3.2 safely carry out qualitative and quantitative chromatographic separations 3.3 interpret results from quantitative chromatographic techniques 3.4 discuss the principles of chromatographic separations and report on analyses that use chromatography
LO4 Be able to use aseptic technique in microbiological procedures	4.1 report on the risks associated with microbiological experiments 4.2 follow guidelines to safely prepare inoculated agar plates with minimal environmental contamination 4.3 safely use decontamination techniques.

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Guidance

Links

This unit has particular links with the following units within this qualification:

- Unit 2: Biochemistry of Macromolecules and Metabolic Pathways
- Unit 3: Physiology of Cellular Systems in Animals
- Unit 5: Analysis of Scientific Data and Information
- Unit 10: Molecular Biology and Genetics
- Unit 14: Infectious Diseases
- Unit 15: Medical Microbiology
- Unit 17: Industrial Microbiology
- Unit 19: Environmental Monitoring and Analysis
- Unit 22: Chemistry for Applied Biologists.

Essential requirements

Delivery

Learners must know about the hazards associated with biological specimens, chemicals, non-chemical hazards, and be able to identify how given procedures minimise the associated risks. They must also learn how to undertake risk assessments for a titrimetric procedure and a spectroscopic procedure.

Learners need to be familiar with the range of procedures needed to make up solutions accurately. This may be carried out by giving learners preparatory tasks or it could be integrated into the application of techniques. Since pH is very important to many biological processes, learners must be taught how to use a pH meter accurately.

Learners must be able to use paper and thin layer chromatography. They may use these techniques to separate mixtures containing coloured substances and use locating agents to identify the position of colourless spots. R_f values must be calculated.

Centre facilities will determine which instrumental chromatographic techniques will be used. Learners must have access to infrared and ultraviolet visible spectrometers, gas chromatographs and high performance liquid chromatographs. If centres do not have these instruments, visits should be arranged so learners can use the spectroscopic techniques and see chromatographic techniques in action.

Aseptic techniques are covered in the specialist microbiology units. Centres do not need to have the facility to carry out advanced microbiology to deliver this unit. However, centres need to devise a meaningful experience for learners in an appropriate context. Learners must be given the opportunity to prepare plates which are inoculated in some way, for example sterile agar and pour plates. Alternatively, sterile plates could be purchased. Inoculation could be carried out with low hazard cultures, with organisms from foodstuffs like yogurt or with low hazard environmental swabs. Appropriate labelling must be carried out. Plates and control plates must be incubated in order to gauge how effective learners' use of aseptic technique has been. Learners must understand the principles and practice of sterilisation and disinfection and have some experience of applying them.

Assessment

Learners must record and report all results, calculations and conclusions formally. This could be achieved in a variety of formats including a formal presentation, written articles or reports.

As part of the assessment for the unit, learners must carry out at least four formal risk assessment procedures (one for a titration, one for a spectroscopic technique, one for paper or thin layer chromatography and one for an instrumental chromatography technique), and produce at least three formal reports (one for titration, one for spectroscopy, one for chromatography).

For learning outcome 1, learners could carry out research into the preparation of slides. Learners do not need to use a microtome but should know and understand its use.

For learning outcome 2, learners must be familiar with aspects of the techniques used to ensure accuracy before carrying out at least two titrations, one involving an acid-base titration and the other a redox titration. Use of primary standards must be built into these exercises. Learners are required to carry out at least two pieces of practical work based on spectroscopy. These will involve the preparation of a calibration plot – instrument readings as a function of concentration. At least one spectroscopic technique should involve the use of serial dilutions. Two formal reports must be produced for this outcome, one for titration and one for a spectroscopic technique, including assessment of the inherent risks.

For learning outcome 3, learners must be observed carrying out competent separations using paper and thin layer chromatography. Since many of these separations involve mobile phases and locating agents with significant chemical hazards, learners need to carry out at least one recorded formal risk assessment for such a procedure and one for an instrumental procedure.

Learners could carry out GC and HPLC quantitatively or be given results to interpret. At least one formal report must be produced on a chromatographic technique.

For learning outcome 4, learners must be observed carrying out practical work which, as a minimum, involves inoculation and labelling of sterile plates and observation of the incubated plates. Aspects of aseptic technique must be included in the exercise. Through their practical work, learners must also be able to show that they understand the risks associated with microbiology practicals and the principles involved in sterilisation and disinfection.

Resources

Access to practical laboratory facilities, technical support, library facilities and IT resources are essential.

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Employer engagement and vocational contexts

Where learners are working in biological industry, discussion on the use of techniques should be encouraged. Visits could be arranged to local industry and to local higher education institutions to see the techniques in action. Guidance on assessment may be contextualised in relation to techniques used routinely in local industry.

Unit 5: Analysis of Scientific Data and Information

Unit code: F/601/0220

Level: 4

Credit value: 15

Aim

This unit develops skills in mathematical and statistical techniques used in the analysis of scientific data, together with an understanding of the limitations in reporting results.

Unit abstract

In the 21st century, a considerable amount of data analysis is performed by computers. The importance of understanding how and in what circumstances to use individual mathematical and statistical techniques, and the significance of the results, is not diminished by the availability of computational facilities. The primary outcome of scientific experimentation frequently comprises data, the volume of which varies significantly depending on the type of work undertaken. Analysis of the data which is obtained needs to be processed in some way to extract meaning.

This unit aims to develop previous knowledge and understanding gained in learning about scientific data analysis and extend it to a level appropriate for use in industry and research. Starting with the fundamental procedures of displaying information and data to standards expected in the field of science, the majority of the unit focuses on the use of mathematical and statistical techniques in appropriate contexts. Treatment of these techniques is practical rather than theoretical.

Learners will examine how the outcomes of processing are used, in terms of values generated and their associated errors, to generate valid conclusions.

Learning outcomes

On successful completion of this unit a learner will:

1 Be able to present information and data to scientific standards

2 Be able to process data using numerical analysis

3 Be able to process data using statistics

4 Understand limitations in concluding results.

Unit content

1 Be able to present information and data to scientific standards

Presentation of information: target audience; fitness for purpose of media used; clarity of information; communication of work carried out

Display data: tabulation; bar charts; pie charts; frequency polygons; ogives; histograms; scatter diagrams

Graphical methods: linear axes; non-linear axes eg logarithmic, exponential; curve fitting; linear regression eg least squares method

2 Be able to process data using numerical analysis

Algebraic methods: transposing equations; linear equations; simultaneous linear equations; quadratic equations; roots of quadratic equations

Use of calculus: standard differentiation; first order derivatives of equations; applications of differential equations eg reaction rates; standard integration; definite integration; application of definite integration eg area under a curve

Errors in data: classification of sources of errors eg random, systematic, gross; difference between accuracy and precision; handling errors in data processing eg absolute, relative, compound

3 Be able to process data using statistics

Descriptive statistics: measures of central tendency eg mode, median, mean; measures of dispersion eg variance, standard deviation; coefficient of variation

Normal distributions: probability distributions; normal distributions; standardising; tests for normality; percentiles; samples of populations; standard error of the mean; confidence limits

Hypothesis testing: null hypothesis; alternative hypothesis

Statistical tests: type eg z-test, student's t-test, F-test, Pearson's chi-squared (χ^2) test, Pearson's product moment correlation coefficient; significance levels; power of the test; one-tailed and two-tailed

4 Understand limitations in concluding results

Total error in results: combination of component errors; representation of numbers; round-off errors; truncation errors; level of confidence in results obtained

Conclusions from the work: values of measured parameters; validity of hypotheses; support for theoretical models; confirmation of model developed; accuracy; precision of measurements

Information on the problem studied: fitness for purpose of the methods used; validity of conclusions; information provided on the systems studied; compatibility of results with those from other sources

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Learning outcomes and assessment criteria

Learning outcomes **On successful completion of this unit a learner will:**	Assessment criteria for pass **The learner can:**
LO1 Be able to present information and data to scientific standards	1.1 create a plan for the presentation of scientific information 1.2 display data to scientific standards using planned methods 1.3 carry out graphical methods of displaying scientific data
LO2 Be able to process data using numerical analysis	2.1 perform numerical analysis on scientific data using an algebraic method 2.2 demonstrate numerical analysis using calculus on standard polynomial equations 2.3 evaluate absolute errors in scientific data
LO3 Be able to process data using statistics	3.1 perform descriptive statistics on a sample of continuous scientific data 3.2 demonstrate the nature of normal distributions using a sample of continuous scientific data 3.3 carry out hypothesis testing using standard statistical tests and draw conclusions
LO4 Understand limitations in concluding results	4.1 evaluate the total error in a sample of continuous scientific data 4.2 assess the accuracy of a model using the outcomes of processing carried out on experimental data 4.3 justify the validity of conclusion(s) from the information on a problem studied.

Guidance

Links

This unit has particular links with the following units within this qualification:

- Unit 6: Project for Applied Science
- Unit 8: Work-based Investigation
- Unit 24: Statistics for Experimental Design.

Essential requirements

Delivery

Delivery must focus on the application of mathematical or statistical techniques in science, rather than on the techniques themselves. Emphasis must be on the selection and implementation of methods appropriate to given scientific contexts, and on the evaluation of the significance of the results and conclusions obtained. Delivery must draw on data from experimental units within the programme of study and use experiments as models for design and analysis. Learners must be taught to use software correctly, and to appreciate both the strengths and limitations of the methods used.

Delivery teams should analyse the mathematical requirements of their programmes and select the set of techniques learners will need to derive meaning from the information and data they will encounter during their studies.

Assessment

Learning outcome 1 involves presenting information and data to standards expected in the science industry.

Learning outcomes 2 and 3 involve the mathematical and statistical techniques commonly used in the process of scientific data analysis. Emphasis must be on the accurate application of the methods covered, rather than on demonstrating understanding of the mathematical concepts. Evidence should include case studies or experimental studies, where appropriate.

Learning outcome 4 involves the generation of a formal conclusion based on the outcome of the data analysis. Evidence may be integrated with evidence from the other three learning outcomes.

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Resources

Learners will need access to IT facilities and appropriate software to enable them to tackle realistic problems. Many of the operations relevant to applied science programmes can be implemented using a generic spreadsheet package (such as Microsoft Excel). Ideally, this will be supplemented by dedicated mathematical or statistical packages, for example Minitab, PASW Statistics or MATLAB.

Employer engagement and vocational contexts

Learners will benefit from visits to industrial and research facilities to observe practical applications of data analysis, or to gain access to learning materials.

Unit 6: Project for Applied Science

Unit code: J/601/0221

Level: 5

Credit value: 20

Aim

This unit enables learners to integrate acquired knowledge, understanding and skills and display a significant degree of autonomy applying them in an individual practically-based study.

Unit abstract

Development of knowledge and skills within higher level qualifications is sometimes limited by the modular structure of the programme. In employment, however, learners are frequently required to use knowledge and skills across a range of subject disciplines and apply them in unfamiliar situations. It is essential therefore that they are able to apply planning, research and analytical skills, in addition to being able to identify, access and use a variety of information sources. They must work safely and accurately, keep detailed records and process information and data precisely, as well as communicating their results in a variety of ways suited to a target audience.

The project topic can be drawn from a wide variety of activities appropriate to the programme of study but learners must be actively involved in the selection and development of the project proposal. Learners must take responsibility for producing a project plan that should be agreed with the assessor. The work should be carried out logically, based on the application of scientific method. The results of the investigation should be evaluated and presented in the form of a scientific report.

Learning outcomes

On successful completion of this unit a learner will:

1 Be able to plan a project

2 Be able to implement the project plan

3 Be able to evaluate the project outcomes

4 Be able to communicate the project investigation and its results.

Unit content

1 Be able to plan a project

Project specification: practical and literature based; scope and purpose of the investigation; intended outcomes; methods of approach; resource requirements

Review key information: background theory; supporting data; published methods; identification and acquisition of sources; use of texts, journals and internet

Experimental design: standard published methods; reported alternative procedures; existing equipment and materials; sources and access to other equipment; achievable timescales; criteria for success; identified monitoring points and procedures

Amend schedule: agreed amendments relating to project specification, timescales etc following discussions with supervisor

2 Be able to implement the project plan

Investigation: experimental work; operating methods and procedures; acquisition of equipment and materials; methods of data collection and recording; accuracy and precision; quality standards; minimisation of errors; use of statistical techniques

Safety: potential hazards eg risk assessment, COSHH analysis

Logbook: dated entries; tables and records of results; correct use of units; error analysis; own versus group results; schedule amendment eg significant or unexpected events, deviations from expected data and results, progress made relative to original plan; agree proposed amendments

3 Be able to evaluate the project outcomes

Analyse: analysis of data and experimental observations; draw conclusions based on analysis of results

Evaluate the study: appropriate evaluation methods set against formulated criteria for success; use of correct statistical techniques; identification of sources of error; confidence limits for results

Further investigations: suggestions for further study relating to minimising errors; extending topic area; confirming or supporting conclusions

Conclusions: conclusions from analysis of data and experimental observations justified in terms of original specifications

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4 Be able to communicate the project investigation and its results

Scientific report: abstract; introduction and objectives; literature survey; fully processed results (raw data; spectra etc may be included as an appendix); experimental work; critical discussion; suggestions for further investigation; appendices; bibliography

Format: conform to accepted scientific format relating to abstract; literature survey; tabulated results; in-text referencing and bibliography; written in third person past tense; use of spreadsheets, presentation packages and scientific software as appropriate

Project specification: practical and literature based; scope and purpose of the investigation; intended outcomes; methods of approach; resource requirements

Presentation: appropriate media; delivery suited to target audience; clear explanations of scope and results; justify conclusions

Learning outcomes and assessment criteria

Learning outcomes **On successful completion of this unit a learner will:**	Assessment criteria for pass **The learner can:**
LO1 Be able to plan a project	1.1 establish a project specification from consideration of the scope and purpose of an appropriate topic 1.2 undertake a review of key information that supports the work 1.3 produce an experimental design for the study 1.4 amend the schedule as appropriate following discussions with supervisor
LO2 Be able to implement the project plan	2.1 record all safety requirements 2.2 undertake the investigation according to the agreed specification and safety codes of practice 2.3 compile a logbook documenting all observations and results
LO3 Be able to evaluate the project outcomes	3.1 analyse results in terms of original specifications 3.2 use appropriate methodology to evaluate the study 3.3 propose areas of further investigation that could lead to improvement of the project outcomes 3.4 justify both the conclusions drawn from the study and the proposals for further investigation
LO4 Be able to communicate the project investigation and its results	4.1 produce a scientific report in an accepted format 4.2 identify the extent to which the project specification has been met 4.3 prepare a presentation summarising the project investigation.

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Guidance

Links

This unit has particular links with the following units within this qualification:

- Unit 4: Laboratory Techniques for Applied Biology
- Unit 5: Analysis of Scientific Data and Information
- Unit 7: Laboratory Management
- Unit 8: Work-based Investigation
- Unit 24: Statistics for Experimental Design
- Unit 27: Management of Projects.

This unit also links with the following NOS:

- NVQ L4 Laboratory and Associated Technical Activities (LATA).

Essential requirements

Delivery

This unit differs from *Unit 8: Work-based Investigation* in that the latter must be carried out in the workplace and gives credit for work-based activity. The *Project for Applied Science* unit is developed and planned within the centre of learning but some or exceptionally all of the practical work could be carried out in the workplace or elsewhere if that is where any specialist equipment is located. This unit requires coverage of broader topics and a greater learner input into topic selection, development and evaluation than is required for Unit 8. The work used for this unit must not be used for *Unit 8: Work-based Investigation*.

The project topic can be drawn from a wide range of activities appropriate to the programme of study but must have a significant practical investigation. It may be carried out individually or as a component of a team investigation. Where teamwork is involved sufficient documentation must be kept to demonstrate the individual efforts of each learner. Logbooks must distinguish clearly between team results and observations and work undertaken by the individual. Learners must display a significant amount of autonomy and apply their initiative and judgement in the selection and development of the project topic together with its execution and evaluation.

To ensure safe work practices, learners must be briefed thoroughly on project work methodology. All project specifications and schedules must be scrutinised and agreed by supervisors before learners start work and regular meetings between learners and supervisors should be scheduled to monitor progress. This support should not prevent learners from achieving the higher grades providing individuals make a significant contribution to the development of the plan, and their suggestions and actions are reasonable within their level of experience. Supervisor support should be available at all times during the project and detailed records kept of the extent of the support individuals required. This information should be used in making decisions on grading.

Learners must be allowed to make their own decisions during the implementation phase and supervisors should normally intervene only when safety is likely to be compromised. A lot can be learned from negative results and failed experiments. Supervisors should not attempt to prevent this providing the learner's actions and decisions are reasonable and fall within the agreed plan. Results and achievements must be evaluated against the aims and criteria in the project plan.

Assessment

Projects may be carried out individually or in small teams. In the case of team projects the supervisor must document individual contributions in sufficient detail to enable accurate grading and verification to take place. The interaction of team members should be considered, along with learner autonomy in completing the project, when looking at higher grading.

In all cases, planning for learning outcome 1 must be completed and agreed before learners start their practical work. The supervisor should also receive a draft report of the literature review and experimental design before the discussion stage in learning outcome 1. For learning outcomes 2 and 3, the supervisor needs to monitor the early stages of the work and the logbook and, providing learners are competent in safe working practices, progressively reduce the amount of supervision relating to the direction and management of the project.

The format of the final report for learning outcome 4 must be determined at the planning stage. Supervisors should set a deadline to see a draft version of the early sections (not the whole report), and provide feedback. Amendment and completion of the final scientific report should then take place without further assistance or comment from the supervisor. The presentation must be made to supervisors and fellow learners and may or may not include peer assessment. If the presentation is to be used to meet the higher grading criteria then minimum guidance should be given.

Resources

This project unit will be developed and planned within the centre but some, or exceptionally all, of the practical work could be carried out in the workplace or elsewhere if this is where any essential specialist equipment can be accessed. Required resources will vary significantly with the nature of the project. The identification of equipment and materials, and establishment of their availability, is a vital part of the planning phase.

Tutors should ensure that learners do not start work that cannot succeed because of lack of access to the required resources. Use of specialised equipment outside the centre is acceptable, however, agreement on access must be reached before work begins. Learners will require access to computer and appropriate software packages in order to produce their report.

Employer engagement and vocational contexts

Ideally, the project topic should have a vocational context. Where this is the case learners will benefit from visits to related industries to observe industrial aspects of their study area. In particular, where analytical procedures form a significant part of the project, a visit to a local company or hospital to see automated analytical procedures in action would be advantageous.

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Unit 7: Laboratory Management

Unit code: L/601/0222

Level: 4

Credit value: 15

Aim

This unit enables learners to gain an understanding of the organisation of different types of laboratory and compare the processes associated with their management.

Unit abstract

Many learners studying at this level will either have supervisory duties or may move into such a role in the future. This unit examines the typical responsibilities of laboratory managers. Types of laboratories considered include contract analytical laboratories, project laboratories supporting innovation in and efficiency of a manufacturing process, quality control laboratories associated with manufacturing, and educational laboratories.

Management roles within these laboratories vary widely. With contract analysis, the emphasis is on providing accurate, accredited and legally defensible results. Project laboratories may carry out pilot studies on how products or production processes may be altered. By focusing on quality control they ensure that products made and supplied have properties within the tolerances specified by the customer. They may also test raw materials to ensure that they are processed into products of the correct quality. Laboratories in education may support learning or have a research focus, as in many universities. All laboratory managers need to ensure that their staff are trained appropriately and understand the tasks they have to perform. They have to ensure that the laboratory is fully resourced and that due regard is given to health and safety. They are also likely to have specific skills, for example expertise in carrying out particular procedures correctly, the ability to work to a project brief and knowledge of statistics and systems.

Learning outcomes

On successful completion of this unit a learner will:

1 Understand the typical duties of laboratory managers in different types of laboratory

2 Understand aspects of laboratory organisation

3 Understand how laboratories comply with health and safety legislation

4 Understand features of managing a quality system.

Unit content

1 Understand the typical duties of laboratory managers in different types of laboratory

Functions of a contract analytical laboratory: production of high quality data; working for a client; low cost; accuracy; reproducibility; traceability; importance of booking in samples; barcoding; legally defensible data; part of an accreditation scheme; ability to respond to customer needs; assessing the quality of data; reporting and discussing results; examples of types of analysis performed by contract laboratories eg oil, food, forensic samples, medical samples, soil, water; possible duties of a laboratory manager in the context of a contract analytical laboratory

Role of an industrial project laboratory: product innovation; investigation of aspects of the operation of a manufacturing plant; producing materials on a pilot scale; project management; importance of timescale; deadlines depending on the project; record keeping – may be non-standard; reporting in a number of formats; possible duties of a laboratory manager in the context of an industrial project laboratory

Role of a quality control laboratory: sampling techniques; storage; testing raw materials; testing product; results within given tolerances for different grades of product; reporting results to production staff; testing product during production and after production; possible duties of a laboratory manager in the context of a quality control laboratory

How an educational laboratory may differ: less likely to use standard protocols/methods; may support research; may support learner's learning; fewer routine activities; possible duties of a laboratory manager in an educational laboratory in comparison to those of other laboratory managers

2 Understand aspects of laboratory organisation

Sources of reference: equipment manuals; staff training records; company policies; staff intranet; CLEAPSS material for school/college technicians

Purchasing: lists of approved suppliers; budget; internal order forms; ordering procedures; need for signatures on orders; approved suppliers; the need to obtain quotes

Stock control systems: inventories of chemicals and other consumables; equipment lists; receiving stock; checking stock; storing stock; stock rotation; stock taking; maintaining records; control of stationery; special storage eg refrigeration, vented storage

Laboratory design: purpose of laboratory; special features relating to purpose; space needed by individuals; water; gas; electricity; sinks; waste; safety features eg extraction, safety shower, solvent sink; lighting; sample entry; space occupied by equipment; areas for writing/use of computer; storage for eg glassware, chemicals, stationery, labels, waste, samples; work surfaces

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3 Understand how laboratories comply with health and safety legislation

Legislation: Health and Safety at Work Act (1974); duties of employers; duties of employees

Regulations: eg the Management of Health and Safety at Work Regulations (1999), COSHH Regulations (2002), Workplace (Health, Safety and Welfare) Regulations (1992); approved codes of practice; guidance

Responsibilities of laboratory managers: management of health and safety eg provision/maintenance of safe systems of work, risk assessment, training, enforcing local laboratory rules, health and safety policy, first aid provision, accident/incident and near miss reporting, health and safety systems, audits, housekeeping

4 Understand features of managing a quality system

Company policies: functions eg health and safety, data management, reporting, customer service, training

Standard operating procedures: procedures eg testing; calibration, assessing data, reporting; consequences of not following standard procedures

Staff training: accreditation requirements; minimisation of random error; training record; being trained to approved standard; self-confidence; pride

Data management: unique sample numbers; sample entry; paper-based systems; computer-based systems; LIMS; back up; worksheets; hard back notebooks; signatures; initialling of errors; results; reports; traceability; training records; standard procedures; calibration records; inventories of equipment and materials; internal quality checks; external quality checks eg details of inter-laboratory testing, accreditation information and records

Learning outcomes and assessment criteria

Learning outcomes **On successful completion of this unit a learner will:**	Assessment criteria for pass **The learner can:**
LO1 Understand the typical duties of laboratory managers in different types of laboratory	1.1 explain how a laboratory manager may contribute to the functions of a contract analytical laboratory 1.2 explain how a laboratory manager supports the role of an industrial project laboratory 1.3 explain how a laboratory manager may facilitate the smooth running of a quality control laboratory 1.4 discuss how the role of an educational laboratory manager may differ from that of an industrial laboratory manager
LO2 Understand aspects of laboratory organisation	2.1 evaluate commonly used sources of reference on laboratory management 2.2 investigate key areas for consideration when purchasing equipment and consumables 2.3 explain the operation of a stock control system 2.4 discuss features of laboratory design
LO3 Understand how laboratories comply with health and safety legislation	3.1 explain the duties of employers and employees under the Health and Safety at Work Act (1974) 3.2 investigate regulations which are relevant to working in laboratories 3.3 explain typical responsibilities of a laboratory manager in terms of managing health and safety
LO4 Understand features of managing a quality system	4.1 discuss the function of company policies 4.2 analyse the importance of following standard procedures 4.3 justify the need for staff training 4.4 review how data are managed in the laboratory.

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Guidance

Links

This unit has particular links with the following units within this qualification:

- Unit 5: Analysis of Scientific Data and Information
- Unit 26: Quality Assurance and Quality Control
- Unit 27: Management of Projects
- Unit 28: Managing the Work of Individuals and Teams.

This unit also links with the following NOS:

- NVQ L4 Laboratory and Associated Technical Activities (LATA).

Essential requirements

Delivery

Literature on laboratory organisation and management is limited. The best resource is the experience of trained laboratory technicians and managers. Where learners are working in laboratories, they should discuss the different functions and roles of their laboratories. Learners who do not work in laboratories must have the opportunity to visit laboratories and/or talk to staff working in a range of laboratories. Where access to a range of laboratories is difficult to obtain, tutors could prepare case study material for learners to use. Learners must be encouraged to discuss features of laboratories that they know well and to evaluate whether the laboratory design is fit for purpose.

There are several excellent textbooks dealing with health and safety legislation. The Health and Safety Executive publishes many free leaflets. Learners must become familiar with the nature of health and safety legislation in general and then think of how it is applied to a laboratory. Again, there is scope for specialist input from health and safety managers and health and safety representatives.

Learning outcome 4 requires understanding of a quality system. Learners may use general information about quality systems and the use of standard procedures to support these systems.

Assessment

For learning outcome 1, learners could research the work that different types of laboratories carry out. This would make use of visits and case studies. Learners can then explain typical duties of managers in each type of laboratory or explain duties common to all functions and analyse specific differences in roles.

For learning outcome 2, learners must make use of information from their workplace, visits, guest speakers and centre technicians. Learners could design an ideal laboratory or they could present a plan of a laboratory that they know and discuss its design and features.

Learners have more reference material to use in approaching learning outcome 3. More-able learners will be able to contextualise general information to the laboratory setting and to envisage the role of the laboratory manager.

For learning outcome 4, tutors should give learners a realistic scenario such as a picture of a failing laboratory and then for learners to explain how using a quality system would enable the laboratory to succeed.

Resources

Case study material relating to a variety of laboratories is essential. Learners should have the opportunity to use the centre technicians as a resource. Library resources on health and safety are important as is access to the internet.

Employer engagement and vocational contexts

Learners must engage with common practice used in industrial and educational laboratories. This could be through visits, guest speakers, case studies or discussion with other learners.

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Unit 8: Work-based Investigation

Unit code: R/601/0223

Level: 4

Credit value: 15

Aim

This unit enables learners to gain credit for work-based practical investigations either as an individual or as part of a team. Learners will plan, undertake, monitor progress and communicate the outcomes of a work-based topic.

Unit abstract

Scientific work-based experience is an important aspect of all practical subjects. For part-time learners their day-to-day activities are a valuable source of learning and should be recognised. Company-based investigations often involve a team working on a common project with each individual carrying out a specific role and contributing key information to the final outcome. It is essential therefore that investigators are able to work safely and accurately, keeping detailed records of their activities and clearly communicating their findings.

This unit allows flexibility in terms of subject content and timescale. The investigation must be carried out in the workplace and the assignment set in an industrial context. The unit is intended for part-time learners in their place of work. This unit develops the skills of negotiation, planning, record keeping, safe practical investigation, report writing and communication.

This unit differs from *Unit 6: Project for Applied Science* as it must be carried out in the workplace and gives credit for work-based activity. The work used for this unit must not be used for either *Unit 6: Project for Applied Science* or *Unit 31: Work-based Experience.*

Learning outcomes

On successful completion of this unit a learner will:

1 Be able to plan a work-based topic

2 Be able to keep a detailed logbook

3 Be able to undertake an extended work-based practical investigation

4 Be able to communicate the investigation and its results.

Unit content

1 Be able to plan a work-based topic

Work-based topic: type eg team, individual; subject area related to HN curriculum

Specification: practical and literature based; scope and purpose of investigation; intended outcomes; methods of approach; resource requirements

Resources: existing equipment and materials; access to other equipment

Amend schedule: following discussions with supervisors eg agreed amendments to specification, timescales

Supervisors: work-based supervisor; academic supervisor

2 Be able to keep a detailed logbook

Document work: dated entries; details of methods used; instrument types and settings; observations; safety measures taken; advice sought; cooperative and own results; tabulated results according to scientific protocols regarding headings, units and significant figures

Amend the schedule: significant or unexpected events; deviations from expected data and results; progress made relative to original plan; agreed amendments with supervisor

3 Be able to undertake an extended work-based practical investigation

Investigation: experimental work; operating methods and procedures; acquisition of equipment and materials; methods of data collection and recording; accuracy and precision; quality standards; minimise errors; use statistical techniques

Safe practice: safety manuals; safety equipment; COSHH analysis; risk assessments

Autonomy: amendments to schedule; practical work; contributions to group work; discussions with supervisors; proposals for additional work

Agreed plans: documented arrangements for group work; agreed deadlines

4 Be able to communicate the investigation and its results

Conclusions: analysis of data and experimental observations; justification in terms of original specification

Scientific report: abstract; introduction and objectives; literature review; results in their fully processed form; raw data, spectra etc included as an appendix; experimental work; discussion; areas of further investigation; appendices; bibliography

Formats: in-text referencing and bibliography according to accepted scientific methodology; third person past tense; tabulated results

Specification: practical and literature based; scope and purpose of investigation; intended outcomes; methods of approach; resource requirements

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Presentation: appropriate media; style appropriate to audience; clear explanations of scope and results; justify conclusions

Learning outcomes and assessment criteria

Learning outcomes **On successful completion of this unit a learner will:**	Assessment criteria for pass **The learner can:**
LO1 Be able to plan a work-based topic	1.1 propose a work-based topic that relates to the programme of study 1.2 produce an outline specification for the topic 1.3 list required resources and support procedures 1.4 amend the schedule as appropriate following consultations with supervisors
LO2 Be able to keep a detailed logbook	2.1 document work undertaken in a systematic manner 2.2 amend the schedule as appropriate 2.3 distinguish between own results and group results
LO3 Be able to undertake an extended work-based practical investigation	3.1 undertake the investigation, working accurately and following safe practice protocols 3.2 demonstrate substantial and appropriate degrees of autonomy 3.3 execute shared work according to agreed plans
LO4 Be able to communicate the investigation and its results	4.1 justify conclusions drawn from the results of the investigation 4.2 produce a scientific report of the investigation using accepted formats suitable for use by an industrial line manager 4.3 explain the extent to which the specification has been met 4.4 deliver a presentation summarising the investigation.

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Guidance

Links

This unit has particular links with the following units within this qualification:

- Unit 4: Laboratory Techniques for Applied Biology
- Unit 5: Analysis of Scientific Data and Information
- Unit 6: Project for Applied Science
- Unit 7: Laboratory Management
- Unit 12: Pharmacological Principles of Drug Actions
- Unit 24: Statistics for Experimental Design
- Unit 27: Management of Projects.

This unit also links with the following NOS:

- NVQ L4 Laboratory and Associated Technical Activities (LATA).

Essential requirements

Delivery

This unit differs from *Unit 6: Project for Applied Science* in that it must be carried out in the workplace and gives credit for work-based activity. The work used for this unit must not be used for either *Unit 6: Project for Applied Science or Unit 31: Work-based Experience*. This *Work-based Investigation* unit places greater emphasis on record keeping, negotiating skills and autonomy.

For learning outcome 1, learners must demonstrate that they can plan a work-based project in cooperation with their supervisors. All learners require a named and suitably qualified industrial supervisor as well as an academic supervisor. The planning stage is crucial and should be carried out jointly by the learner and both supervisors. Supervisors should agree protocols jointly for monitoring learner performance and independence of effort. The chosen topic may be part of a team investigation but sufficient documentation must be kept to clearly demonstrate the individual work of each learner.

For learning outcome 2, learners must keep a dated, day-to-day logbook listing details of all work undertaken and results obtained. Logbook entries must be completed either during or immediately after each session spent on the topic. The logbook must distinguish clearly between team member results and observations and those undertaken by the individual learner. It should also record details of meetings and discussions with supervisors.

For learning outcome 3 it is envisaged that the industrial supervisor will be mainly responsible for overseeing the project and ensuring that it is carried out safely. The industrial supervisor should have regular meetings with the learner during the experimental period to guide and, where appropriate, comment on the direction of the project. They will also be responsible for ensuring that the learner carries out substantial independent activity.

For learning outcome 4, learners must produce a scientific report and deliver a presentation (preferably PowerPoint) summarising the investigation and its results. The report should be produced in accordance with industrial reporting protocols. Clear guidelines for the style and content of the industrial report should be agreed and documented, but in all cases reports must be produced using a recognised scientific format. Suggestions for further work should relate to minimising errors, extending the topic area, confirming or supporting conclusions etc.

Assessment

The work used for this unit may be part of the learner's normal workload or an activity designed specifically to deliver the required evidence, or a combination of the two. In either case, the negotiation and planning required for learning outcome 1 must be completed and agreed before detailed practical work begins. The process of the work and its recording for learning outcomes 2 and 3 should follow normal site practices as closely as possible.

The format of the final report for learning outcome 4 should be determined at the planning stage. Supervisors must set a deadline to see a draft version of the early sections (not the whole report), and provide feedback on these. Amendment and completion of the final report should then take place without further assistance or comment from either supervisor. The presentation should be made to supervisors and fellow learners and may or may not include peer assessment. Input from fellow employees is encouraged. If the presentation is to be used as evidence for higher grading criteria then minimum guidance should be given.

Resources

The work for this unit will normally be achievable within the resource constraints of the employer. Additional use of resources at the centre may be appropriate in specific cases. For example laboratory facilities or resources to develop the report and/or presentation.

Employer engagement and vocational contexts

Work for this unit should be carried out in the workplace under the direct supervision of the works supervisor, in consultation with the academic supervisor.

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Unit 9: Neurophysiology and Homeostatic Control of the Human Body

Unit code: Y/601/0224

Level: 5

Credit value: 15

Aim

This unit provides learners with an understanding of cellular communication via the central nervous system, homeostatic control mechanisms and how the human body organ systems maintain a constant internal environment.

Unit abstract

The ability to utilise underpinning knowledge and apply theoretical concepts to the practical elements of human physiology is fundamental for learners at this level of study.

Neurophysiology covers the nervous function ranging from individual nerve cells to the complex behaviours of the central nervous system. Additionally, the nervous system not only functions at the cellular and system levels, but also at a mechanistic level.

This unit provides learners with an understanding of cellular communication and homeostasis in the human body. Homeostasis is a function that maintains natural balances within the body. It is the ability, or tendency, of an organism or cell to maintain internal equilibrium by adjusting its physiological processes.

The unit considers the role of the central nervous system in communicating between tissues and organs. Detailed features of a neurone are discussed and learners will study the function of the central nervous system and consider how homeostatic control mechanisms are regulated.

Learning outcomes

On successful completion of this unit a learner will:

1 Understand the processes of nervous communication between distinct tissues and organs

2 Understand the components of the nervous system and homeostatic control

3 Understand the coordinated activity of organ systems in the maintenance of a constant internal environment.

Unit content

1 Understand the processes of nervous communication between distinct tissues and organs

Central nervous system: brain (cerebral hemispheres, hypothalamus, cerebellum and medulla oblongata); spinal cord (tracts and nuclei)

Structure of an individual neurone: dendrites; cell body; axon; terminal; sensory, motor neurones; interneurones; ionic basis of the resting membrane potential

Formation and transmission of an action potential: the all-or-none principle; initiation and propagation; saltatory conduction; synapse and synaptic transmission; principle of spatial and temporal summation

2 Understand the components of the nervous system and homeostatic control

Central nervous system: brain eg cerebrospinal fluid (CSF), cerebrum, hypothalamus, medulla oblongata, pons, the meninges (dura mater, arachnoid mater, pia mater); spinal cord eg vertebrae, transverse and spinal processes, spinal nerves, sensory (dorsal) roots, motor (ventral) root, dermatones

Peripheral nervous system: somatic nervous system (reflex arcs, efferent nerves, motor end plate, synapse, neurons, sensory organs, skeletal muscle); autonomic nervous system (sympathetic and parasympathetic activity)

Reflex arcs: monosynaptic and polysynaptic

Endocrine system: endocrine glands (pituitary, pancreas, ovaries, testes, thyroid, adrenal, hypothalamus); roles

Homeostatic control: positive and negative feedback mechanisms; homeostatic imbalance

3 Understand the coordinated activity of organ systems in the maintenance of a constant internal environment

Thermoregulation: body temperature; hypothermia/hyperthermia; the role of skin in temperature regulation

Osmoregulation: structure of the kidney (the nephron, glomerulus and Bowman's capsule, proximal convoluted tubule, loop of Henle, distal convoluted tubule); the influence of antidiuretic hormone (ADH); the role of osmoreceptors in the hypothalamus

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Learning outcomes and assessment criteria

Learning outcomes **On successful completion of this unit a learner will:**	Assessment criteria for pass **The learner can:**
LO1 Understand the processes of nervous communication between distinct tissues and organs	1.1 explain the structure of the central nervous system 1.2 explain the structure of the nerve cell 1.3 discuss the generation of a resting membrane potential 1.4 explain the formation and transmission of an action potential
LO2 Understand the components of the nervous system and homeostatic control	2.1 review the key functions of the central nervous system 2.2 review the key features of the peripheral nervous system and compare the structure of a monosynaptic (stretch reflex) and a polysynaptic reflex arc 2.3 discuss the relationship between the nervous system and the endocrine system 2.4 assess two different ways in which the body uses the nervous and endocrine system to gain homeostatic control
LO3 Understand the coordinated activity of organ systems in the maintenance of a constant internal environment	3.1 explain mechanisms of temperature regulation 3.2 review the process of osmoregulation.

Guidance

Links

This unit has particular links with the following units within this qualification:

- Unit 1: Cell Biology
- Unit 2: Biochemistry of Macromolecules and Metabolic Pathways
- Unit 12: Pharmacological Principles of Drug Actions
- Unit 13: The Immune Response
- Unit 14: Infectious Diseases
- Unit 15: Medical Microbiology.

Essential requirements

Delivery

The use of practical work throughout each of the three learning outcomes is highly recommended. Learners should use clinical and/or fitness testing procedures in order to fully understand how the body responds to specific stimuli.

Assessment

In terms of assessment, the learning outcomes can be treated separately, although an integrated approach to delivery is possible. Assessment evidence may be in the form of assignments, laboratory reports, or practical investigations.

Resources

Learners will need access to well-equipped laboratory facilities, technical support, library and ICT resources.

Employer engagement and vocational contexts

Visits to laboratories and employers engaged in neurophysiological practice would facilitate learner understanding of the concepts developed in this unit. The use of research scientists as guest speakers would also put some theoretical aspects into context.

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Unit 10: Molecular Biology and Genetics

Unit code: D/601/0225

Level: 5

Credit value: 15

Aim

This unit enables learners to understand the processes responsible for the maintenance, transmission and expression of genetic information at a molecular level and carry out experimental techniques associated with them.

Unit abstract

In recent times there has been a revolution in terms of understanding the processes responsible for the maintenance, transmission and expression of genetic information at the molecular level. Molecular biology seeks to explain the relationships between the structure and function of biological molecules and how these relationships contribute to the operation and control of biochemical processes. This unit will enable learners to understand the structure and function of macromolecules and macromolecular complexes of DNA, RNA and protein. The unit will also enable learners to understand the processes of replication, transcription and translation, and how gene regulation is controlled. Learners will be able to predict how alleles are transferred within populations. The factors that alter the gene pool of a population and contribute to variation within the population will also be discussed. The unit enables learners to understand the human genome and proteome projects and their applications.

The new experimental technologies involved in manipulating DNA, RNA and protein not only yield fundamental information about these molecules, but also have important practical applications. For example, in the development of new and safe products such as therapeutics and vaccines, in the diagnosis of genetic disease and in disease therapy. This unit enables learners to learn how to manipulate genetic material in vitro and gives them the opportunity to profile and amplify DNA. Learners will gain an understanding of genetic engineering and its importance.

The unit also provides learners with the opportunity to explore bioinformatics methods and their applications.

Learning outcomes

On successful completion of this unit a learner will:

1 Understand the processes of information transfer from DNA to protein

2 Understand factors involved in the regulation of gene expression

3 Be able to carry out experimental techniques involved in manipulating DNA, RNA and protein

4 Be able to determine patterns of inheritance

5 Understand how changes in gene frequencies result in changes in populations.

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Unit content

1 Understand the processes of information transfer from DNA to protein

Sub-cellular organelles: nucleus; cytoplasm; endoplasmic reticulum; ribosomes

Organisation of Deoxyribonucleic acid (DNA): nucleotide sub-units of DNA; nitrogenous bases; phosphodiester linkages; formation of the double helix; formation of chromosomes; introns; exons

Protein structure: amino acids; peptide bond; primary structure; secondary structure; tertiary structure; quaternary structure

Structure of Ribonucleic acid (RNA): ribose; uracil; messenger RNA, codon, transfer RNA

Transcription of DNA: RNA polymerase, promoter, upstream; downstream; termination signals; leader sequence; coding sequence; stop codon; messenger RNA processing

Translation of messenger ribonucleic acid (mRNA): properties of transfer RNA; initiation; elongation; termination

2 Understand factors involved in the regulation of gene expression

Operons: promoters; operators; repressor genes

Negative and positive control: negative control (structure of the lactose operon, inducible genes, inducer molecules, repressible genes, co-repressor); positive control (structure of the tryptophan operon, catabolite gene activator protein-cyclic adenosine monophosphate (CAP-cAMP) complex)

3 Be able to carry out experimental techniques involved in manipulating DNA, RNA and protein

DNA replication: RNA primer; origin of replication; replication fork; DNA polymerase; leading strand; lagging strand; Okazaki fragments; DNA ligase

DNA and mRNA isolation: DNA extraction eg agarose gel electrophoresis, polyacrylamide gel electrophoresis, sodium dodecyl sulfate polyacrylamide gel electrophoresis (SDS-Page), DNA fingerprinting, cesium chloride gradient, affinity chromatography, western blot, southern blot, northern blot

Polymerase chain reaction (PCR): PCR cycle; template; primers; enzymes; optimisation; variations

Production of recombinant DNA: restriction endonucleases; ligase; reverse transcriptase

Transformation: complementary DNA (cDNA); host; cloning vectors; bacteriophages; plasmid

Bioinformatics: methods eg gene prediction software, sequence alignment software, BLAST program

4 Be able to determine patterns of inheritance

Terminology: gene; allele; locus; homozygous; heterozygous; dominant; recessive; genotype; phenotype

Exemplar crosses: monohybrid; punnet square; dihybrid; autosomal linkage; two-point test cross; frequency of crossing over; chi-square test; sex-linked traits; multiple alleles; co-dominance; pleitropy; epistasis; polygenic inheritance

Inherited diseases: autosomal recessive traits eg phenylketonuria (PKU), cystic fibrosis, sickle cell anaemia; autosomal dominant traits eg Huntington's disease, pedigree analysis

5 Understand how changes in gene frequencies result in changes in populations

Mutations: base substitution mutations; missense mutations; nonsense mutations; frameshift mutations; transposons; hotspots; mutagens; mutations and disease

Hardy-Weinberg principle: gene pool; allele frequency; genetic equilibrium; five conditions for Hardy-Weinberg equilibrium; application of Hardy-Weinberg principle

Genetic drift: explanation of genetic drift; genetic bottlenecks; the founder effect; gene flow

Natural selection: stabilising; directional; disruptive; polymorphism; heterozygote advantage; frequency dependent selection

Human genome project: history of the human genome project; bioinformatics and evolution; ethical issues

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Learning outcomes and assessment criteria

Learning outcomes **On successful completion of this unit a learner will:**	Assessment criteria for pass **The learner can:**
LO1 Understand the processes of information transfer from DNA to protein	1.1 explain the role of subcellular organelles 1.2 describe the organisation of DNA in prokaryotic and eukaryotic cells 1.3 review the structure of proteins and RNA 1.4 explain the process of transcription and translation
LO2 Understand factors involved in the regulation of gene expression	2.1 discuss the structure of operons 2.2 explain the features of positive and negative control
LO3 Be able to carry out experimental techniques involved in manipulating DNA, RNA and protein	3.1 explain the process of DNA replication 3.2 safely perform techniques to isolate DNA and mRNA 3.3 describe the Polymerase Chain Reaction 3.4 illustrate the stages in the production of recombinant DNA 3.5 carry out genetic transformations, using safe practices 3.6 use bioinformatics software to interpret data
LO4 Be able to determine patterns of inheritance	4.1 explain the terminology used in determining patterns of inheritance 4.2 construct appropriate crosses from information provided to show patterns of inheritance 4.3 relate inherited diseases to patterns of inheritance
LO5 Understand how changes in gene frequencies result in changes in populations	5.1 explain how mutations provide the variation necessary for evolution to occur within a given species 5.2 assess the significance of the Hardy-Weinberg principal as it relates to evolution 5.3 explain how in genetic drift random events change allele frequencies 5.4 discuss factors influencing natural selection using appropriate examples 5.5 discuss the human genome project.

Guidance

Links

This unit has particular links with the following units within this qualification:

- Unit 1: Cell Biology
- Unit 2: Biochemistry of Macromolecules and Metabolic Pathways
- Unit 3: Physiology of Cellular Systems in Animals
- Unit 4: Laboratory Techniques for Applied Biology
- Unit 5: Analysis of Scientific Data and Information
- Unit 7: Laboratory Management
- Unit 11: Applied Genetics of Industry, Agriculture and Medicine
- Unit 12: Pharmacological Principles of Drug Actions
- Unit 13: The Immune Response System
- Unit 14: Infectious Diseases
- Unit 15: Medical Microbiology.

Essential requirements

Delivery

Unit delivery must emphasise how molecular biology yields fundamental information about the structure and function of biological molecules. How manipulating DNA, RNA and protein has practical applications in the development of therapeutics, vaccines and foodstuffs, and in the diagnosis of genetic disease and in gene therapy must be covered. Digital presentations, illustrations and CD-ROMs should be available to illustrate the structure of DNA, RNA, proteins and operons. Digital presentations should also be used to illustrate the processes of transcription, translation, operon control and DNA replication.

Experimental work has been central to developments in molecular biology and genetics, and as a result must form the basis of delivery where possible. Where complex experiments may not be feasible, case studies could be used. Group resource-based research work and learner-led seminars could also be helpful.

The use of case histories must be integrated where possible into laboratory investigations. Diagnostic kits should be used as part of the laboratory programme. Tutors must emphasise the importance of health and safety throughout the delivery and assessment of learning outcome 3. Learners must understand the importance of adhering to laboratory health and safety guidelines when working with serum and live tissue. Practical tasks must include risk analyses consistent with COSHH guidelines.

Industry links, work placements and visits from personnel with technical expertise in using molecular biology techniques would enhance delivery of this unit.

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Assessment

Learning outcome 1 involves understanding the structure of DNA, RNA and protein. It also involves understanding how the genetic code on DNA is used to produce proteins.

Learning outcome 2 involves understanding how gene transcription in prokaryotes is controlled. Evidence could include a time-constrained assessment.

Learning outcome 3 involves carrying out laboratory investigations, handling specimens safely, interpreting results and applying them to case histories or medical situations. The techniques used will depend on the equipment available in the centre but must include DNA extraction, electrophoresis, genetic transformation, comparative proteomics and BLAST searches as a minimum. Learners may provide evidence by performing appropriate molecular biology techniques and interpreting the results. Where equipment is not available, for example thermocyclers for PCR, evidence could include general reviews, presentations, literature searches and interpretation exercises. Assessor observation records should be completed to confirm achievement.

Learning outcome 4 involves being able to predict patterns of inheritance. Evidence must include carrying out genetic crosses to include monohybrid, dihybrid, two-point test crosses and sex linkage studies. Evidence could also be produced from experimental work involving Drosophila and clover.

Learning outcome 5 involves understanding how changes in gene frequencies result in changes in populations. Evidence can be derived from carrying out Hardy-Weinberg problems. General reviews, literature searches and interpretation exercises are also appropriate for providing evidence. In addition, the completion of comparative proteomics experiments, and the construction of cladograms, can be used to provide evidence.

Resources

Learners require laboratory access, ideally with facilities that enable them to study a reasonable range of common molecular biology methods. Molecular biology teaching kits containing workbooks, review questions and interpretation exercises are now available commercially and should be used where possible.

Learners will need access to appropriate tutorial support and library resources. The use of DVDs, computer teaching programmes and CD ROM simulations of experiments should be encouraged. Learners will also need suitable access to the internet in order to use genetic databases. Visits to centres with molecular biology facilities would be advantageous.

Employer engagement and vocational contexts

Understanding molecular biology and genetics is of fundamental importance in understanding the processes responsible for the maintenance, transmission and expression of genetic information. The new experimental technologies involved in manipulating the molecules associated with the transfer of genetic information and protein expression have many practical applications in the development of therapeutics, vaccines and foodstuffs. They are also valuable tools in the understanding, diagnosis and development of treatments for genetic diseases. The unit gives learners opportunities to appreciate the importance of molecular biology technology as a valuable tool in industry and diagnostic research.

Learners will have an opportunity to learn many of the current molecular techniques and how to use the genetic databases that are now available as a result of the human genome project. Learners will benefit from visiting industrial molecular biology facilities to observe genetic engineering in operation.

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Unit 11: Applied Genetics of Industry, Agriculture and Medicine

Unit code: H/601/0226

Level: 5

Credit value: 15

Aim

This unit enables learners to relate their understanding of molecular biology and genetics to biological applications in agriculture, medicine and industry.

Unit abstract

This unit enables learners to experience and apply Mendelian principles, molecular biology and microbial genetics to relevant areas such as disease and medication, genetic counselling and selective breeding. Molecular techniques will be studied in the context of industry, agriculture and medicine. Learners will also study the positive aspects of genetic manipulation and modification.

The unit provides opportunities to discuss social, cultural, moral, ethical and environmental issues raised by topics such as gene cloning.

The importance of extra-nuclear inheritance and its connection to human disease and alterations in plants is examined. Learners have the opportunity to review, based on previous knowledge, the applications of molecular biology and genetics in plants and animals, which are of importance to society as a whole.

Learning outcomes

On successful completion of this unit a learner will:

1 Understand the application of Mendelian principles

2 Understand molecular biology techniques and their application to industry, agriculture and the medical profession

3 Understand the relationship between microbial genetics and human diseases

4 Understand extra-nuclear genetic principles.

Unit content

1 Understand the application of Mendelian principles

Genetic counselling: autosomal eg Marfan syndrome, Huntingdon Chorea, neurofibromatosis, spinal muscular dystrophy, cystic fibrosis, sickle cell anaemia, thalassaemia, achondroplasia; sex-linked diseases eg Duchenne muscular dystrophy, haemophilia, colour blindness; polygenically controlled diseases eg spina bifida, diabetes mellitus, cleft palate, coronary heart disease, schizophrenia; lethal alleles eg Tay-Sachs disease, brachydactyl; use of pedigree diagrams

Parenthood testing: blood group tests, enzyme tests; deoxyribonucleic acid (DNA) testing

Selective breeding: agricultural uses eg bovine milk yield, multiple births (sheep), rapid growth (chickens, lambs, calves); disease resistance in plants and animals; inbreeding problems eg reduction in gene pool, mutations; selected commercial breeding eg for flower colour, seed viability, animal coat colour, increased crop production; selected breeding eg to eliminate inherited disease (dog hip dysplasia, eye problems in dogs) malformations

2 Understand molecular biology techniques and their application to industry, agriculture and the medical profession

Mapping genetic defects: restricted fragment length polymorphism (RFLP) analysis eg Huntingdon's disease, sickle cell anaemia paternity cases; criminal cases eg to identify DNA source; variable number tandem repeat analysis eg identification of strains of disease in sheep and goats

Forensic science: variable number tandem repeat (VNTR) analysis eg identification of suspect body tissues, genetic fingerprinting

Gene therapy: inherited colour blindness; cystic fibrosis; diabetes mellitus

Protein products from genetically modified organisms: insulin; factor IX; human growth hormone; importance medically and commercially

Genetic modification of higher plants: use of agrobacterium tumifaceans; commercial benefits eg pest resistance, herbicide resistance, yield increases

Ethical issues: value to the public; environmental considerations; toxicity; public opinion

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3 Understand the relationship between microbial genetics and human diseases

Reproductive cycles: fungal eg candida, malassezia furfur, tinea, ergot; bacteria eg staphylococcus aureus, vibrio cholerae, clostridium botulinum; viral eg influenza (Severe Acute Respiratory Syndrome, swine, avian), coxsackie A or B, common cold; bacteriophage eg e.coli and phage T4

Bacterial genetic variation: acquisition of foreign DNA (transformation, conjugation, transduction, recombination eg general, site specific, replicative); antibiotic resistance eg role of plasmids

Mutation: mechanisms eg spontaneous, induced, mutations including nuclear, cytological; mutation rates (implications); types of mutagens – chemical, physical eg x-ray, gamma rays, ultra-violet light

Pathogenicity: human disease eg Acquired Immune Deficiency Syndrome (AIDS), oncogene viruses

4 Understand extra-nuclear genetic principles

Mitochondrion: genome; protein synthesis; maternal inheritance

Chloroplast: genome; protein synthesis; maternal inheritance

Examples of extra-nuclear inheritance: extra-nuclear inheritance eg leaf variegation in Mirabilis jalapa

Extra-nuclear mutations: effect of large amounts of extra nuclear material eg maternal/paternal genes, sperm mitochondria DNA, chloroplast DNA

Extra-nuclear human disease: Kearns-Sayre syndrome; myoclonic epilepsy; Leber's hereditary optic neuropathy (LHON); ragged red fibre

Learning outcomes and assessment criteria

Learning outcomes **On successful completion of this unit a learner will:**	Assessment criteria for pass **The learner can:**
LO1 Understand the application of Mendelian principles	1.1 explain the role of genetic counselling in genetically controlled human diseases 1.2 explain the application of Mendelian principles to genetic risk assessment 1.3 describe the methods used in parental testing 1.4 discuss the use of commercial selective breeding programmes
LO2 Understand molecular biology techniques and their application to industry, agriculture and the medical profession	2.1 review the methods used in mapping genetic defects 2.2 assess the use and application of molecular biological techniques to forensic science 2.3 explain the use of gene therapy in inherited human conditions 2.4 assess the importance of products from genetic modification 2.5 analyse the ethical issues associated with genetic modification
LO3 Understand the relationship between microbial genetics and human diseases	3.1 review the major types of microbial reproductive cycles 3.2 explain the mechanisms involved in prokaryote genetic variation 3.3 analyse the significance of genetic bacterial variation 3.4 explain how the life cycle of a virus is related to its pathogenicity in a human
LO4 Understand extra-nuclear genetic principles	4.1 explain the significance of extra-nuclear inheritance in mitochondria and chloroplast 4.2 compare and contrast Mendelian and extra-nuclear modes of inheritance 4.3 review human diseases caused by extra-nuclear inheritance 4.4 evaluate the influence of extra-nuclear mutations on human diseases.

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Guidance

Links

This unit has particular links with the following units within this qualification:

- Unit 1: Cell Biology
- Unit 2: Biochemistry of Macromolecules and Metabolic Pathways
- Unit 4: Laboratory Techniques for Applied Biology
- Unit 10: Molecular Biology and Genetics
- Unit 15: Medical Microbiology.

Essential requirements

Delivery

Using practical work supported by a sound theoretical knowledge will enable learners to gain the maximum benefit from this unit.

Learning outcome 1 lends itself to theoretical input from tutors and guest speakers plus case studies and role play in genetic counselling. Practical work can be carried out using commercial and laboratory testing kits. Ideally, selective breeding should be a practically-based exercise, but where various constraints prevent this, case studies, discussion seminars and 'real example' problem-solving exercises will help with meeting this learning outcome.

Learning outcome 2 is best delivered through learners experiencing molecular biology analysis techniques. If this is not possible then laboratory visits are essential. Gene therapy can be covered as part of genetic counselling in learning outcome 1. Protein production and genetic modification can be combined with discussions on ethics, providing theoretical work has been carried out first. In this way learners can discuss GM organisms and ethics from an informed baseline.

Learning outcomes 3 and 4 must be delivered through a combination of practical work and theory with the emphasis on applications. Human diseases are mentioned in both learning outcomes, and learners should be aware that knowledge of bacterial genetic variation and extra-nuclear inheritance is of great benefit when developing medicines to combat disease.

Assessment

Practical work must underlie much of the assessment. If group work is used care must be taken to ensure each learner has carried out and presented enough work to meet the unit assessment criteria on an individual basis.

Resources

Learners need access to a well-equipped biology laboratory and technical support. Visits to university and commercial laboratories are essential and guest speakers will enhance learners' understanding of the applications covered in this unit.

Employer engagement and vocational contexts

Visits to laboratories and contact with employers engaged in molecular biology and genetics are essential parts of this unit. The use of research scientists and employers as guest speakers will put theoretical work into context. Tutors should be aware of the sensitivity shown by some employers in this area of work especially where genetic modification and selective breeding are concerned. Some laboratories will not accept visitors because of the biohazards, strict hygiene precautions and security measures in place, but speakers from these institutions may be available.

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Unit 12: Pharmacological Principles of Drug Actions

Unit code: K/601/0227

Level: 5

Credit value: 15

Aim

This unit enables learners to analyse clinical data and understand the pharmacokinetic processes of diseases affecting the nervous system and the subsequent effects of drug treatments.

Unit abstract

This unit covers key areas of pharmacology enabling learners to gain an understanding of the principles of drug action and the interactions that occur between chemical substances and living organisms. Prior knowledge and understanding of human physiology are essential.

The unit introduces learners to pharmacokinetic principles allowing them to practically analyse and calculate clinical data including rates of absorption and excretion. Learners will then explore factors which affect pharmacokinetic processes and the drug/food and drug/drug interactions which arise from pharmacokinetic mechanisms.

Learners will gain an understanding of the transmission of nerve impulses and the effects of drugs on transmission. Finally, they will study the function of the immune system, gaining an appreciation of the drugs that stimulate and suppress it.

Learning outcomes

On successful completion of this unit a learner will:

1 Be able to analyse and calculate clinical data

2 Understand factors that affect pharmacokinetic processes

3 Understand the transmission of nerve impulses, diseases that affect transmission and their modification by drugs

4 Understand the function of the immune system and how drugs may affect it.

Unit content

1 Be able to analyse and calculate clinical data

Pharmaceutical data: graphical representations of plasma concentration against time for a drug administered by iv bolus, single oral dose, multiple oral dose, continuous iv infusion

Rates of absorption and excretion: the use of semi-log plots; calculation of rates of absorption and excretion, half-life, fraction absorbed and total amount absorbed

2 Understand factors that affect pharmacokinetic processes

Absorption, *distribution*, *metabolism and excretion*: factors eg food, diseases, age, other drugs, blood flow, lipid content, renal and hepatic impairment

Dosage regime: terminology; effect of factors eg food, disease, age, other drugs, blood flow, lipid content; recommendations used in the British National Formulary (BNF)

Interactions: drug/food and drug/drug interactions arising from pharmacokinetic mechanisms

3 Understand the transmission of nerve impulses, diseases that affect transmission and their modification by drugs

Transmission of nerve impulses: the structure and function of nerves of the central nervous system, the autonomic nervous system and voluntary nerves; movement of ions in the transmission process; the synapse; receptors; role of transmitter substances; enzymic breakdown; re-uptake

Effects of drugs: on transmission and treatment of disease; central nervous system eg Parkinson's disease, depression; voluntary nervous system eg myasthenia gravis; other disease states or treatments which involve transmitter substances or their modification eg use of beta-blockers, beta-receptor agonists, anticholinergics

4 Understand the function of the immune system and how drugs may affect it

Defence mechanism: non-specific and specific mode of action of antigens; vaccines and immunosuppressant drugs in relation to specific and non-specific defence mechanisms

Use of drugs: immune system stimulation and suppression antigens; corticosteroids; cyclosporin; use in autoimmune diseases; organ transplants and immunocompromised patients

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Learning outcomes and assessment criteria

Learning outcomes **On successful completion of this unit a learner will:**	Assessment criteria for pass **The learner can:**
LO1 Be able to analyse and calculate clinical data	1.1 plot pharmacokinetic data for given drug doses 1.2 calculate rates of absorption and excretion, half-life, total amount absorbed and fraction absorbed
LO2 Understand factors that affect pharmacokinetic processes	2.1 discuss factors affecting absorption, distribution, metabolism and excretion of drugs 2.2 explain how factors influence dosage regimes, including those for patients with renal and hepatic impairment 2.3 explain types of drug interactions arising from pharmacokinetic mechanisms
LO3 Understand the transmission of nerve impulses, diseases that affect transmission and their modification by drugs	3.1 explain key stages in the transmission of nerve impulses 3.2 explain the effects of drugs on transmission of nerve impulses and the treatment of disease
LO4 Understand the function of the immune system and how drugs may affect it	4.1 explain functions of defence mechanisms 4.2 discuss the use of drugs that stimulate and suppress the immune system.

Guidance

Links

This unit has particular links with the following units within this qualification:

- Unit 1: Cell Biology
- Unit 2: Biochemistry of Macromolecules and Metabolic Pathways
- Unit 4: Laboratory Techniques in Applied Biology
- Unit 5: Analysis of Scientific Data and Information
- Unit 9: Neurophysiology and Homeostatic Control of the Human Body
- Unit 13: The Immune Response System.

Essential requirements

Delivery

The delivery of pharmacokinetic principles (learning outcome 1) could start with a review of graph plotting, and the use of semi-log paper. Derivation of equations could be illustrated practically using examples. Software could be used to illustrate trends, patterns and exceptions.

To explore the four areas of absorption, distribution, metabolism and excretion, (learning outcome 2) learners, in groups, could draw on a flipchart the processes they think happen following the ingestion of for example paracetamol tablets. Learners could then use this example as a basis for a thorough coverage of factors affecting pharmacokinetic processes.

Learners could individually research BNF dosage regimes for common drugs, for example via a group discussion of a commonly used antibiotic, and then share this information with the class.

Drug interactions can be delivered through a question and answer session, as learners should now have the understanding to deduce the reasons for many interactions. A class exercise using information sources could be carried out. Learners need to explain three types of drug interactions arising from pharmacokinetic mechanisms.

For learning outcome 3, learners could produce and present a scientific poster to illustrate the processes involved in the transmission of nerve impulses. DVDs/videos could be used to illustrate the effects drugs have on the transmission of diseases such as Parkinson's and the treatment of diseases.

DVDs/videos are available which cover the function of the immune system and autoimmune disease. Learners could prepare and deliver a presentation to highlight the use of drugs that stimulate and suppress the immune system, supported by a group question and answer session.

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Assessment

Evidence for learning outcome 1 may be an assignment, based on producing graphs on plain and semi-log paper, as appropriate, from clinical data, extracting information from these graphs and carrying out calculations based on this information.

Evidence for learning outcome 2 may be a report reviewing factors affecting absorption, distribution, metabolism and excretion of drugs, short answers to problems based on clinical data, suggested dosage regimes and written explanations for a range of drug/food and drug/drug interactions.

Evidence for learning outcome 3 may be an annotated diagram of the theory of nerve transmission and the role of transmitter substances. Evidence may also be in the form of a written account of disease states and their treatment.

Evidence for learning outcome 4 may be presentations on the use of drugs that act by modifying the immune system.

Resources

Learners will need access to library and information technology resources, tutorial and technical support, molecular models and laboratory facilities to demonstrate experiments.

Employer engagement and vocational contexts

Learners would benefit from visits to industrial laboratories to observe practical diagnostic techniques in operation.

Unit 13: The Immune Response System

Unit code: M/601/0228

Level: 5

Credit value: 15

Aim

This unit develops an understanding of the function and manipulation of the immune system and its abnormalities. Learners also acquire skills in immunological techniques.

Unit abstract

The ability to understand and utilise the immune response is of utmost importance for people working in biomedical science to ensure the effective control, treatment and prevention of disease. Understanding the immune system and its constituents enables medical personnel to understand and control many autoimmune disorders. Learners will appreciate the role the skin, mucus membranes, soluble substances such as cytokines and complement, and the inflammatory response play in defending the body against disease. Learners will also appreciate the importance of the leukocyte group and antibodies in preventing and combating invasion by foreign antigens.

The unit will enable learners to understand the difference between primary and secondary immune responses and active and passive immunity. Learners will understand how to raise vaccines and how to use elements of the immune response as therapeutic agents. The unit also provides an opportunity to appreciate the role of the immune system in tissue transplantation.

Learning outcomes

On successful completion of this unit a learner will:

1 Understand the innate immune response

2 Understand the acquired immune response

3 Understand the methods used to manipulate the immune response

4 Understand the mechanisms and consequences of an abnormal immune response

5 Be able to carry out a range of immunological techniques used to study the immune system.

Unit content

1 Understand the innate immune response

Skin and mucus membranes: structure of the skin; langerhans and granstein cells; keratin; sebum; perspiration; lysozyme; mucus; cilia escalator; lacrimal apparatus; urine

Complement system: complement; complement cascades

Cytokine network: interferons; interleukins; tumour necrosis factors

Leukocytes: granulocytes (neutrophils, basophils, eosinophils); monocytes; macrophages; dendritic cells

Inflammation and phagocytosis: process of inflammation; mononuclear phagocytic system; mechanism of phagocytosis

2 Understand the acquired immune response

Lymphatic system: primary and secondary lymphoid organs; the lymph node

Lymphocytes: B lymphocytes; cytotoxic T cells; helper T cells; suppressor T cells; natural killer cells

Antigen presentation: major histocompatibility complex (MHC); role of macrophages; foreign antigen – MHC complexes

Antibody (immunoglobulin) molecules: prevalence and function of the five classes of antibody; structure of a typical antibody molecule; antibody function

Antibody mediated response: activation of B cells; role of interleukins and T cells; clonal selection; plasma cells; memory cells

Cell mediated response: activation of T cells; cytotoxic T cells; substances secreted by cytotoxic T cells to include perforins, granzymes and lymphotoxins; memory cells

3 Understand the methods used to manipulate the immune response

Vaccination: primary and secondary response; active immunity; passive immunity; methods of raising vaccines

Transplantation: issues eg rejection, manipulation

Clinical uses of the immune response: applications eg tumour immunology, cytokines as therapeutics

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4 Understand the mechanisms and consequences of an abnormal immune response

Hypersensitivity reactions: Type I (allergic reactions); Type II (cytotoxic reactions); Type III (immune complex reactions); Type IV (cell mediated reactions)

Autoimmunity: responses to self-antigens eg multiple sclerosis, Addison's disease, type 1 diabetes, rheumatoid arthritis, Graves disease

Immune deficiencies: congenital and acquired eg DiGeorges syndrome, Wiskott-Aldrich Syndrome, X-linked Agammaglobulinemia (XLA), selective Immunoglobulin A (IgA) deficiency, Severe Combined Immunodeficiency (SCID), Acquired Immune Deficiency Syndrome (AIDS)

5 Be able to carry out a range of immunological techniques used to study the immune system

Methods to study constituents of the immune system: flow cytometry; enzyme-linked immunosorbent assay (ELISA) to include detecting cytokines using beads attached to antibodies; intracellular cytokine analysis; magnetic cell sorters (MACS); cell sorters

Immunological molecules as diagnostic tools: ELISA; immuno-cytochemistry; complement fixation test; immunodiffusion test; tetramer/pentamer technology

Diagnostic immunological techniques: agglutination reactions; white blood cell counts; ELISA; immunodiffusion test

Case studies: apply results of diagnostic procedures to patient scenarios and case studies

Learning outcomes and assessment criteria

Learning outcomes **On successful completion of this unit a learner will:**	Assessment criteria for pass **The learner can:**
LO1 Understand the innate immune response	1.1 explain the role of the skin and mucus membranes in the inflammatory response 1.2 describe the complement system 1.3 explain the importance of the cytokine network as an integral part of the immune system 1.4 identify the leukocytes involved in the innate response 1.5 explain the major phases of the inflammatory response, including phagocytosis
LO2 Understand the acquired immune response	2.1 describe the locations and functions of lymphatic tissues 2.2 identify the types of lymphocytes and the role they perform in the acquired immune response 2.3 explain how antigen presentation occurs via MHC interaction 2.4 review the structures and functions of antibody molecules 2.5 explain the antibody mediated and cell mediated immune response
LO3 Understand the methods used to manipulate the immune response	3.1 discuss the strategies used in active and passive vaccination 3.2 assess the issues associated with tissue transplantation 3.3 explain the potential clinical uses of components of the immune system
LO4 Understand the mechanisms and consequences of an abnormal immune response	4.1 explain the differences between the four types of hypersensitivity reaction 4.2 describe autoimmune responses using a range of clinical examples 4.3 review examples of congenital and acquired immune deficiencies

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Learning outcomes **On successful completion of this unit a learner will:**	Assessment criteria for pass **The learner can:**
LO5 Be able to carry out a range of immunological techniques used to study the immune system	5.1 describe the methods used to study the major constituents of the immune system 5.2 review the methods of using immunological molecules as diagnostic tools 5.3 safely carry out practical diagnostic immunological techniques and apply results to case studies of patients.

Guidance

Links

This unit has particular links with the following units within this qualification:

- Unit 1: Cell Biology
- Unit 2: Biochemistry of Macromolecules and Metabolic Pathways
- Unit 3: Physiology of Cellular Systems in Animals
- Unit 4: Laboratory Techniques for Applied Biology
- Unit 5: Analysis of Scientific Data and Information
- Unit 7: Laboratory Management
- Unit 9: Neurophysiology and Homeostatic Control of the Human Body
- Unit 10: Molecular Biology and Genetics
- Unit 12: Pharmacological Principles of Drug Actions
- Unit 14: Infectious Diseases
- Unit 15: Medical Microbiology.

Essential requirements

Delivery

Delivery must emphasise the relationship between the strategies the body uses to prevent and combat infection and the strategies used by pathogenic micro-organisms to cause disease.

Rapid diagnostic assays or kits must be used as part of the laboratory programme. Tutors must emphasise the importance of health and safety throughout delivery and assessment of learning outcome 5 (immunological techniques). Learners must understand the importance of adhering to laboratory health and safety guidelines when working with blood serum and live tissue. Practical tasks must include risk analyses consistent with COSHH guidelines.

Industry links, work placements and visits from personnel with technical expertise in using immunological diagnostic techniques would enhance delivery of this unit.

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Assessment

Learning outcomes 1 and 2 involve gaining the basic knowledge of the innate and acquired immune responses. The microscopic examination of different leukocytes must be carried out and written evidence of this provided.

For learning outcome 3, learners must understand how the immune response can be manipulated to prevent disease and confer immunity. Learners also need to understand the role of the immune response in organ transplantation and the potential of elements of the immune systems to be used as clinical tools.

Learning outcome 4 requires learners to understand the mechanisms and consequences of an abnormal immune response. Evidence could be in the form of presentations on individual autoimmune responses and congenital and acquired deficiencies.

Learning outcome 5 involves learners carrying out laboratory investigations, handling medical specimens safely, interpreting results from a range of diagnostic methods and applying them to medical situations or case histories. A differential white cell count, agglutination reactions, immunodiffusion and ELISA must be performed. The techniques used will depend on the equipment available in the centre but must encompass serological methods and the use of manufactured diagnostic kits. Learners must provide evidence of performing the appropriate immunological techniques, supported by assessor observation records. Evidence of applying laboratory results to patient scenarios must also be provided. Learning outcome 5 requires learners to become familiar with the techniques used to study the constituents of the immune system, including flow cytometry.

Resources

Learners require access to a laboratory with suitable equipment for carrying out immunological techniques.

Employer engagement and vocational contexts

This unit gives learners the opportunity to understand the immune system and to carry out immunological techniques. Learners will have opportunities to appreciate the importance of immunology as a valuable tool in diagnostic research. Learners would benefit from visits to industrial immunology facilities to observe the practical applications of immunology in operation. Learners would also benefit from visits to centres with flow cytometry and magnetic cell sorting facilities.

Unit 14: Infectious Diseases

Unit code: M/601/0231

Level: 5

Credit value: 15

Aim

This unit provides an understanding of infection and disease and uses the dynamic relationship between micro-organism and host to examine infectious microbial strategies. Learners also develop skills in diagnostic techniques used to identify pathogens.

Unit abstract

The ability to investigate and study the underlying cause, effect and treatment of infectious diseases is of utmost importance in the biomedical sciences industry in order to ensure the effective control of pandemic diseases. This unit introduces learners to the underlying principles of specimen collection and diagnostic microbiology.

Learners will examine the features of micro-organisms which contribute to microbial infection and infectious diseases in the human body. They will become familiar with diagnostic and microbiology techniques through carrying out a range of laboratory-based investigations.

This unit also enables learners to examine the host-parasite relationship and the nature of pathogenesis. Learners will have the opportunity to explore how micro-organisms can evade the immune response, the resulting damage that occurs to the body during disease processes, and how diseases spread throughout the population.

This unit gives learners opportunities to carry out scientific investigations in the laboratory, using scientific equipment and diagnostic techniques to examine specimens in order to accurately identify the virulence factors of a range of micro-organisms. Integral to scientific practical investigations is the need to work safely and accurately, adhering to laboratory safety guidelines and protocol.

Learning outcomes

On successful completion of this unit a learner will:

1 Understand host-microbial relationships

2 Understand microbial features that contribute to infection at different body sites

3 Understand the virulence factors for major microbial diseases

4 Be able to use diagnostic techniques to identify pathogens.

Unit content

1 Understand host-microbial relationships

Normal microbiota: bacteria eg vaginal (lactobacilli), oral (streptococci, staphylococci), skin (actinobacteria, firmicutes, proteobacteria, bacteriodetes); fungi in gut eg candida; on skin eg malassezia; archaea eg methanogens; relationship with host eg commensals, mutualistic, pathogenic, symbiotic

Normal gut flora: roles eg fermentation, triggering immune responses, prevent growth of harmful species, production of biotin and vitamin K, production of hormones involved in fat storage causing disease (cancer, infections)

Pre-disposition factors to infection: immunosuppressant drugs eg cancer treatments; genetics eg predisposition to ascariasis, malarial infection

2 Understand microbial features that contribute to infection at different body sites

Microbial strategies to avoid the first line of defence: adherence to host cells; contribution of capsules and cell walls to pathogenicity

Evasion of the immune response: microbial strategies to evade phagocytosis; complement; adaptive immune response

Damage to host cells: enzymes; direct damage; toxin production; cytopathic effects of viral infections

Innate immune responses: mechanisms eg receptors on epithelial cells (toll like receptors), cytokines, natural killer cells (triggering apoptosis), phagocytes, complement activation (phagocytic action), antimicrobial peptides

3 Understand the virulence factors for major microbial diseases

Virulence factors: adherence and colonisation; invasions; capsules and surface components; endotoxins; exotoxins; siderophores

Microbial diseases: skin infections eg bacterial (impetigo, folliculitis, furuncle), fungal eg tinea (ringworm), candidiasis, viral (herpes simplex, shingles, warts); wound infections; respiratory tract infections eg upper respiratory tract infections (common cold, croup, pharyngitis, laryngitis), lower respiratory tract infections (pneumonia, influenza, bronchitis, whooping cough); fungal diseases of the respiratory tract; diseases of the nervous system eg meningitis, encephalitis, brain and spine abcess, poliomyelitis, syphilis; diseases of the urinogenitary tract eg urinary tract infections, gonorrhoea, syphilis, herpes simplex, papilloma virus, chlamydia; infections of the gastrointestinal tract, diarrhoeal diseases eg food poisoning, gastroenteritis

Global infections: effect on human population eg measles, mumps, influenza (bird flu, swine flu), haemorrhagic fever (ebola virus)

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4 Be able to use diagnostic techniques to identify pathogens

Diagnostic procedures: specimens eg collection of samples from blood, urine, faeces, wounds and abscesses, genital specimens; culture of anaerobes; transport of specimens; handling of pathogens; laboratory safety; protocols; receiving and analysing specimens; which tests to use; quality control

Identification: techniques eg growth-dependent identification methods, polymerase chain reactions (PCR), precipitation reactions, agglutination reactions, neutralisation tests, complement fixation test, enzyme-linked immunosorbent assay (ELISA), radioimmunoassay (RIA), fluorescent antibodies

Data: report eg written, graphical, charts, comparison with the norm, machine error, accuracy of diagnostic techniques

Report: appropriate presentation of results eg graph, chart, written; reliability and limitations of tests used; inclusion of relevant factors if appropriate eg contamination, significance of pathogen levels, deterioration of specimen, levels of false negative/false positive results, sensitivity of tests used

Molecular methods: for diagnosis eg isothermal techniques, nucleic acid hybridisation techniques, nucleic acid probes, diagnostic virology, microarray, genotyping

Learning outcomes and assessment criteria

Learning outcomes **On successful completion of this unit a learner will:**	Assessment criteria for pass **The learner can:**
LO1 Understand host-microbial relationships	1.1 describe the locations of normal microbiota 1.2 discuss the roles of normal gut flora 1.3 discuss predisposing factors for disease
LO2 Understand microbial features that contribute to infection at different body sites	2.1 explain strategies used by micro-organisms to evade the immune response 2.2 explain the mechanisms of damage to host cells used by micro-organisms 2.3 analyse the innate immune responses shown by humans
LO3 Understand the virulence factors for major microbial diseases	3.1 explain the main features of virulence factors 3.2 explain clinical features and possible outcomes of the major microbial diseases 3.3 explain the effect of global infections on the human population
LO4 Be able to use diagnostic techniques to identify pathogens	4.1 follow guidelines to carry out diagnostic procedures safely 4.2 follow guidelines for the identification of micro-organisms, using safe practices 4.3 report on data from a range of identification procedures 4.4 report experimental results clearly and concisely, including possible errors 4.5 review molecular methods for diagnosis.

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Guidance

Links

This unit has particular links with the following units within this qualification:

- Unit 1: Cell Biology
- Unit 4: Laboratory Techniques for Applied Biology
- Unit 9: Neurophysiology and Homeostatic Control of the Human Body
- Unit 10: Molecular Biology and Genetics
- Unit 13: The Immune Response System
- Unit 15: Medical Microbiology.

Essential requirements

Delivery

The application of the principles of diagnostic microbiology must be integrated into the laboratory-based element.

Tutors must emphasise the importance of health and safety throughout delivery and assessment of this unit. Learners must understand the importance of adhering to laboratory health and safety guidelines. Practical tasks and activities must include risk analyses consistent with COSHH guidelines.

The medical relevance of the unit must be emphasised whenever possible. Industry links, work placements and visits from personnel with technical expertise would enhance delivery of this unit.

Assessment

Learning outcome 1 involves an understanding of normal flora and the principles of infection and disease. Learning outcome 2 focuses on the characteristics of micro-organisms that allow for successful colonisation and how the body responds to these invasions.

Learning outcome 3 involves the application of the knowledge and principles from learning outcomes 1 and 2 to a broad range of microbial diseases. Evidence could include laboratory studies and the use of case studies.

Learning outcome 4 involves learners carrying out laboratory investigations, selecting appropriate methods in a laboratory situation, handling medical specimens safely, interpreting results and applying them to medical situations. The techniques used will depend on the equipment available in the centre but must encompass a range of identification and diagnostic techniques, including serological methods and the use of manufactured diagnostic kits.

The use of patient case histories or ‘whodunnit’ scenarios in either a tutorial or laboratory-based exercise may allow learners to apply the knowledge gained from many aspects of the unit and allow generation of evidence covering several learning outcomes.

Resources

Learners require access to a microbiology laboratory and a range of different micro-organisms. The range of techniques should include some growth-dependent methods and rapid diagnostic assays or kits. Ideally, some of the diagnostic virology should be experienced in the laboratory, but this can be covered without the need to actually handle viruses.

Employer engagement and vocational contexts

Learners will benefit from visits to industrial laboratories and biomedical facilities to observe practical diagnostic techniques in operation.

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Unit 15: Medical Microbiology

Unit code: T/601/0232

Level: 5

Credit value: 15

Aim

This unit develops an understanding in theoretical and practical aspects of medical microbiology. Bacterial isolation and identification are covered together with specimen collection and screening methodology.

Unit abstract

Pathogenic micro-organisms are the main cause of infectious diseases and their control depends largely on an ability to collect and transport specimens, isolate and identify them and assess the effectiveness of the measures applied in their eradication.

Learners will appreciate the importance of collecting specimens from patients in a manner that is appropriate for the condition being investigated. They will review the methods of collection and transport and the factors involved, especially in relation to preservation of the sample and safety.

This unit enables learners to examine the theory and practice involved in the isolation and identification of certain micro-organisms. Learners' practical techniques will be enhanced through laboratory-based investigations.

Learners will also have the opportunity to assess the role of certain antibiotics in combating pathogenic micro-organisms and explore methods of screening antibiotic sensitivity from a practical perspective.

Learners will look at other types of pathogens such as chlamydia, viruses, fungal pathogens and parasites and draw comparisons between these and bacteria.

Learning outcomes

On successful completion of this unit a learner will:

1 Understand methods for specimen collection from patients

2 Be able to isolate bacteria

3 Be able to identify bacteria

4 Be able to examine methods of screening for antibiotic sensitivity

5 Understand the structural features and techniques of isolating other pathogens.

Unit content

1 Understand methods for specimen collection from patients

Specimens: blood; urine; faeces; skin samples; biopsies

Collection and transport: collection device; type and design of container; transport medium

Factors involved in the choice of method: operator safety; lability of the specimen; quality control needed to assure the outcome; avoidance of cross-contamination; requirements to keep records

2 Be able to isolate bacteria

Morphological features of bacteria: the bacterial cell; gram positive and gram negative bacteria; examples from pathogenic species

Isolation: preparation of specimens; growth conditions; microscopy; aseptic techniques

Primary identification: colonial appearance; gram staining; practical use of methods; merits and applications of other possible staining techniques

Selective and differential media: media composition; influence of the nature of the sample and the clinical findings; aseptic techniques

3 Be able to identify bacteria

Medically important bacteria: taxonomic classification; gram positive and gram negative, cocci, bacilli; other bacteria eg spirochactales, chlamydiacae, mycoplasmataceae, rickettsiaceae; diseases caused

Testing systems: biochemical; serological; coagulase; DNA-based test (rapid diagnosis) for classification; influence of the nature of the sample; clinical findings

Test kits: biochemical tests eg API 20E; serological test eg OXOID Strep

4 Be able to examine methods of screening for antibiotic sensitivity

Determination of antibiotic sensitivity: gram positive and gram negative bacteria; advantages and disadvantages of disc diffusion; possible effects due to treatments that the patient may already have had; synergistic and antagonistic effects

Determination of minimum inhibitory concentration (MIC): tube dilution; E-test

Mode of action and clinical conditions: aminoglycosides; tetracyclines; sulphonamides; trimethoprin; rifampicin

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5 Understand the structural features and techniques of isolating other pathogens

Chlamydia and rickettsia: co-contrast chlamydia and rickettsia with normal bacteria

Fungal pathogens: main structural features of named fungi; methods for their isolation

Viruses: nature and composition; techniques for the isolation and identification of viruses; molecular and serological tests

Other pathogens: isolation and identification of pathogens likely to be encountered in the medical microbiology laboratory; parasitic diseases

Learning outcomes and assessment criteria

Learning outcomes **On successful completion of this unit a learner will:**	Assessment criteria for pass **The learner can:**
LO1 Understand methods for specimen collection from patients	1.1 discuss the range of possible specimens, and methods for their safe collection and transportation 1.2 discuss the factors involved in the choice of method of collection of the sample
LO2 Be able to isolate bacteria	2.1 describe the structure and function of the main morphological features of bacteria 2.2 safely demonstrate the isolation of micro-organisms from a prepared specimen 2.3 compare different staining techniques used for the primary identification of micro-organisms 2.4 safely demonstrate the use of selective and differential media to isolate bacteria from mixed populations
LO3 Be able to identify bacteria	3.1 produce a classification of the major groups of medically important bacteria with reference to the related disease 3.2 discuss the selection and application of testing systems used to identify bacteria 3.3 demonstrate the use of biochemical tests in kit form to identify an unknown organism to species level 3.4 demonstrate the use of a serological test in kit form to identify an unknown organism to species level
LO4 Be able to examine methods of screening for antibiotic sensitivity	4.1 safely demonstrate the use of disc diffusion in the determination of antibiotic sensitivity 4.2 perform a determination of the MIC for a named antibiotic, using safe practices 4.3 discuss the mode of action of antibiotics and clinical conditions for use
LO5 Understand the structural features and techniques of isolating other pathogens	5.1 assess the manner by which Chlamydia and Rickettsia differ from normal bacteria 5.2 explain the main structural features of named fungal pathogens and methods for their isolation 5.3 discuss the nature and composition of viruses and the techniques used for their isolation and identification 5.4 review other pathogens including diseases caused by parasites.

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Guidance

Links

This unit has particular links with the following units within this qualification:

- Unit 1: Cell Biology
- Unit 4: Laboratory Techniques for Applied Biology
- Unit 13: The Immune Response System
- Unit 14: Infectious Diseases
- Unit 17: Industrial Microbiology.

Essential requirements

Delivery

Delivery must include practical exercises designed to give learners experience of the full range of available methods. Demonstrations of more complex, or more hazardous, operations should be included.

For learning outcome 1, learners must be introduced to the differences between specimens and the problems encountered in collecting and transporting them to the laboratory, including considerations of safety for the operator. Attention must be paid to the nature and lability of the specimen and also to the quality control needed to assure the outcome. This must include discussion of cross-contamination and record keeping and should be reinforced through delivery of the other learning outcomes.

Learning outcome 2 is in two parts; firstly a theoretical understanding of the bacterial cell, growth conditions and isolation; secondly, practical experience of isolation and primary identification using microscopy and colonial appearance. The nature of the sample and the clinical findings should inform discussion and determine the type of isolation medium to be used. Aseptic techniques must be stressed throughout and reinforced through the other learning outcomes.

Learning outcome 3 must cover the techniques required to give a rapid diagnosis of a bacterial isolate and should also consider the broader principles of classification. The nature of the sample and the clinical findings should inform discussion and determine the type of test to be used. Learners must have the opportunity to carry out at least one example of a biochemical testing system (for example API 20E) and one example of a serological testing system (for example OXOID Strep). Learners must be aware of the underlying principles of these tests. Other tests, for example coagulase, should be covered, as should DNA-based tests.

Learning outcome 4 requires an understanding of the antibiotic therapy that is needed to underpin sensitivity testing.

Learning outcome 5 covers the range of other pathogens encountered in the medical microbiology laboratory, their isolation and identification. Although this learning outcome can be met through theoretical knowledge alone, the opportunity to use demonstrations should be taken.

Assessment

Evidence for learning outcome 1 must be underpinned by safety and quality assurance considerations. Each learner must be assessed on their ability to use aseptic techniques. The practical assessment for learning outcomes 2, 3 and 4 could be delivered as an integrated exercise where learners start from an 'unknown', preferably mixed culture specimen and proceed through the various stages. Case studies could provide additional experience, especially when considering organisms such as viruses which would be too hazardous to use in class.

Tutor observation records must be provided to confirm individual learner achievement in practically-based experiments and tasks.

Resources

A laboratory in which bacteria can be handled safely is required. This must include oil-immersion microscopy, an incubator, preferably at 37°C, and an autoclave. Use of disposable inoculating loops is now common practice, but learners should experience using wire loops and their sterilisation as part of aseptic technique.

Employer engagement and vocational contexts

Learners will benefit from visits to industrial laboratories. In particular, visits to biomedical facilities to observe practical techniques concerned with the identification and isolation of micro-organisms as well as methods for screening their sensitivity to antibiotics.

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Unit 16: Human Health and Nutrition

Unit code: F/601/0234

Level: 4

Credit value: 15

Aim

This unit provides an understanding of the fundamental role of nutrients in maintaining health in relation to the biological functioning of the body and relates nutrient function to specific individual requirements.

Unit abstract

This unit will enable learners to develop an understanding of how nutrients are structured and the function that each one has in the human body. It allows learners to investigate how each nutrient fulfils its own specific role within the human body.

Learners will explore the nutritional value of foods and their components, and the role of diet in providing the essential elements for the body to function. Different dietary needs will be investigated and 'good nutrition' emphasised. Current recommended daily intake information from specialist organisations will be applied to the dietary requirements of different individuals with regard to life cycle, lifestyle and health.

The source, role, digestion and assimilation of nutrients will be studied and current research, controversial and topical aspects investigated.

Learning outcomes

On successful completion of this unit a learner will:

1 Understand the sources, functions and uses of macro and micro-nutrients in the diet

2 Understand the fate of nutrients after consumption

3 Understand the nutritional requirements of individuals in relation to food choice, lifestyle, life cycle and health

4 Understand the role of nutrition in health and diet-related diseases.

Unit content

1 Understand the sources, functions and uses of macro and micro-nutrients in the diet

Sources and types of carbohydrates: simple and complex sugars; glycogen; starches; non-starch polysaccharides; food sources

Use and function of carbohydrates: as a source of energy; role of dietary fibre

Use and types of protein: nitrogen balance; growth and maintenance; enzymes; hormones; antibodies; as a source of energy

Source and types of lipids: fats; oils; phospholipids and steroids; triglycerides; omega 3 and 6 trans-fats; saturated, monounsaturated and polyunsaturated; food source

Use and function of lipids: as a source of energy; source of fat-soluble vitamins; role of cholesterol and phospholipids; essential fatty acids

Sources of water: food; metabolism

Uses and functions of water: temperature regulation; excretion; hydration and water balance

Vitamins and their sources: water soluble and fat-soluble food sources; losses and destruction; fortification and enhancement

Uses and functions of vitamins: physiological roles; antioxidants

Sources of minerals: mineral elements and trace elements; food sources; fortification and enhancements

Uses and functions of minerals: role in energy production; physiological role; antioxidants

Diet analysis: how to analyse nutritional content of diets; use of food tables

2 Understand the fate of nutrients after consumption

Digestion: mechanical and chemical digestion; the role of enzymes in the breakdown of foods

Absorption: absorption and transportation of digested nutrients

Metabolism: catabolism; enzymic production of co-enzymes; co-factors; excretion; role of hormones

Assimilation: anabolism; storage of nutrients

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3 Understand the nutritional requirements of individuals in relation to food choice, lifestyle, life cycle and health

Recommended intakes: recommended dietary allowance (RDA); recommended daily intake (RDI); dietary reference values (DRVs); nutrition and guidelines; healthy eating suggestions (COMA, NACNE, WHO); government policy on nutrition

Factors affecting food choice: stages of life eg childhood, adolescence, pregnancy, old age; factors affecting requirements of individuals; requirements of communities; bioavailability of nutrients; assessing nutritional status; tools and techniques for interpreting nutritional status; work of nutritionists and dieticians

Nutritional labelling: uses; regulations and format

4 Understand the role of nutrition in health and diet-related diseases

Deficiencies: malnutrition; symptoms of deficiencies; causes of deficiencies eg poor intakes, poor bioavailability, presence of anti-nutrients

Diet-related disease: health factors interacting with nutrition eg stress, exercise; cause, effect and prevention of common diseases related to nutrition (coronary heart disease, osteoporosis, over nutrition, allergies)

Weight management: weight gain and loss; use of fat replacers; artificial sweeteners

Achieving optimal nutrition: how to use guidelines to modify and adapt diets to improve health; use of supplements

Study current related areas: topics eg role of phytochemicals and future foods

Learning outcomes and assessment criteria

Learning outcomes **On successful completion of this unit a learner will:**	Assessment criteria for pass **The learner can:**
LO1 Understand the sources, functions and uses of macro and micro-nutrients in the diet	1.1 explain the difference between macro and micro-nutrients 1.2 evaluate the sources of nutrients from the diet, foods and other sources 1.3 explain the uses and functions of nutrients in the body 1.4 compare the nutritional content of foods and diets using food tables for nutritional data
LO2 Understand the fate of nutrients after consumption	2.1 explain the digestion, absorption, metabolic and assimilation processes 2.2 discuss how the body uses nutrients once digested 2.3 examine the factors which affect each process
LO3 Understand the nutritional requirements of individuals in relation to food choice, lifestyle, life cycle and health	3.1 compare RDAs, RDIs and DRVs in setting nutritional requirements 3.2 review codes of practice, legislation and EU regulations with regard to nutritional requirements 3.3 explain the different lifestyle, life choice and health factors affecting food choice of individuals and selected groups 3.4 explain the use and control of nutritional labelling with reference to legal requirements and the provision of information to consumers
LO4 Understand the role of nutrition in health and diet-related diseases	4.1 explain the relationship between diet and health 4.2 discuss factors affecting incidences of diet-related disease 4.3 review current nutritional research relating to weight management and optimal nutrition 4.4 discuss selected health and diet topics currently under controversy.

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Guidance

Links

This unit has particular links with the following units within this qualification:

- Unit 1: Cell Biology
- Unit 2: Biochemistry of Macromolecules and Metabolic Pathways
- Unit 9: Neurophysiology and Homeostatic Control of the Human Body
- Unit 18: Food Molecules, Additives and their Roles.

Essential requirements

Delivery

Throughout delivery emphasis must be placed on the evaluation of controversial areas, using up-to-date research material, encompassing related lifestyle issues and addressing bioavailability of nutrients, together with how to obtain nutritional information from a variety of sources. The role of nutritionists and dieticians is an integral part of the unit and a visiting speaker or visit to a dietetic department would be beneficial.

Wherever possible, practical investigations must be used to confirm theoretical concepts.

Assessment

Learners must demonstrate a clear understanding of the sources of nutrients from the diet and their role in human health. Fundamental to this is a thorough knowledge of the functions of nutrients within the body and how they relate to the nutritional requirements of an individual.

The consequences of poor nutrition must be appreciated, together with an awareness of the information available to help prevent diet-related disease.

Resources

Learners require access to laboratory facilities, standard food tables and diet analysis computer software.

Employer engagement and vocational contexts

Learners would benefit from visits to dietetic specialist departments and also from visiting speakers who deal with dietetics within industry, for example a nutritional coach/adviser, food manufacturer or health practitioner.

Unit 17: Industrial Microbiology

Unit code: J/601/0235

Level: 5

Credit value: 15

Aim

This unit develops learners' understanding of the legislation and use of micro-organisms in industrial and commercial applications. The techniques needed to prevent and detect microbial contamination are also examined.

Unit abstract

Micro-organisms have been used to produce certain food products and beverages since ancient times but today they are grown on a large scale to produce valuable commercial products or to carry out chemical reactions.

In this unit learners will undertake practical investigations to study microbial growth, growth cycles and the factors which affect population growth and the yield of products. Learners will need to understand how growth conditions can be manipulated to influence the end product and the role of genetic engineering in industrial microbiology.

Biotechnology has had a major impact on modern food production, and the production of insulin, growth hormones and blood clotting factors. Through this unit learners will also develop their knowledge of current legislation relevant to industrial microbiology.

In addition, learners will gain an understanding of the physical and chemical methods used to control microbial contamination and how to undertake quality control measures.

Learning outcomes

On successful completion of this unit a learner will:

1 Be able to investigate microbial growth

2 Understand the commercial and industrial applications of micro-organisms

3 Understand the methods available for the control of microbial contamination

4 Be able to detect microbial contaminants and undertake quality control procedures

5 Understand current legislation relating to industrial microbiology.

Unit content

1 Be able to investigate microbial growth

Practical investigations: examples of small-scale production of micro-organisms; dilution plating; direct count (haemocytometer); death phase

Growth cycles: batch and continuous fermentation; lag, log; stationary; death phase

Growth characteristics: factors affecting population growth and yield of product

Limits to growth: factors limiting growth and the problems of large-scale production

2 Understand the commercial and industrial applications of micro-organisms

Fermentation processes: brewing, beer, wine; lactic fermentations; production of antibiotics, hormones, amino acids, enzymes, citric acid; microbes as food

Biotechnology: recombinant DNA techniques; genetically modified organisms; production of insulin growth hormone; blood clotting factors

Bioreactors: batch and continuous processes; contamination control; growth parameters; process control mechanisms; sampling techniques and parameters; product control and monitoring

Water management: sewage/effluent treatment and disposal; purification of drinking water; surveillance of water supplies; high/low temperature treatments; irradiation; filtration; removal of available water; disinfectants

3 Understand the methods available for the control of microbial contamination

Physical and chemical methods of contamination control: reduction of viable population against time; heat treatments, pasteurisation, sterilisation; irradiation; filtration; disinfection

Chemicals used: types eg germicide/biocide, antisepses, disinfectants, sterilising agents; limitations

4 Be able to detect microbial contaminants and undertake quality control procedures

Standard methods of detection and identification of microbial contaminants: skin flora eg staphylococcus; gut flora eg E coli; mycoplasma; cryptosporidium in water supplies; organisms in air and dust eg micrococcus; moulds and yeasts

Rapid methods: detection and identification eg use of luciferase, RNA activity

Hazard analysis: Hazard Analysis Critical Control Point (HACCP)

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5 Understand current legislation relating to industrial microbiology

Statutes which are relevant to industrial microbiology: EU Drinking Water Directive 98/83/EC; Nitrates Directive 91/676/EEC; Urban Waste Water Treatment Directive 98/15/EEC; Genetic Manipulation Regulations 1989; Genetically Modified Organisms (contained use) Regulations 1992; European Patent Convention 1978

Biotechnology industry: types eg agri-food, pharmaceutical, medical, environmental

Learning outcomes and assessment criteria

Learning outcomes **On successful completion of this unit a learner will:**	Assessment criteria for pass **The learner can:**
LO1 Be able to investigate microbial growth	1.1 carry out practical investigations in order to obtain data on microbial growth, using safe practices 1.2 construct graphs that provide information and data on microbial growth cycles and characteristics 1.3 interpret the experimental growth data relating to growth cycles and characteristics 1.4 explain the limits of growth in large-scale production of micro-organisms
LO2 Understand the commercial and industrial applications of micro-organisms	2.1 review commercially important products from microbial fermentation processes 2.2 review the species commonly used in the fermentation processes for the production of products 2.3 discuss the principles of biotechnology that underpin the manufacture of products 2.4 discuss the use of bioreactors in manufacturing 2.5 analyse the routine practices underlying water management in terms of sewage treatment and water purification
LO3 Understand the methods available for the control of microbial contamination	3.1 assess the effectiveness of physical and chemical methods of reducing microbial growth 3.2 assess the effectiveness of the types of chemicals used
LO4 Be able to detect microbial contaminants and undertake quality control procedures	4.1 carry out selectively and safely, standard and rapid methods of detection and identification of microbial contaminants 4.2 create a scheme of hazard analysis for two commercial applications of micro-organism
LO5 Understand current legislation relating to industrial microbiology	5.1 discuss the statutes which are relevant to industrial microbiology and their impact.

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Guidance

Links

This unit has particular links with the following units within this qualification:

- Unit 1: Cell Biology
- Unit 4: Laboratory Techniques for Applied Biology
- Unit 15: Medical Microbiology
- Unit 18: Food Molecules, Additives and their Roles
- Unit 19: Environmental Monitoring and Analysis
- Unit 26: Quality Assurance and Quality Control.

Essential requirements

Delivery

Delivery of learning outcome 1 must include learners participating in practical activities concerned with investigating growth cycles and characteristics of micro-organisms and limitations in relation to large-scale production. Tutors must emphasise the importance of health and safety.

For learning outcome 2, appreciation of the commercial and industrial application of micro-organisms must involve a detailed review of the fermentation processes used in a range of sectors including water management. This must include a detailed examination of the principles of biotechnology that underpin each process.

For learning outcome 3, there must be a detailed assessment of the physical and chemical methods used to control microbial contamination and any associated limitations.

Practical activities form the focus of learning outcome 4, where learners need to experience standard and rapid methods for the detection and identification of microbial contaminants.

For learning outcome 5, learners must discuss the main points of current British and European legislation that are relevant to microbiology and give examples of how certain statutes can influence biotechnological activities across a range of industrial sectors.

Assessment

For learning outcomes 1 and 3, learners must understand the growth of micro-organisms and the control methods available. Evidence may be generated through a combination of experimental work and written reports including graphical representations of data for learning outcome 1, and answering appropriate questions.

Learning outcome 2 involves investigation of the commercial and industrial applications of micro-organisms. Evidence should be supported by laboratory exercises, for example the culture of yoghurt or a small-scale fermentation. The standard methods for enumeration of important organisms in drinking water should be performed in the laboratory, the results reported and their significance discussed.

Learning outcome 4 involves practical work to familiarise learners with the range of techniques available for the culture, identification and quality control of micro-organisms. The choice of techniques will depend on the facilities and equipment available, but learners must be introduced to a range of rapid identification kits.

Learning outcome 5 involves learners becoming familiar with relevant legislation. The content to be covered is likely to change over time and the importance of keeping up-to-date with developments must be stressed.

Resources

Learners require access to a microbiology laboratory and a range of different micro-organisms. Appropriate technical support is also required. The range of practical techniques undertaken must include some growth-dependent methods and rapid diagnostic assays or kits.

Employer engagement and vocational contexts

Learners will benefit from visits to industrial and commercial establishments that are engaged in microbiological activities. For example breweries, water treatment works and food manufacturing plants.

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Unit 18: Food Molecules, Additives and their Roles

Unit code: R/601/0237

Level: 5

Credit value: 15

Aim

This unit provides learners with an understanding of the relationship between structures of food chemicals within key nutrients and their roles in food.

Unit abstract

This unit is designed for those learners with a specialist interest in food science and, in particular, the role of complex biological molecules within food. The unit will be of value to learners wishing to gain employment within analytical laboratories in the food industry or the County Analyst and Scientific Advisory Service. It would also be valuable for those wishing to pursue a career in nutrition or dietetics.

This unit provides a detailed look at macro-nutrients and their function in foodstuffs. It will give learners the opportunity to see the effect of food processing on each nutrient and, in turn, to identify their nutritional value after this process.

Food additives are also considered in order to show how they can be used positively within the manufacturing of food and why food labelling is so important.

Learning outcomes

On successful completion of this unit a learner will:

1 Understand the relationship between the structure of food carbohydrates and their functions in foodstuffs

2 Understand the structures and functions of food proteins and enzymes

3 Understand the structures and functions of food lipids

4 Understand the nature and functions of additives in food.

Unit content

1 Understand the relationship between the structure of food carbohydrates and their functions in foodstuffs

Structure of carbohydrates: simple ring and straight chain forms of monosaccharides; formation of glycosidic bonds to form disaccharides; formation of polysaccharides

Structure and function of carbohydrates: monosaccharide structure (Fischer and Haworth structures); starch granules; amylase; amylopectin; glucose syrups; dextrose equivalent; modified starches; cellulose; pectin; alginate; carageenan; homo- and heteroglycans; linear and branched chains

Properties of food carbohydrates: gelatinisation and retrogradation of starch; effect of chemical modification on properties of starch; importance of hydrogen bonds in thickening and gelling; importance of pH to thickening and gelling eg carboxylate ions in pectin; role of calcium ions in gelling eg alginate egg-box model; importance of branched and linear chains to thickening and gelling; occurrence of junction and super junction zones; properties of glucose syrups eg sweetener, thickener, humectant

Effects of processing on carbohydrates: pH; heat; browning reactions

2 Understand the structures and functions of food proteins and enzymes

Protein structure: hydrophilic and hydrophobic nature of proteins; globular and fibrous proteins in foods; isoelectric point and its importance in foods; denaturation and its importance in foods; categories of proteins eg albumins, globulins

Food proteins: milk proteins eg caseins, albumins and globulins and their relative stability to heat and pH; egg proteins eg ovalbumin and phospho and lipoproteins; the effect of age on pH; effect of heat; meat proteins eg actin and myosin; post-mortem glycolysis; myoglobin and its oxidation

Effect of processing on food proteins: heat; pH; emulsification

Occurrence of enzymes in food: phosphatase and lipase in milk; pectinase; phenol oxidase; lipoxygenase

Use of enzymes in food: invertase; glucose oxidase; chymosin; amylases; glucose isomerase; lipase; lactase; proteases; immobilised enzymes

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3 Understand the structures and functions of food lipids

Lipid structure: mono and diglycerides as emulsifiers; fatty acid classification eg International Union of Pure and Applied Chemistry (IUPAC) and omega nomenclature; saturated and unsaturated eg cis and trans isomers and their occurrence in foods; phospholipids as emulsifiers

Reactions of lipids: hydrogenation eg production of trans isomers and hydrogenated fat; interesterification and its effect on melting point; hydrolytic and oxidative rancidity (causes and prevention); measurement of rancidity eg peroxide value (PV) and free fatty acids (FFA)

Plasticity in food processing: production of different fat crystal types and their importance in foods such as chocolate and butter; solid fat index and plasticity of fats

4 Understand the nature and functions of additives in food

Antioxidants: functions of antioxidants eg ascorbic acid, propyl gallate, butylated hydroxyanisole

Anti-caking agents: functions of anti-caking agents eg magnesium carbonate, calcium hydroxy phosphate

Flavour enhancers: functions of flavour enhancers eg monosodium glutamate, ethyl acetate, ethyl formate

Preservatives: functions of preservatives eg vitamin B12, vitamin A, vitamin D, nicotinic acid, citric acid, acetic acid

Sweeteners: functions of sweetners eg sorbic acid, sulfur dioxide, sodium metabisulfate

Thickeners and emulsifiers: lecithins; pectin; alginates; guar gum; carboxymethyl cellulose

Colouring agents: functions; E-numbers examples; natural eg ß-carotene, chlorophyll, caramel; synthetic eg erythrosine, tartrazine

Codes of practice: legislation; the Food Standards Act 1999, 1994

Learning outcomes and assessment criteria

Learning outcomes **On successful completion of this unit a learner will:**	Assessment criteria for pass **The learner can:**
LO1 Understand the relationship between the structure of food carbohydrates and their functions in foodstuffs	1.1 explain how carbohydrates are affected by food processing 1.2 evaluate the relationship between the structure of food carbohydrates and their function as thickeners and gelling agents
LO2 Understand the structures and functions of food proteins and enzymes	2.1 compare the structure of food proteins to their function and properties 2.2 explain how the properties of food proteins affect the methods used in the production of food 2.3 discuss the use of enzymes in food
LO3 Understand the structures and functions of food lipids	3.1 explain how the structure of lipids and modified lipids relates to their properties 3.2 explain the causes and prevention of rancidity 3.3 discuss the effects of plasticity of fats and their role in foods
LO4 Understand the nature and functions of additives in food	4.1 discuss the functions and use of additives in food 4.2 discuss the labelling of food products.

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Guidance

Links

This unit has particular links with the following units within this qualification:

- Unit 2: Biochemistry of Macromolecules and Metabolic Pathways
- Unit 4: Laboratory Techniques for Applied Biology
- Unit 16: Human Health and Nutrition
- Unit 17: Industrial Microbiology.

Essential requirements

Delivery

Tutors must, wherever possible, utilise practical applications relating structures to functions of food chemicals.

Industrial liaison with food manufacturers and food science laboratories would enhance delivery of this unit.

Assessment

Learners must demonstrate a clear understanding of the relationship between the structures of food chemicals and their roles in foods. In order to do this evidence may take the form of a series of laboratory-based experiments/investigations which consider each identified nutrient and the effects of food processing.

Resources

Learners will need access to appropriate laboratory facilities and library and ICT resources.

Employer engagement and vocational contexts

Learners would benefit from being able to see food being manufactured in industry and also how food science is managed within an industrial laboratory. Visiting speakers working within the food industry, and also individuals working in dietetics, would enhance unit delivery.

Unit 19: Environmental Monitoring and Analysis

Unit code: Y/601/0238

Level: 5

Credit value: 15

Aim

This unit provides learners with an understanding of natural environmental cycles and the influence of pollutants on ecosystems. The sources and effects of environmental pollutants together with techniques of sampling and chemical analysis are examined.

Unit abstract

The analysis of the natural environment and the impact of human activity on it are central to this unit. Through studying this unit learners will learn about the environment close to where they live and work, as well as the global systems we all depend on.

Learners will learn how the balance of the natural environment relies on transfer mechanisms to cycle and purify its components. The complex nature of the interactions involved and the influence of pollutants on ecosystems are covered.

The importance of fossil fuel combustion as a source of pollution is studied and the effects on ecosystems assessed.

Following the initial introduction to the natural environment, and the potential pollutants within it, learners will plan and carry out an analysis of appropriate material from a selected site. Learners will assess the suitability of a sampling site and select material for analysis and analytical techniques under guidance from their tutor. This practical study allows for an iterative approach to the development of suitable sampling and analytical procedures.

Learning outcomes

On successful completion of this unit a learner will:

1 Understand how biogeochemical cycles result in the transfer of substances between components of ecosystems

2 Understand the sources and effects of environmental pollutants

3 Be able to apply sampling methods appropriate to an analyte

4 Be able to determine the concentration of analytes in samples.

Unit content

1 Understand how biogeochemical cycles result in the transfer of substances between components of ecosystems

Abiotic components of biogeochemical cycles: hydrosphere; lithosphere; atmosphere; soil structure and composition; atmospheric transport; aquatic systems

Mechanisms of substance transfer: water cycle; nutrient cycles (carbon, nitrogen, oxygen, phosphorus, sulfur); non-nutrient transfer; by organic species eg PCBs, DDT, hydrocarbons; metals eg lead, cadmium, mercury

Influences on substance cycling: abiotic components of ecosystems; physical properties and composition of aquatic habitats, soil and air; biotic components of ecosystems; feeding, uptake from soil, assimilation, excretion, decomposition

2 Understand the sources and effects of environmental pollutants

Sewage treatment: composition of raw sewage; role and effect of primary, secondary and tertiary treatment processes; typical process equipment

Industrial sources of pollutants: sources of water, air and soil pollutants eg petrochemical processing, power generation, mining, manufacturing

Agricultural sources of pollutants: fertilisers; herbicides; pesticides; animal wastes; methane; cleaning agents

Fossil fuel combustion products: gas, petrol, oil and coal combustion products; environmental impact of carbon, nitrogen and sulfur oxides; photochemical smog

Effect of pollutants on ecosystems: toxicity; bioconcentration; biodiversity effects; viral and bacterial pathogens; acidification; greenhouse effect

3 Be able to apply sampling methods appropriate to an analyte

Selection of sampling location: appropriate site eg local, field trip, industrial, agricultural; type of pollutant (water, soil, air); accessibility; health and safety considerations

Design of sampling protocol: protocol related to sample type eg water volume, flow, time, container volume, storage and stabilisation, analyte mobility, analyte stability

Quality control: planning for sampling; random sampling; internal standards

Environmental sampling: implementation of sampling protocol; iterative cycle for improvement

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4 Be able to determine the concentration of analytes in samples

Planning: selection of analytical technique related to analyte eg pre-treatment, extraction, dissolution, spectrometry, chromatography, titration, electrochemical, voltammetry, fluorescence, chemiluminescence

Determination of analyte concentration: implementation of planned analysis; evaluation of results; alteration of plan; repeat of sampling and analysis

Report on analytical procedure: accuracy; reliability; statistical analysis; suggestions for future work

Maximum permitted levels: related to selected analyte eg total organic carbon, nitrate, nitrite, ammonia, biochemical oxygen demand, pH, particulates, suspended solids, heavy metals

Learning outcomes and assessment criteria

Learning outcomes **On successful completion of this unit a learner will:**	Assessment criteria for pass **The learner can:**
LO1 Understand how biogeochemical cycles result in the transfer of substances between components of ecosystems	1.1 discuss the abiotic components of biogeochemical cycles 1.2 explain mechanisms by which substances are transferred between environmental components 1.3 explain the abiotic and biotic factors that influence the cycling of substances
LO2 Understand the sources and effects of environmental pollutants	2.1 explain the key stages in sewage treatment 2.2 analyse industrial processes as sources of pollutants 2.3 compare agricultural processes as sources of pollutants 2.4 discuss the environmental impact of fossil fuel combustion products 2.5 assess the effects of selected pollutants on ecosystems
LO3 Be able to apply sampling methods appropriate to an analyte	3.1 select a suitable location for sampling 3.2 design a sampling protocol for specified analytes at a location 3.3 implement quality control criteria for a sampling regime 3.4 carry out appropriate environmental sampling, using safe practices
LO4 Be able to determine the concentration of analytes in samples	4.1 plan analyses appropriate for a specified analyte 4.2 determine the concentration of an analyte in a sample 4.3 report on the accuracy of the results of an analytical procedure 4.4 relate the concentration of an analyte to the maximum permitted levels.

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Guidance

Links

This unit has particular links with the following units within this qualification:

- Unit 5: Analysis of Scientific Data and Information
- Unit 21: Environmental Management and Conservation.

Essential requirements

Delivery

Learning outcome 1 covers the complexity of the natural environment and natural material cycles. The nature of soil types including acid-base character and ion exchange effects must be stressed.

Learning outcome 2 can be achieved through case studies and industrial visits. Flow diagrams for the selected industrial or agricultural process, with quantification of the potential pollutant and waste flows, could be produced before the visit to provide a greater appreciation of the emphasis on environmental protection in modern industrial processes. Learners in industry must be encouraged to investigate environmental protection measures at their place of work.

Learning outcomes 3 and 4 are essentially practical and could be delivered using a project-based approach. The intention is to follow a given analysis from selecting an appropriate site through planning sampling regimes to applying suitable chemical analysis to provide an accurate and reproducible result. If group work is used, tutors must ensure that each individual learner provides sufficient evidence of meeting the assessment criteria on an individual basis. Learners may be guided in selecting an appropriate analyte depending on the analytical facilities available at the centre.

Visits to commercial analytical laboratories would be useful in allowing learners to observe quality control systems in practice and appreciate the issues raised by a delay between sampling and analysis.

Assessment

Learning outcome 1 involves the general principles of biogeochemical cycles and as with learning outcome 2, evidence could be generated from case studies.

Learning outcomes 3 and 4 involve planning and practical work and could be suitable for group or individual projects.

Resources

Learners will need access to appropriate laboratory facilities and technical support. The apparatus and instrumentation required will depend on local resources and the analytical methods chosen. Suitable local sampling sites should be identified to support laboratory work. General library facilities, including internet access, will also be needed. Relevant periodicals would be beneficial for resource-based research work.

Employer engagement and vocational contexts

Learners would benefit from visits to industrial settings where effluent treatment and environmental monitoring can be observed. Visits would enable learners to appreciate how reducing environmental impact is central to modern industrial design and processing.

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Unit 20: Ecological Principles and their Application

Unit code: D/601/0239

Level: 4

Credit value: 15

Aim

This unit provides learners with an understanding of the delicate balance and interaction of life on our planet and how disruption to this balance threatens the continuing existence of life on Earth. Learners are also able to develop skills in ecological research.

Unit abstract

The unit is designed to give learners an understanding of the fundamental concepts of ecology and how they may be applied in the modern world. By looking at examples of the interaction between biotic and abiotic factors within ecosystems learners will appreciate how a delicate balance is maintained for life within that community and why ecological study is important in monitoring these changes. They will be encouraged to discuss named examples of changes within ecosystems today and the implications of these changes on life within that community.

Learners will study how different species have evolved, adapted and survived in particular environments, as well as how communities change over time. Within this, learners will be encouraged to examine how energy and nutrients flow within ecosystems and why some species fail to survive and become extinct.

Learners will have the opportunity to plan a small-scale ecological research study of their own, and collect, analyse and interpret the ecological information they obtain.

Learners will have opportunities to discuss current social, ethical, moral and environmental issues which impact on survival.

Learning outcomes

On successful completion of this unit a learner will:

1 Understand the importance of ecological study

2 Understand basic ecological theory

3 Be able to conduct ecological research.

Unit content

1 Understand the importance of ecological study

Balance of the world's ecosystems: reasons for maintaining a balance eg regulation of atmospheric gases, regulation of climate, nutrient cycling, treatment of pollutants, water supply, pollination, food supply, biological pest control, supplies of fuel and building materials, supplies of medicines, recreation and culture, quality of life for humans

Important ecological issues: key issues affecting living organisms eg acid rain, global warming, eutrophication, deforestation, biodiversity, human population growth, sustainability, pesticide use, eco-tourism

Implications of ecological change: affect of change on ecosystems eg global warming, deforestation, human population growth, acid rain, eutrophication, reducing impact of change, maintaining balance in ecosystems

2 Understand basic ecological theory

Evolutionary ecology: variation in individuals; the diversity of life; natural selection; speciation; adaptation; extinction

Behavioural ecology: survival and reproduction ecology eg group selection versus individual selection, altruism, life histories, age and sex structures, dispurtion, kin selection

Population ecology: population growth, abiotic factors, competition, coexistence; predation; herbivory; parasitism

Community ecology: characteristics of change eg classification of terrestrial and aquatic community types, ecological niches, zonation, succession, biodiversity

Ecosystems ecology: primary and secondary production; energy flow; food webs; nutrient cycling

3 Be able to conduct ecological research

Plan an ecological study: type of study eg laboratory experiment, field experiment, correlations, direct observation of behaviour, case studies, modelling

Techniques: hypotheses and objectives; planning experiments; sampling and replication eg quadrants, transects, abundance scales, mark-release recapture techniques; use and interpretation of statistics

Data analysis: types of data collected eg nominal, ordinal, interval; non-parametric statistical tests eg Spearman rank correlation coefficient, Chi-square, Wilcoxon, Mann-Whitney

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Learning outcomes and assessment criteria

Learning outcomes **On successful completion of this unit a learner will:**	Assessment criteria for pass **The learner can:**
LO1 Understand the importance of ecological study	1.1 explain the importance of maintaining a suitable balance to the world's ecosystems for life to exist 1.2 review important ecological issues affecting the distribution and abundance of living organisms 1.3 discuss the implications of changes to ecological equilibrium and include examples of ecosystems undergoing change
LO2 Understand basic ecological theory	2.1 explain the theories behind the evolution and extinction of species and the factors that lead to extinction 2.2 discuss the behavioural ecology of three named animals or plants for survival and reproduction 2.3 discuss population ecology and the distribution of living organisms using a named animal or plant 2.4 review community ecology to demonstrate how communities may change over time 2.5 examine models for energy flow and nutrient cycling within ecosystems
LO3 Be able to conduct ecological research	3.1 plan a small-scale ecological study 3.2 carry out a piece of ecological research using appropriate techniques and safe practices 3.3 analyse recorded data, draw conclusions and make recommendations.

Guidance

Links

This unit has particular links with the following units within this qualification:

- Unit 4: Laboratory Techniques for Applied Biology
- Unit 19: Environmental Monitoring and Analysis
- Unit 21: Environmental Management and Conservation
- Unit 23: Biodiversity, Conservation and Threats
- Unit 24: Statistics for Experimental Design
- Unit 25: Plant Physiology and Environmental Adaptation.

Essential requirements

Delivery

The unit can focus on the ecology of animals, plants or humans. Learners must gain a general understanding of ecology and then apply that knowledge to important ecological issues.

Learning outcome 1 gives learners an understanding of the interdependence of organisms within ecosystems and the balance between biotic and abiotic factors, which if disturbed can have catastrophic effects on all life within that environment and beyond.

Learning outcome 2 provides a general overview of ecological issues including evolution, adaptation, nutrient cycles and factors influencing distribution of organisms. Learners must start to develop their independent research into the effects of their own workplace on both local and wider ecosystems.

It is important that learners gain some experience of practical ecology. This can be achieved in learning outcome 3 by learners planning their own small ecological study, carrying out a piece of practical research and then analysing the data obtained. The research topic must reflect the learner's main interest. Learners can draw on knowledge gained in other units and also from their own workplace and assess the effect/influence they may be having on the community both locally and generally. A suggested word count for this study would be between 4500 and 5500 words.

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Assessment

Evidence may be generated using a series of written and practical assignments. For learning outcome 1, learners research a named ecosystem undergoing change, with an emphasis on maintaining a suitable ecological environment. Learners then discuss how the changes taking place could have consequences for life within the system.

For learning outcome 2, the use of named ecosystems will help learners focus their responses and may help them to link tasks together. Desert or arctic ecosystems could serve as suitable examples.

Learning outcome 3 must be assessed through learner projects, where individual or small groups of learners plan, undertake and write up a practical study. Learners must, as individuals or groups, plan, conduct and analyse a relevant piece of ecological research. Learners should be allowed to choose, or be guided towards, issues that are relevant to their interests and vocational background.

If group work is chosen, each learner must provide sufficient evidence to meet the assessment criteria on an individual basis. Practical work must be supported by appropriate tutor observation records or witness statements.

Resources

Access to basic ecological survey equipment will be necessary. Information can be obtained from books and journals and, in addition, the press may carry articles that emphasise current issues. The internet has a large number of ecological sites, for example www.whfreeman.com/biology.

Access to statistical packages or spreadsheets will be important for analysing collected data. For up-to-date statistical information (published annually):

- Defra – Sustainable development indicators in your pocket (Defra Publications, 2009) Code PB 13265
- Defra – The environment in your pocket (Defra Publications, 2009) Code PB 13185.

These documents do not have an ISBN as they are published directly by Defra annually.

Employer engagement and vocational contexts

Learners should be encouraged to apply their research and studies, where possible, to their workplace, looking at the impact of their own organisation both locally and globally. This will allow learners to link the unit theory to practical examples in their everyday working lives. Examples can be as diverse as waste and recycling to emissions, depending on the work setting.

Unit 21: Environmental Management and Conservation

Unit code: K/601/0289

Level: 5

Credit value: 15

Aim

This unit reviews environmental issues such as conservation sites, recycling and land reclamation. Learners gain an understanding of the causes and effects of pollution, global environmental issues, renewable energy, and the work of environmental pressure groups.

Unit abstract

Learners will have the opportunity to explore environmental issues in their own community. To make the most of this, learners may visit Sites of Special Scientific Interest, recycling facilities, brownfield land that is being reused, and local industry. Learners will investigate the origins and effects of pollutants and study how pollution may be controlled.

Evidence for human impact on global climate change and international initiatives to combat the effects through carbon trading will be explored. The work of environmental pressure groups in bringing environmental issues into the public domain will be investigated.

Finally, learners will study legislation, particularly in relation to waste, in order to gain an understanding of the quality of the information that government provides to business. Case studies will be used to assess the effectiveness of environmental management systems.

Learning outcomes

On successful completion of this unit a learner will:

1 Understand the major strategies for conservation of resources

2 Understand the causes, effects and the control of pollution

3 Understand global environmental issues

4 Understand how environmental legislation may be put into practice.

Unit content

1 Understand the major strategies for conservation of resources

Statutory designations: designated areas eg Sites of Special Scientific Interest (SSSI) (biological and geological), Special Areas of Conservation (SAC), Ramsar sites, national and local nature reserves and Marine Protected areas; establishment of designated areas; design of designated areas; development of designated areas; management of designated areas

Processes: guidelines for selection eg geological conservation review, notification, consultation and confirmation with respect to Sites of Special Scientific Interest, identification of SACs in line with Habitats Directive, government approval of SACs, adoption of UK list of SACs by European Union, criteria in Ramsar convention

Resource recycling: recycling eg glass, aluminium, paper, wood, plastic; the strategies employed by local councils; packaging waste regulations eg Producer Responsibility Obligations (Packaging Waste) Regulations 2007; compliance schemes for relevant packaging waste regulations eg Valpak

Land resource management: relevant legislation eg Planning and Compulsory Purchase Act 2004; the role of the spatial planning system in conserving the natural environment and delivering high quality environmentally sustainable development; the technical and management issues in the remediation and use of brownfield land; local authority registers of contaminated land

2 Understand the causes, effects and the control of pollution

Pollutants: common air pollutants eg sulfur oxides (SO_x), nitrogen oxides (NO_x), low level ozone, benzene, 1,3 butadiene, lead, PM10; sources of the common air pollutants eg transport, energy use, manufacturing industry; List 1 aquatic pollutants from the Dangerous Substances Directive; sources of List 1 aquatic pollutants; agricultural aquatic pollutants eg silage run off, nitrates, phosphates, slurry, sheep dip

Effects on organisms within an ecosystem: eutrophication; increase in chemical oxygen demand; effects of sulfur dioxide on vegetation

Current relevant strategies: Environment Act 1995; National Air Quality Strategy; National Air Quality Standards and Objectives; National Atmospheric Emissions Inventory; European Pollutant Emission Register (EPER); Environmental quality standards; river ecosystem classifications bio-monitoring; indicator species; keystone species

Control methods: legislation eg Integrated Pollution Prevention Control (IPPC), The Water (Prevention of Pollution) (Code of Good Agricultural Practice) (England) Order 2009; identification of areas at risk eg Air Quality Management Areas (AQMA), Nitrate Vulnerable Zones; best available techniques; best available techniques reference documents; specific techniques eg flue gas desulfurisation

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3 Understand global environmental issues

Climate change: greenhouse gases and their atmospheric effects; economic and social consequences of global warming; global initiatives eg the Kyoto Treaty, Copenhagen Climate Summit; ozone depletion and the Montreal protocol

Carbon trading: EU Emission Trading (ETS) Scheme; Clean Development Mechanism; carbon markets

Energy security: peak oil; biofuels; carbon capture and storage; clean coal; nuclear power, renewable energy sources; energy security; the UK Low Carbon Transition Plan

Pressure groups: national or international eg Friends of the Earth, World Wide Fund for Nature (WWF), Greenpeace

Global campaigns: campaign of topical interest eg carbon footprint, lifecycle analysis, food miles, sustainable transport, saving the rainforests, limiting ozone depletion (Montreal Protocol)

4 Understand how environmental legislation may be put into practice

Legislation: UK/EU eg the Environmental Protection Act 1990, Environmental Permitting Regulations 2007, Environmental Liability Directive, Waste Framework Directive, Batteries Directive

Operation of environmental permitting regulations: managing activities; suitable environmental management system; use of competent persons; accident management plan; permit conditions/rules; waste acceptance; point source emissions to air, water and land; fugitive emissions; odour; noise and vibration; monitoring; records; reporting/notification

Waste management: environmental permitting regime (England and Wales) eg pollution prevention and control, waste management licenses, waste carriers and broker registrations, water discharge consents, groundwater authorisations; waste management duty of care; Pollution Prevention Guidelines

Environmental management systems: structured and documented environmental management systems (EMS) to manage environmental performance and responsibilities; EMS certification, ISO 14001; the EU Eco-Management and Audit Scheme (EMAS); BS 8555 (a British Standard for Small and Medium Enterprises (SMEs))

Learning outcomes and assessment criteria

Learning outcomes **On successful completion of this unit a learner will:**	Assessment criteria for pass **The learner can:**
LO1 Understand the major strategies for conservation of resources	1.1 discuss current national and international statutory designations protecting the UK's natural environment 1.2 explain the processes involved in the establishment of a designated area for conservation 1.3 discuss how the UK reduces waste and promotes recycling 1.4 discuss issues involved in land resource management
LO2 Understand the causes, effects and the control of pollution	2.1 discuss pathways of named pollutants from source to receptor 2.2 assess the effects of a named pollutant on organisms within an ecosystem 2.3 discuss strategies used for monitoring pollutants in water and air emissions 2.4 assess methods for controlling pollution
LO3 Understand global environmental issues	3.1 evaluate evidence for the contribution of human activities to climate change 3.2 review international carbon trading 3.3 discuss environmental aspects of the UK's energy security policy 3.4 assess the role of an environmental pressure group in a global environmental campaign
LO4 Understand how environmental legislation may be put into practice	4.1 review current UK/EU/environmental protection legislation 4.2 explain operation of the Environmental Permitting Regulations 4.3 explain how businesses comply with their duty of care for waste management 4.4 assess, using case studies, the effectiveness of using an environmental management system.

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Guidance

Links

This unit has particular links with the following units within this qualification:

- Unit 5: Analysis of Scientific Data and Information
- Unit 19: Environmental Monitoring and Analysis
- Unit 20: Ecological Principles and their Application
- Unit 23: Biodiversity, Conservation and Threats
- Unit 26: Quality Assurance and Quality Control.

Essential requirements

Delivery

Current legislation and initiatives are mentioned in the unit content but these must be replaced by suitable alternatives if they become out of date. In all cases the latest legislation must be used. Where possible, learners should visit sites and organisations and the use of visiting speakers is strongly encouraged.

Learning outcome 1 covers Sites of Special Scientific Interest, recycling and waste minimisation and reclamation of brownfield land. Ideally, learners should visit a Site of Special Scientific Interest, a brownfield site that is being put to a new use and a council recycling facility. Input from experts at the site will deepen learner understanding. If this is not possible, learners must be encouraged to find out about relevant sites in their area.

Learning outcome 2 has a particularly wide scope, which has been limited to consideration of air and water (and not land). It could be delivered by introducing the general content and then focusing on issues of particular relevance to the centre's location. Centres in a predominantly rural area, for example, may wish to concentrate on aquatic agricultural pollution, such as nitrate pollution. Other centres in industrial areas may choose to consider the effects of sulfur dioxide in great detail.

For learning outcome 3, there is a great deal of information about global warming available. One strategy would be to select a number of documents from a variety of sources for learners to study. This would allow them to evaluate the information in the evidence, and also the quality of the evidence, and to decide whether they would need more/different evidence to be able to draw firm conclusions. Possible strategies for the UK's energy security policy must be discussed and the Government's preferred options identified. The environmental implications of alternative forms of energy must be explored. This could involve analysis of numerical data.

Learning outcome 4 gives learners the chance to explore the value of Netregs, the government website dealing with environmental legislation. This will support the first three assessment criteria.

Assessment

For learning outcome 1, learners may look at current national and international statutory designations protecting the UK's natural environment in general but go into more depth to address the unit content in relation to the processes involved in setting up one of these sites. Where possible, learners should visit a local site. Learners must address the unit content in outlining the reclamation of brownfield land, using a local case study where possible.

For learning outcome 2, the focus needs to be limited to allow learners to gain a depth of understanding. Particular pollutants need to be selected with reference to the pathways from source to receptor. Pollutants need to be chosen carefully in order to be relevant and to allow learners to select good quality information. In discussing strategies used for monitoring pollutants, emphasis must be on the overview of data taken by Government agencies and local authorities, rather than on specific analytical techniques. Methods of controlling one or more pollutants must be covered. This must involve specific pollution abatement techniques and also the supporting legislation. Once again, the focus could be different, for example industrial or agricultural.

For learning outcome 3, learners could source articles about global warming. They could assess the quality of the articles, the quality of the evidence and identify further desirable work in this area. Learners must review the nature and extent of international carbon trading. Government information on future energy supplies is available. The focus is not only on the nature of the energy security policy but the implications for the environment. Learners must identify a high profile global campaign, which a pressure group is/has been involved with and assess the role of the pressure group in that campaign.

Learning outcome 4 gives learners scope to present material on legislation that they have obtained from Netregs or other sources. Learners must assess the features of an environmental management system and how it operates. Additionally, case study information from industry is required about the effectiveness of using an environmental management system. ISO 14000 is the most common environmental management system. However, learners may write about the effectiveness of others if they have suitable industrial input.

Resources

Learners must have access to real case studies and/or real-life situations. Access to current legislation and initiatives is also essential.

Employer engagement and vocational contexts

Learners would benefit from visiting Sites of Special Scientific Interest, recycling facilities and reclaimed land. The causes, effects and control of pollution may be assessed in a local context. It is essential to have industrial input to assess the effectiveness of using an environmental standard. Guest speakers from industry and other groups would enhance delivery.

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Unit 22: Chemistry for Applied Biologists

Unit code: K/601/0292

Level: 4

Credit value: 15

Aim

This unit covers bonding, thermodynamics, reaction rates, equilibrium, oxidation and reduction and organic chemistry that are necessary to facilitate understanding of aspects of the biological sciences.

Unit abstract

Biological subjects such as biochemistry, genetics, pharmacology and physiology require an understanding of chemical concepts. Learners who have studied chemistry to Level 3 are likely to have sufficient background knowledge to gain a full understanding of the chemical aspects of these subjects.

This unit will help learners who may not have studied chemistry at Level 3 or learners who have not applied chemical knowledge for some time. On completion of this unit, learners should be more familiar with topics such as reactions of organic functional groups, intermolecular interactions, equilibrium, membrane potential, biochemical pathways involving oxidation and reduction, enzyme catalysis, pH and ionisation of amino acids.

The unit involves use of illustrative practical work and analysis of data and information to explain the chemical and physical behaviour of substances.

Learning outcomes

On successful completion of this unit a learner will:

1 Understand how chemical bonding affects chemical and physical properties of molecules

2 Be able to relate feasibility of reactions to thermodynamic quantities

3 Understand the features of equilibrium processes

4 Understand the chemical behaviour of the main classes of organic compounds.

Unit content

1 Understand how chemical bonding affects chemical and physical properties of molecules

Chemical bonding: ionic; covalent; polar covalent; metallic; electrostatic interactions; intermolecular forces; Van der Waals forces; dipole-dipole interactions; hydrogen bonding

Physical properties: melting point; boiling point; electrical conductivity; surface tension; solubility

Enthalpy changes: reaction profile; activation energy; endothermic; exothermic; sign of ΔH; standard conditions; ΔH^{θ}; Hess's Law; enthalpy of combustion; enthalpy of formation; other types of enthalpy eg enthalpy of dissociation, mean bond enthalpy, enthalpy of solution, lattice enthalpy, enthalpy of hydration; enthalpy associated with breaking and making bonds; thermodynamic tables

Factors affecting rate of chemical reactions: concentration; particle size; temperature; presence of a catalyst

Effect of factors on rate: number of collisions per second; surface area; reaction profile; activation energy; distribution curve of particle energy at a given temperature; change in shape of distribution curve with temperature; number of particles with sufficient energy to react; lower activation energy in presence of a catalyst; enzymes as catalysts; examples of reactions

2 Be able to relate feasibility of reactions to thermodynamic quantities

Thermodynamic quantities: enthalpy; entropy; Gibb's energy; standard enthalpy change, ΔH^{θ}; standard entropy change ΔS^{θ}; standard change in Gibb's energy ΔG^{θ}; $\Delta G = 0$ as the condition for equilibrium; ΔG being negative for a reaction where products predominate; ΔG being positive for a reaction where reactants predominate; feasibility; sign of ΔG^{θ}; exergonic; endergonic

Oxidation and reduction: oxidation as loss of electrons; reduction as gain of electrons; half equations; overall redox equation; requirement to balance overall reaction in terms of the number of electrons; oxidation numbers

Standard reduction potentials: simple metal ion/metal half cells; half cells with a redox couple in solution and a platinum electrode; biological examples of redox half cells eg NAD^{+}/NADH; E^{θ}_{cell}; sign and magnitude of E^{θ}_{cell}; feasibility of reactions

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3 Understand the features of equilibrium processes

Features: rates of forward and reverse reactions; sign of ΔH for forward and reverse reactions; dynamic equilibrium; concentration of reactants and products at equilibrium; examples eg osmosis, partition, dissociation of weak acids, Fe^{3+}/SCN^-

Calculated equilibrium constants: calculation of K_c from concentrations of reactants and products at equilibrium; meaning of magnitude of equilibrium constant

Effect of changes in conditions on equilibrium: concentration; pressure; pressure changes affecting reactions which involve gases; dependence on effect of pressure of the change in stoichiometric number for the reaction; temperature; dependence on effect of temperature of the sign of the enthalpy change; catalyst; Le Chatelier's Principle

pH and acid dissociation constant: Bronsted-Lowry theory; $pH = - \log [H^+]$, ionic product for water $K_w = [H^+][OH^-] = 1 \times 10^{-14}$; pH of acidic solutions, neutral and alkaline solution; strong and weak acids; K_a; pKa; calculation of the pH of a weak acid solutions; Henderson Hasselbach equation; buffer solutions; ionisation of amino acids in solutions of different pH

4 Understand the chemical behaviour of the main classes of organic compounds

Bonding: spd notation; concept of sp^3, sp^2 and sp hybridisation of carbon, σ and π bonds, delocalisation; bond lengths; examples of compounds eg ethane, ethene, benzene; lone pairs of electrons in compounds containing nitrogen, oxygen and halogens

Classes of organic compounds: alkanes; alkenes; alcohols; haloalkanes; aldehydes; ketones; carboxylic acids; esters; amines; amides

Names and structural formulae: International Union of Pure and Applied Chemistry (IUPAC) system; full structural formulae; shortened structural formulae; other representations eg three dimensional, Fisher projection; functional groups

Main reactions of organic compounds: alkanes eg combustion and free radical substitution; alkenes addition eg Br_2, HBr, H_2, H_2O; alcohols eg oxidation of primary, secondary and tertiary, esterification; haloalkanes eg substitution; carboxylic acids eg reaction with base, esterification; esters eg hydrolysis to alcohol and acid; amines eg as bases

Isomerism: structural (chain, positional, functional group); stereoisomerism (geometric); optical; biological examples

Learning outcomes and assessment criteria

Learning outcomes **On successful completion of this unit a learner will:**	Assessment criteria for pass **The learner can:**
LO1 Understand how chemical bonding affects chemical and physical properties of molecules	1.1 explain the physical properties of substances in terms of their chemical bonding 1.2 explain enthalpy changes in terms of bonding and interactions 1.3 explain the effect of various factors on rates of chemical reactions
LO2 Be able to relate feasibility of reactions to thermodynamic quantities	2.1 use values of thermodynamic state functions to assess the feasibility of reactions 2.2 write oxidation and reduction half equations for given reactions 2.3 categorise reactions as oxidation/reduction (redox) on the basis of oxidation numbers 2.4 justify the feasibility of redox reactions in terms of standard reduction potentials
LO3 Understand the features of equilibrium processes	3.1 explain the features of equilibrium processes 3.2 interpret the values of calculated equilibrium constants 3.3 explain the effects of changes in conditions on the position of chemical equilibrium 3.4 explain the relationship between acid dissociation constant and pH
LO4 Understand the chemical behaviour of the main classes of organic compounds	4.1 explain how bonding in organic molecules relates to shape 4.2 relate classes of organic compounds to the presence of functional groups 4.3 relate names of compounds to their structural formulae 4.4 write equations for the main reactions of organic compounds 4.5 relate types of isomerism in organic compounds to shapes.

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Guidance

Links

This unit has particular links with the following units within this qualification:

- Unit 2: Biochemistry of Macromolecules and Metabolic Path
- Unit 4: Laboratory Techniques for Applied Biology
- Unit 10: Molecular Biology and Genetics.

Essential requirements

Delivery

Where possible, the unit content must be contextualised in terms of biological systems. Learners are likely to have a wide range of prior chemistry knowledge. It may be necessary to revise basic concepts before starting the unit. This is likely to include Atomic Number, Mass Number, electronic arrangement, chemical formulae, writing simple formulae, writing and balancing equations and performing calculations involving molar mass, mass, number of moles, volume and concentration.

For learning outcome 1, it is essential to explore the effects of intermolecular forces, for example hydrogen bonding, on physical properties.

Learners must become familiar with reaction profiles for exothermic and endothermic processes. Tables of values of enthalpy of formation and mean bond enthalpy can be used in calculations based on Hess's Law. Learners must understand that there are enthalpy changes associated with physical processes such as melting and condensation.

Learners must be able to explain the effect of changes in concentration, particle size, temperature and presence of a catalyst in terms of collision theory, reaction profile and the distribution curve for the energy of molecules at a particular temperature.

Negative enthalpy change and positive entropy change may be introduced as contributing to the feasibility of a reaction. Learners can be taught to calculate ΔH^{θ} and ΔS^{θ} from thermodynamic tables and hence ΔG^{θ} from $\Delta H^{\theta} - T\Delta S^{\theta}$. They can work out whether reactants or products are likely to predominate under standard conditions from the sign of ΔG^{θ} and whether the reaction is likely to go virtually to completion or not to take place at all under standard conditions from the magnitude of ΔG^{θ}.

Since many reactions of biochemical significance involve oxidation and reduction (redox), for learning outcome 2, learners must become familiar with the terminology and features of redox before introducing standard reduction potentials as a method of assessing feasibility of redox reactions. Biological examples must be used where possible.

For learning outcome 3, learners must carry out practical exercises involving equilibrium processes, in order to appreciate that equilibrium may be reached from different initial concentrations.

Learners must be introduced to the Bronsted-Lowry theory of acids as proton donors and bases as proton acceptors. After introducing the concept of weak acids and acid dissociation constant, learners should be able to draw conclusions about the strength of acids, given values of acid dissociation constants and values of pK_a from tables.

Learners must be introduced to spd notation for the electronic arrangement of atoms. Learners must be familiar with the shapes of atomic orbitals before hybridisation is introduced. They must understand the nature of the overlap needed to produce sigma bonds and pi bonds. Learners must be familiar with different representations of organic molecules and also the different biochemical properties of isomers. Molecular model kits can be used to help learners understand the three dimensional qualities of molecules.

Assessment

For learning outcome 1, learners must be given the opportunity to calculate enthalpy changes and to explain the size and sign of the results in terms of the associated bonding and interaction. This may include physical processes.

For learning outcome 2, feasibility is likely to only relate to standard conditions. Learners may calculate values of ΔS^{θ} from tables of standard molar entropy of substances and values of ΔH^{θ} from tables of standard enthalpy changes for formation. The resulting values of ΔG^{θ} may be used to predict whether reactions are feasible under standard conditions. The sign and magnitude of the cell voltage should be used to justify whether, under standard conditions, a reaction is likely to go to completion, be an equilibrium process or hardly take place at all.

For learning outcome 3, learners could carry out measurements to determine equilibrium constants, or be given values for concentrations to calculate equilibrium constants. Assessment should involve straightforward substitution of values into equations. In explaining the relationship between acid dissociation constant and pH, learners must demonstrate the ability to calculate the pH of a weak acid solution and a buffer solution.

The emphasis in learning outcome 4 is on breadth, rather than depth. Assessment of knowledge of bonding could be based on specific straightforward molecules, involving sp^3 and sp^2 orbitals which form sigma bonds and p orbitals which form pi bonds or which are lone pairs of non-bonding electrons. It is expected that learners will name molecules whose structure is given and provide representations of the structures, given the names.

Resources

Learners will need access to appropriate laboratory, library and IT facilities.

Employer engagement and vocational contexts

Where possible, learners should have the opportunity to listen to speakers from industry. Visits would also be useful, for example to a pathology laboratory of a local hospital.

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Unit 23: Biodiversity, Conservation and Threats

Unit code: A/601/0295

Level: 5

Credit value: 15

Aim

This unit provides learners with an understanding of the phenomenon of biodiversity, and an opportunity to investigate the factors that promote and threaten it.

Unit abstract

The concept of biodiversity and its importance in maintaining a sustainable global environment gained prominence as a result of the 1992 Rio Conference. As the implications of global warming have become better understood, the importance of maintaining biodiversity and reducing our impact on the planet have come to the forefront of both scientific and political thinking.

This unit explores the mechanisms by which biotic diversity is generated and the benefits associated with biodiversity. Learners will discuss the threats facing biodiversity, and will explore practical measures to ensure the maintenance and enhancement of this resource for future generations.

Learners will initially study biodiversity in relation to their immediate environment. They will be expected to apply their knowledge and understanding at a national and international level. In doing this, an appreciation of the conflicting demands made on the planet's resources should emerge along with ideas on how they can be met without sacrificing the planet's wellbeing.

Learning outcomes

On successful completion of this unit a learner will:

1 Understand the mechanisms that result in biodiversity

2 Understand the value of biodiversity as a resource

3 Understand the factors that threaten global biodiversity

4 Be able to investigate the efficacy of practical measures to conserve biodiversity.

Unit content

1 Understand the mechanisms that result in biodiversity

Factors: continuous and discontinuous variation; random and induced mutation; natural selection through competition; selection pressure; mechanisms and examples of parallel, divergent and convergent evolution

Adaptation: plant and animal species adaptations, (anatomical, morphological, physiological, behavioural); adaptation to environments eg extremes of temperature ranges, water/desert, wind, food availability; advantages to animals/plants of developing diversity

Abiotic factors: climate eg temperature, solar radiation, availability of oxygen and carbon dioxide, air/water pressure, water potential, mineral availability, water and air movement; promotion/inhibition relating to diversity and types of habitats

2 Understand the value of biodiversity as a resource

Utilitarian uses: agriculture eg development of new crops; breeding programmes eg disease resistance, productivity, resistance to harsh climate conditions, sustainable harvesting of natural products; medicine; pharmaceutical products eg drugs from plants/animals; industry eg new product developments, ethnobotanical products; tourism

Global wellbeing: effects of ecological factors eg life support systems, ecological cycles, environmental stability

Biodiversity: values eg conservation, costs/benefits, exploitation, contingency, economic

3 Understand the factors that threaten global biodiversity

Direct factors: atmospheric pollution eg carbon dioxide, sulfur dioxide, particulate matter, metals such as lead and mercury; land and water pollution eg heavy metals, pesticides, fungicides, sewage, oil spillage; land use change eg deforestation, mining, enclosure of land by fences, slash and burn, hunting; effect of changes eg desertification, loss of amenities, loss of special/rare habitats

Indirect factors: global climate change and human population growth eg increase demand for land, buildings, farming land, encroachment on wildlife habitat, development and loss of indigenous knowledge

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4 Be able to investigate the efficacy of practical measures to conserve biodiversity

Measures to conserve biodiversity: conservation scheme eg conservation/management of natural/semi-natural ecosystems, living captive collections, captive breeding and release, seed banks, cryopreservation; role of data banks and databases in directing conservation activities

Local conservation activities: locations eg wetlands, community woodlands, nature reserves, zoological gardens, wildlife centres, land reclamation sites (brown sites, ex-industrial, disused canals, water filled excavation pits)

National conservation activities: measures eg red data books, Wildlife and Countryside Act (1985), This Common Inheritance, Environmental Protection Act (1990), Countryside and Right of Way Act (2000), Environmental Damage (Prevention and Remediation) Regulations (2009, S1 153), Natural Environment and Rural Communities Act (2006), mandatory Environmental Impact Assessment, local agenda 21 (environmental protection, economic prosperity, community wellbeing)

Global conservation activities: international summits eg UN World Conservation Strategy, Earth Summits (Stockholm and Rio), Convention on International Trade in Endangered Species (CITES), EU Habitats Directive

Learning outcomes and assessment criteria

Learning outcomes **On successful completion of this unit a learner will:**	Assessment criteria for pass **The learner can:**
LO1 Understand the mechanisms that result in biodiversity	1.1 discuss factors within an ecosystem which result in biodiversity 1.2 explain how adaptation and speciation give rise to increased biodiversity within an ecosystem 1.3 discuss the abiotic factors which can be a factor in biodiversity
LO2 Understand the value of biodiversity as a resource	2.1 discuss the utilitarian uses made of a global biodiverse environment 2.2 explain the value of ecology to global well being 2.3 assess how values are placed on biodiversity
LO3 Understand the factors that threaten global biodiversity	3.1 assess the direct factors that are threats to global biodiversity 3.2 explain the relative severity of indirect factors which threaten global biodiversity
LO4 Be able to investigate the efficacy of practical measures to conserve biodiversity	4.1 discuss biodiversity conservancy measures in a local practical conservation scheme 4.2 carry out an analysis of the measures to enhance biodiversity nationally 4.3 report on the effects of international conservation summits on global diversity.

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Guidance

Links

This unit has particular links with the following units within this qualification:

- Unit 19: Environmental Monitoring and Analysis
- Unit 20: Ecological Principles and their Application
- Unit 21: Environmental Management and Conservation
- Unit 25: Plant Physiology and Environmental Adaptation.

Essential requirements

Delivery

Part of the unit delivery will be theoretical in nature but site visits must be incorporated to enable learners to recognise the differing levels of biodiversity found within UK habitats.

It is important that learners are made aware of the range of phyla that exist in any given habitat, and do not focus on a single kingdom.

Tutors should provide a range of case studies to explore high and low diversity habitats (for example woodland versus moorland) so that learners can recognise the values associated with each, and recognise that more is not necessarily better.

Learners must be familiar with local and national conservation and biodiversity issues and use these to understand the global situation. They should also be encouraged to use their knowledge to debate the different ways in which maintaining biodiversity is tackled by different countries.

Assessment

Evidence for learning outcome 1 can be integrated with evidence for learning outcomes 2 or 4 to form a detailed analysis of a chosen ecosystem/biome.

For learning outcome 2, learners need to synthesise their own opinions through research and discussion. Their opinions should be backed up by facts.

Learning outcome 3 is intended to develop learners' skills in researching and evaluating complex information from a range of differing sources.

Learning outcome 4 could be achieved by learners visiting a local practical conservation scheme, and producing a report or critique of the scheme. Learners need to then look at, and analyse, the national picture regarding the measures taken to enhance biodiversity. Finally, learners must report on the effects that global summits have on conservation and their success or otherwise. Case material using international examples such as whales, tigers and rainforests can be used to illustrate the effects of global conferences on conservation.

Resources

Library, laboratory and internet facilities should be available to learners. Links with local conservation groups and specialist lecturers/research staff will help learners appreciate the conservation work being carried out.

Employer engagement and vocational contexts

Visits to conservation sites and engagement with local conservationists are vital for effective delivery of this unit.

Contact with employers such as the Royal Society for the Protection of Birds (RSPB), local wildlife centres, zoological gardens (animal breeding programmes), the Royal Horticultural Society (seed banks, plant breeding programmes) and farm rare breeds programmes will help learners place the unit in a vocational context.

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Unit 24: Statistics for Experimental Design

Unit code: J/601/0297

Level: 5

Credit value: 15

Aim

This unit provides learners with an understanding of the role of statistics in experimental design and hypothesis testing. Learners will be able to use significance testing to make statistical decisions and analyse the relationship between variables.

Unit abstract

The designing of scientific experiments involves multiple stages, often requiring an understanding of statistical analysis.

The unit starts with an overview of experimental design and examines the basic principles of sampling populations, probability and distributions. Learners will examine and address how statistical decisions form an important part of experimental design. Learners will gain an understanding of hypothesis testing, before looking at the differences between parametric and non-parametric models of analysis.

Understanding statistical decisions is extended to cover the role of significance testing, examining one, two and multiple sample tests. The unit concludes with correlation and linear regression; the mathematical processes are covered, as well as the impact of the limitations of correlation analysis on experimental design.

Emphasis throughout the unit is on a practical approach to applications familiar to learners together with an explanation of the theory underpinning the methods used.

Learning outcomes

On successful completion of this unit a learner will:

1 Understand the role of statistics in experimental design

2 Understand how statistical decisions are made using hypothesis testing

3 Be able to make statistical decisions using significance testing

4 Be able to analyse the relationship between variables.

Unit content

1 Understand the role of statistics in experimental design

Experimental design: treatments; controls and replicates; factorial designs; specialised designs eg clinical trials, ecological field studies, microbial assays

Population sampling: populations; sampling; sampling error; random sampling; random allocation; use of random number tables

Probability: concept of probability; laws of probability eg addition, multiplication; binomial approximation; Poisson approximation

Probability distributions: normal probability distribution; standard normal variate; central limit theorem; standard error; confidence limits; student's t distributions

2 Understand how statistical decisions are made using hypothesis testing

Hypothesis testing: the null hypothesis; significance (alpha) level; type 1 errors; type 2 errors; one tailed tests; two tailed tests; the power of a test; estimation of sample size

Parametric and non-parametric methods: assumptions of parametric analysis; the normal plot; transformation; non-parametric methods; selecting the correct test

3 Be able to make statistical decisions using significance testing

One and two sample tests: one sample z test; one sample t test; sign test; two unpaired sample tests; Wilcoxon ranked-sum test; two paired sample tests; Wilcoxon signed-rank test

Multiple sample tests: errors in multiple hypothesis testing; one-way analysis of variance (ANOVA); testing pairs of means; two-way ANOVA; interaction; factorial experimental design; randomised block; latin square; non-parametric; Kruskal-Wallis test

Categorical data: χ^2 goodness of fit test; χ^2 test for association; correction for continuity

4 Be able to analyse the relationship between variables

Linear correlation: scatter diagrams; Pearson's correlation coefficient; Spearman rank correlation coefficient; predicting values; assumptions of linear correlation; transformation; testing the significance of coefficients

Linear regression analysis: least squares method; regression equation; assumptions of linear regression; assessing the significance of slope coefficient and intercept; assessing the goodness of fit

Assessment of agreement: reproducibility and repeatability; numerical variables; limitations of correlation analysis; use of paired t tests; limits of agreement; analysis of differences; category variables; Cohen's kappa

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Learning outcomes and assessment criteria

Learning outcomes **On successful completion of this unit a learner will:**	Assessment criteria for pass **The learner can:**
LO1 Understand the role of statistics in experimental design	1.1 discuss the factors behind experimental design from a statistical view point 1.2 explain the mechanics of population sampling with regards to controlling error 1.3 evaluate probabilities using approximation methods
LO2 Understand how statistical decisions are made using hypothesis testing	2.1 assess the use of hypothesis testing in experimental design 2.2 illustrate the differences between parametric and non-parametric models of analysis
LO3 Be able to make statistical decisions using significance testing	3.1 carry out one and two sample tests on a given population sample 3.2 use multiple sample tests in experimental design 3.3 use categorical data to test hypotheses
LO4 Be able to analyse the relationship between variables	4.1 use scatter diagrams to assess linearity with regression lines 4.2 carry out linear regression analysis with all assumptions clearly indicated 4.3 discuss how the assessment of agreement is utilised in experimental design.

Guidance

Links

This unit has particular links with the following units within this qualification:

- Unit 5: Analysis of Scientific Data and Information
- Unit 6: Project for Applied Science.

Essential requirements

Delivery

The focus of delivery must be on a practical approach to the application of statistical analysis, although some theoretical background should be included to aid understanding, in particular of probability and parametric methods. There must be a balance between hand calculation (scientific calculator) and software use. Simple examples illustrating the method must be used to build up understanding and confidence before learners use software.

Learners must use the results of analyses as a basis for suggesting improvement in experimental design or extensions of the study in question. They must also be aware of potential errors, for example resulting from data entry, the wrong choice of analysis, misinterpretation and the limitations of the methods used.

Assessment

Learning outcome 1 involves demonstrating an understanding of how statistics are used in designing experiments. Some emphasis must be placed on understanding the role that sampling, probability and probability distributions have in design, rather than on mathematics. Evidence may be drawn from activities that form a normal part of the applied science programme of study.

Learning outcome 2 involves understanding the use of hypothesis testing to make statistical decisions in experimental design. Emphasis must be placed on demonstrating understanding of the application of statistics, rather than the fundamental mathematics.

Learning outcome 3 covers the mathematical techniques used to test significance. Emphasis must be on the accurate application of the methods covered.

Learning outcome 4 covers the mathematical techniques used to examine correlation between variables. Emphasis must be on the accurate application of the methods covered, with evidence showing how experiments are designed with correlation limitations in mind.

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Resources

Learners will need access to IT facilities and appropriate software, to enable them to tackle realistic problems.

Many of the operations relevant to applied science programmes can be implemented using a generic spreadsheet package (such as Microsoft Excel). Ideally, this will be supplemented by dedicated mathematical or statistical packages, for example Minitab, SPSS, PASW Statistics or MATLAB.

Employer engagement and vocational contexts

Learners will benefit from visits to industrial and research facilities to observe practical applications of data analysis, or to gain access to learning materials.

Unit 25: Plant Physiology and Environmental Adaptation

Unit code: R/601/0299

Level: 5

Credit value: 15

Aim

This unit provides learners with an understanding of plants and their habitats and the environmental issues which can affect their survival. Learners also develop skills in assessing the use of plants in environmental restoration.

Unit abstract

This unit enables learners to explore the main areas of plant anatomy and their functions. This knowledge can then be used to look at how xerophytic and hydrophytic plant species have become adapted to their particular habitats. Following on from this, learners will use the information to understand how plants can be used in habitat formation, restoration, maintenance and regeneration.

The underlying science is studied along with its application in conservation projects locally and nationally.

The role of genetics is considered from the point of view of genetic manipulation and its usefulness to society. This includes the interbreeding of genetically modified and natural species and the effect this could have on the natural population.

Visits to centres engaged in conservation and site visits form an essential part of this unit.

It is envisaged that learners will have the opportunity to gain practical experience in maintaining and monitoring sites and working with interested groups, be they farmers, ecologists or conservationists.

Learning outcomes

On successful completion of this unit a learner will:

1 Understand plant anatomy in relation to physiological processes

2 Understand plant adaptation to extreme habitat type

3 Be able to investigate the use of plants in the environmental restoration of industrial and waste land

4 Understand the use of plant types in local re-vegetation and habitat maintenance sites.

Unit content

1 Understand plant anatomy in relation to physiological processes

Root type and structure: cell types and cellular arrangements; function of cell types in relation to the structure; water and mineral uptake and pathways followed; soil-plant-water relations

Stem structure: cell types and cellular arrangements; functions of cell types in relation to structure; specific mechanisms of transportation

Leaf structure: cellular arrangements in relation to functional capacity in terms of optimising photosynthesis; leaf morphology

Identification of the range and variation of plant anatomical arrangements: algae eg chlorophyta, phaeophyta, euglenophyta; bryophyta eg mosses; pteridophyta eg ferns; spermatophyta eg gymnosperms, angiosperms

2 Understand plant adaptation to extreme habitat type

Xerophytic: adaptation eg comparative anatomy and physiology of the root, stem and leaf structures; changes that result in physiological pathways

Hydrophytic: adaptation eg comparative anatomy and physiology of the root, stem and leaf structures; changes that result in physiological pathways

Plant classification: overview of plant species; the wide variety of life cycles and habitat dwellings eg in relation to their use in habitat restoration and maintenance

3 Be able to investigate the use of plants in the environmental restoration of industrial and waste land

Plants adapted to different habitats: types of habitat eg nutrient rich water, acid/alkaline soil, polluted soil, atmospheric pollution, dry conditions

Development of communities and ecosystems: assessment eg using local areas of interest, site assessment inclusions (soil sampling, toxicology, drainage), factors affecting the choice of typical soil and native plant species, community/public use of site post restoration, maintenance requirements

Typical plant species: classification eg indigenous to the area, typical of the habitat type, plant interrelations and long-term survival for biodiversity establishment

Local agenda 21: worldwide origins; local groups; aims and objectives; implementation in the UK; effects of agenda 21

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4 Understand the use of plant types in local re-vegetation and habitat maintenance sites

Characteristics for plant type selection: ability to survive environmental factors eg drainage, weathering, general climatic fluctuations, soil characteristics, surrounding foliage type; theoretical interpretations of different maintenance techniques for different site types eg Sites of Special Scientific Interest (SSSI), natural re-vegetation site, low maintenance techniques

Current technology: application eg use of plant species for rectifying sites of toxicity, harmful run off

Farm conservation and biodiversity: policies of alternative site use, the interaction of standard farm practices with habitat creation and maintenance eg hedgerows, aquatic areas, SSSI corners; incentives available to farmers to create and maintain such sites within their farm lands; personnel skills and educational aspects for dealing with introduction of ideas; the use of farm sites in local authority research

Plant genetics and habitats: the theoretical interpretation of genetically modified species and their usefulness in society; the interrelationship of natural and modified species; the effect on the natural population of plant species in terms of interbreeding and species dominance; public opinion on genetically modified plants

Learning outcomes and assessment criteria

Learning outcomes **On successful completion of this unit a learner will:**	Assessment criteria for pass **The learner can:**
LO1 Understand plant anatomy in relation to physiological processes	1.1 explain the functions of root type and structure 1.2 discuss stem structure in relation to functions 1.3 explain the functions of leaf form and structure 1.4 identify the major anatomical arrangements in a range of plant groups
LO2 Understand plant adaptation to extreme habitat type	2.1 discuss xerophytic adaptation to habitat compared to the mesophytic plant form 2.2 explain hydrophytic adaptation to habitat in comparison with the mesophytic plant form 2.3 explain how to identify plants using binomial classification keys
LO3 Be able to investigate the use of plants in the environmental restoration of industrial and waste land	3.1 assess the adaptations shown by plants to different habitats 3.2 discuss how a site is assessed to encourage the development of animal and plant species for long-term biodiversity survival 3.3 carry out a survey of typical plant species indigenous to a local area 3.4 explain the effects of Local Agenda 21
LO4 Understand the use of plant types in local re-vegetation and habitat maintenance sites	4.1 explain the plant characteristics which need to be taken into account when selecting for planting in a variety of sites 4.2 discuss how current technology is used to combat the effect of a damaged site 4.3 assess the role of farm conservation and management in enhancing indigenous biodiversity 4.4 assess the role of plant genetics in habitat construction or destruction.

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Guidance

Links

This unit has particular links with the following units within this qualification:

- Unit 1: Cell Biology
- Unit 3: Physiology of Cellular Systems in Animals
- Unit 20: Ecological Principles and their Application
- Unit 23: Biodiversity, Conservation and Threats.

Essential requirements

Delivery

This unit is designed to enable learners to examine practical evidence wherever possible. Centres are encouraged to develop links with local environmental centres, agencies, conservation groups, councils and research centres. Delivery of the unit must be based on learner interaction and participation in practical techniques.

Learning outcome 1 is best delivered using practical laboratory work supported by theoretical input. Learners must be taught to interpret the plant structures seen and practical exercises can be used to reinforce the learning process. The use of visual material is recommended as an aid to learning, for example when learners are looking at plant types such as algae, gymnosperms.

The use of visual texts and actual species is expected in delivery of learning outcome 2. Visits to sites where plants can be seen or the use of video material can prepare learners for future fieldwork. Learners must be familiar with the use of classification keys for the naming of specific examples. Learners must be able to classify to genus, species level. Emphasis is on the use of the keys and the relevance to fieldwork.

Where possible, learners should conduct their own literature searches to investigate current techniques being used within local establishments, providing evidence for learning outcome 3. Again, practical work at local sites is essential to make learner research relevant to real situations.

This also applies to learning outcome 4, where site visits and practical discussions, along with some theoretical delivery help to make theory and practical investigations vocationally relevant.

Health and safety protocols must be followed closely when delivering this unit.

Assessment

Learners must be able to demonstrate a clear understanding of the major physiological processes that occur in plants and relate their structure and adaptation to the habitat type. Through understanding these concepts learners will be able to interpret the use of plants in habitat formation and maintenance. The unit is also designed to enable learners to come into contact with many common species, so improving the identification of species as a secondary skill.

Resources

Current plant and environmental journals, papers and magazines are essential for current techniques and research, as are plant identification guides.

Some specialist lectures would enhance more detailed aspects of the unit. University department websites are a useful source of information and they often publish their research and results or a summary of them. Likewise local authority websites, under conservation or ecology, often contain a section on their work which covers aspects of this unit and often refers to agenda 21.

The ability to transport learners to local sites to carry out survey work and habitat assessments is needed.

Employer engagement and vocational contexts

Visits to centres engaged in conservation and site visits are essential parts of this unit. Contact with employers is vital if learners are to use such facilities.

Visits to laboratories at a local university to see the structures visible using electron microscopes etc would be valuable. Local farmers and conservation groups welcome interested groups especially if they can join in with some activities.

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Unit 26: Quality Assurance and Quality Control

Unit code: F/601/0301

Level: 4

Credit value: 15

Aim

This unit reviews quality assurance and quality control measures. Learners are provided with an understanding of quality control and assurance procedures, methods of expressing quality and the benefits of accreditation.

Unit abstract

Laboratories carry out analysis for a number of reasons. For example, some laboratories support a manufacturing process while others are contracted by external organisations to carry out analysis. Analytical data must be sufficiently accurate for the customer to use. All laboratories have measures in place to ensure that results are fit for purpose.

In this unit learners will gain an understanding of the possible sources of inaccuracy within analytical processes and consider quality control measures required to improve data quality. The quality assurance procedures used to guarantee effective quality control are then reviewed. An efficient way of implementing quality assurance is to use a quality management system. Different quality management standards are examined along with how quality management systems are implemented. Finally, the benefits of external accreditation are reviewed.

Learning outcomes

On successful completion of this unit a learner will:

1 Understand how the quality of an analytical result may be expressed

2 Understand features of quality control and quality assurance

3 Understand quality management systems

4 Understand the accreditation process.

Unit content

1 Understand how the quality of an analytical result may be expressed

Features of quality: quality as closeness to the true value; accuracy; precision; repeatability; reproducibility

Different types of error: random; bias; reasons for error eg incompetence, calculation, transcription, unsuitable method used, contamination, extraction/sample preparation technique, interferences, calibration errors, sampling errors, losses and degradation; consequences of the reason for error

Minimising types of error: elimination of bias; minimisation of spread of random errors; ways of reducing error eg training, performing calculations on computer, system of double checking entry of data, method validation, steps to reduce contamination, optimising extraction/sample preparation, select method or modifying method to reduce interference, rigorous calibration procedures, validated sampling procedure, adequate sample storage

Distribution of results: mean result; distribution of results about mean; normal distribution curve; standard deviation from the mean; % results between $\pm 2\sigma$ and $\pm 3\sigma$

2 Understand features of quality control and quality assurance

Internal quality control measures: use of suitable quality materials; analysing blanks; analysing samples of known concentration/spiked samples; method validation; sampling method; sampling plan

External quality control measures: inter-laboratory comparisons; proficiency testing eg aquacheck, CONTEST, EQA, FAPAS, LEAO, MAPS, QMS, QWAS, RICE, WASP; benefits; organisation; quantification of performance eg z score, E_n number, Q score, organisms isolated and identified (microbiology)

Features of quality assurance: activities providing confidence that results are correct eg staff training, record keeping, data management, provision of adequate laboratory, appropriate storage for samples and materials, sample entry procedures, traceability, calibration, maintenance, ensuring validated methods are used; carrying out documented statistical analysis on data

Control charts: calculation of standard deviation; setting confidence limits; Sewhart Chart; Moving Average Chart; CUSUM chart; confidence limits; actions when results are outside confidence limits

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3 Understand quality management systems

Features of a quality management system: management structure; chain of responsibility; third party assessment; documentation; records eg calibration, validation, quality control; training; auditing; review; quality cycle

Quality management standards: ISO 9001; ISO/IEC 10725; ISO 15189; GLP; applicability to different types of laboratory

Operation of a quality management system: description specific to real workplace; quality manual; quality procedures; standard operation procedures; work instructions; locally held documents; records; controlled copies; audit eg internal, external; views eg management view of operation of processes, views of other staff of operation of processes, customer views; analysis eg analysis of data, records, audit report on reconciliation of processes, data and records

Differences between quality management systems: laboratories with different functions eg water analysis, food analysis, control of a manufacturing process, contract oil analysis, forensic, microbiological; laboratories of different sizes; allocation of roles of staff

4 Understand the accreditation process

Benefits of accreditation: benefits to business eg economic benefits, reputation and competitiveness, customer/laboratory relationships, reliability reduces risks; benefits to government eg simplification, common standard across range of laboratories, improved public confidence; benefits to the individual eg confidence in contributing to a service of proven high quality

Accreditation procedures: accreditation bodies eg United Kingdom Accreditation Service (UKAS), Clinical Pathology Accreditation (UK) Ltd, GLP Monitoring Authority; accreditation process eg UKAS (accreditation standard, application, pre-assessment visit, initial assessment visit, actions, approval, reassessment)

Influence of accreditation: effect on quality management system eg suggestions for improvement implemented ahead of planned time, greater emphasis on record keeping and maintenance of standard procedures; case study on an accredited laboratory

Learning outcomes and assessment criteria

Learning outcomes **On successful completion of this unit a learner will:**	Assessment criteria for pass **The learner can:**
LO1 Understand how the quality of an analytical result may be expressed	1.1 discuss features of the quality of analytical results 1.2 evaluate different types of error 1.3 explain how errors may be minimised 1.4 express the distribution of results in statistical terms
LO2 Understand features of quality control and quality assurance	2.1 explain internal quality control measures 2.2 review the benefits of external quality control 2.3 discuss the features of quality assurance 2.4 explain the use of control charts
LO3 Understand quality management systems	3.1 review the features of a quality management system 3.2 compare quality management standards 3.3 explain the operation of a quality management system 3.4 analyse the differences between quality management systems in two laboratories
LO4 Understand the accreditation process	4.1 explain the benefits of accreditation 4.2 discuss laboratory accreditation procedures 4.3 analyse how accreditation may influence the quality management system.

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Guidance

Links

This unit has particular links with the following units within this qualification:

- Unit 5: Analysis of Scientific Data and Information
- Unit 7: Laboratory Management
- Unit 27: Management of Projects
- Unit 28: Managing the Work of Individuals and Teams.

This unit also links with the following NOS:

- NVQ L4 Laboratory and Associated Technical Activities (LATA).

Essential requirements

Delivery

Learners who work in analysis will find many of the concepts covered in the unit straightforward and will be able to work on assignments with little direction. Learners who are not employed in an analytical laboratory will need to visit laboratories and discuss how they operate to maintain the high quality of their data. Repetitive analysis and simulation may support learner understanding. Although the emphasis is on analytical chemistry results, most of the features of quality management systems also apply to other types of analysis, for example microbiology. Technicians who do not carry out this type of analysis may still appreciate features such as statistical treatment of numerical results.

For learning outcome 1, learners must have experience of carrying out routine analysis. Where distribution of results is concerned, learners could be given data to analyse.

Visits to analytical laboratories will help learners who do not work in the industry to identify the features of quality control and quality assurance. Many UKAS accredited laboratories routinely use control charts.

The UKAS website provides useful information about the benefits of accreditation and the accreditation process. This can be supplemented by visiting speakers from a laboratory which has gone through the accreditation process.

Assessment

For learning outcome 1, learners must have a specific context in which to set their analysis, for example their workplace or the centre environment. Learners must complete tasks covering features of quality, different types of error and how errors may be minimised. Learners could be given data to analyse. Learners can then discuss how data follow a normal distribution curve or are skewed in some way. Ideally, the context used for learning outcome 1 will be used for the other learning outcomes.

For learning outcome 2, learners could produce a suitable document containing their reflections on the features of quality control and quality assurance apparent in a laboratory they are familiar with. Learners could then explain the actions taken when results fall outside the parameters set on control charts and how control charts are updated on a regular basis.

For learning outcome 3, learners will require case studies or observations from visits, on which to base their work and generate evidence towards meeting the assessment criteria.

For learning outcome 4, learners could carry out a case study. They could design and deliver a presentation explaining the benefits of accreditation, the accreditation process and how a quality management system may be affected by accreditation.

Resources

Learners require access to a laboratory where routine analysis can be performed.

Employer engagement and vocational contexts

Learners will benefit more from this unit if they work in an analytical laboratory or can visit a suitable laboratory. Details of the elements of a quality management system, and control of the analytical process, are more easily understood where learners have access to an industrial laboratory.

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Unit 27: Management of Projects

Unit code: J/601/0302

Level: 4

Credit value: 15

Aim

This unit provides an understanding and experience of project management principles, methodologies, tools and techniques that may be used in industry and the public sector.

Unit abstract

Management of projects is a key element to ensure successful scientific investigations related to academic research, company research and development or consultancy.

Through this unit learners will develop an understanding of what constitutes a project and the role of a project manager. They will examine the criteria for the success or failure of a project, evaluate project management systems and review the elements involved in project termination and appraisal.

Learners will also understand the need for structured organisation within the project team, effective control and coordination and good leadership qualities in the project manager. They will be able to analyse and plan the activities needed to carry out a project. This includes how to set up a project, how to control and execute a project, how to cost a project and how to carry out project reviews using a specialist project management software package. Together with factors associated with effecting project change, learners will also appreciate how the project fits into the strategy or business plan of an organisation.

Learning outcomes

On successful completion of this unit a learner will:

1 Understand the principles of project management

2 Be able to plan a project in terms of organisation and people

3 Be able to manage project processes and procedures.

Unit content

1 Understand the principles of project management

Project management: project management and the role of the project manager eg management of change, understanding of project management system elements and their integration, management of multiple projects, project environment and the impact of external influences on projects; identification of the major project phases and why they are required; understanding of the work in each phase; the nature of work in the lifecycles of projects in various industries

Success/failure criteria: the need to meet operational, time and cost criteria; define and measure success eg develop the project scope, product breakdown structure (PBS), work breakdown structure (WBS), project execution strategy and the role of the project team; consideration of investment appraisal eg use of discount cash flow (DCF) and net present value (NPV); benefit analysis and viability of projects; determine success/failure criteria; preparation of project definition report; acceptance tests

Project management systems: procedures and processes; knowledge of project information support (IS) systems; how to integrate human and material resources to achieve successful projects

Terminating the project: audit trails; punch lists; close-out reports

Post-project appraisals: comparison of project outcome with business objectives

2 Be able to plan a project in terms of organisation and people

Organisational structure: functional, project and matrix organisational structures eg consideration of cultural and environmental influences, organisational evolution during the project lifecycle; job descriptions and key roles eg the project sponsor, champion, manager, integrators; other participants eg the project owner, user, supporters, stakeholders

Roles and responsibilities: the need for monitoring and control eg preparation of project plans, planning, scheduling and resourcing techniques

Control and coordination: use of work breakdown structures eg to develop monitoring and control systems, monitoring performance and progress measurement against established targets and plans; project reporting; change control procedures; the importance of cascading; communications briefing; instilling trust and confidence in others

Leadership requirements: stages of team development eg Belbin's team roles, motivation and the need for team building, project leadership styles and attributes; delegation of work and responsibility; techniques for dealing with conflict; negotiation skills; chair meetings

Human resources and requirements: calculation; specification; optimisation of human resource requirements; job descriptions

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3 Be able to manage project processes and procedures

Project organisation: the product breakdown structure (PBS) and the work breakdown structure (WBS); project execution strategy and the organisation breakdown structure (OBS) eg preparation of organisational charts, task responsibility matrix, statement of work (SOW) for project tasks

Project management plans: the why, what, how, when, where and by whom of project management eg contract terms, document distribution schedules, procurement, establishing the baseline for the project

Scheduling techniques: relationship between schedules, OBS and WBS; bar charts; milestone schedules; network techniques; resourcing techniques; computer-based scheduling and resourcing packages; project progress measurement and reporting techniques; staff-hours, earned value and progress 'S' curves; critical path analysis and reporting; milestone trending

Cost control techniques: cost breakdown structure eg types of project estimate, resource needs, estimating techniques, estimating accuracy, contingency and estimation, bid estimates, whole-life cost estimates, sources of information, cost information sensitivity, computer-based estimating; allocation of budgets to packages of work; committed costs; actual costs; cash flow; contingency management

Performance: cost performance analysis eg budgeted cost for work scheduled (BCWS) budgeted cost for work performed (BCWP); concept of earned value; actual cost of work performed (ACWP); cost performance indicators

Change control procedures: the need for formal control of changes eg project impact of changes, principles of change control and configuration management; changes to scope, specification, cost or schedule; change reviews and authorisation; the formation of project teams; project initiation and start-up procedures

Recommendations: changes in relation to eg scope, specification, cost, improving reliability of outcomes

Learning outcomes and assessment criteria

Learning outcomes **On successful completion of this unit a learner will:**	Assessment criteria for pass **The learner can:**
LO1 Understand the principles of project management	1.1 explain the principles of project management 1.2 discuss viability of projects with particular emphasis on the criteria for success/failure 1.3 explore principles behind project management systems and procedures 1.4 explain key elements involved in terminating projects and conducting post-project appraisals
LO2 Be able to plan a project in terms of organisation and people	2.1 plan the most appropriate organisational structure 2.2 discuss roles and responsibilities of participants within a project 2.3 carry out the control and co-ordination of a project 2.4 document project leadership requirements and qualities 2.5 plan specific human resources and requirements for a project
LO3 Be able to manage project processes and procedures	3.1 design the project organisation with reference to prepared project management plans 3.2 use project scheduling and cost control techniques 3.3 report the methods used to measure project performance 3.4 report project change control procedures 3.5 discuss the outcomes of the project and make recommendations.

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Guidance

Links

This unit has particular links with the following units within this qualification:

- Unit 5: Analysis of Scientific Data and Information
- Unit 6: Project for Applied Science
- Unit 7: Laboratory Management
- Unit 8: Work-based Investigation
- Unit 26: Quality Assurance and Quality Control
- Unit 28: Managing the Work of Individuals and Teams.

Essential requirements

Delivery

This unit gives learners the opportunity to build on the concepts learned in *Unit 7: Laboratory Management*, by managing a 'live' project. Therefore a practical approach to delivery must be adopted.

For learning outcome 1, learners must choose their own project and outline their plan of action in writing. Tutors need to check their plans to ensure that the project is realistic and achievable before learners proceed. During the course of carrying out their project, learners should be allowed to make mistakes and learn from them. However, tutors may need to provide some guidance which should be recorded so that it can be taken into account when grading the unit.

It is important that learners do not spend too much time carrying out numerical work, or preparing or analysing large quantities of data. The analysis of data is an inevitable aspect of project management. It is best learned using pre-prepared examples in electronic form that enable the principles to be demonstrated quickly without oversimplifying the complexity of everyday project operations.

For the operation of complex proprietary computer software systems, project managers must know what to expect from these facilities, but are not necessarily expected to be able to operate them.

Project management principles and techniques are important, together with an appreciation of how the various operations within the project integrate with each other.

Learners must be given the opportunity to chair meetings.

Assessment

Although this unit may be linked with *Unit 6: Project for Applied Science*, the emphasis must be on the management of the project rather than the project itself. Where projects are carried out by small groups, the project manager must keep detailed records of each individual's performance in order to confirm achievement of the assessment criteria and to allow achievement to be audited.

For learning outcome 1, learners must demonstrate an understanding of the principles of project management and discuss the criteria for success or failure. This must also include recognition of the importance of selecting appropriate systems for the successful management and completion of the project.

Evidence for learning outcome 2 must include a plan where learners identify the most appropriate organisational structure for the project, highlighting the roles and responsibilities of those involved, including the project manager. In addition, there must be an account of how the project is controlled and coordinated.

A large part of the evidence for learning outcome 3 could be linked with that for learning outcome 2, ie design of the project organisation and scheduling. Reporting of the methods used to measure project performance and project control procedures could be incorporated into an overall evaluation of the exercise.

Resources

Appropriate software packages need to be used to demonstrate project control and reporting techniques which might include time and cost scheduling packages, documentation and procurement control packages, spreadsheet packages and graphic presentation packages.

Other packages, for items such as risk analysis, project accounting and procurement control, could be used to illustrate particular techniques in specific industries.

Access to real project data in electronic spreadsheet form would be an advantage.

Employer engagement and vocational contexts

Learners would benefit from visits to organisations engaged in project work as a part of academic research, research for public bodies, company research and development or consultancy activities.

An ideal situation would be for learners to manage a project of interest to a particular organisation.

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Unit 28: Managing the Work of Individuals and Teams

Unit code: R/601/0304

Level: 5

Credit value: 15

Aim

This unit develops learners' understanding and skills associated with managing the work of individuals and teams. It enhances the ability to motivate individuals and to maximise the contribution of teams to achieve outcomes.

Unit abstract

All scientific tasks are carried out by personnel working either as an individual or as a member of a team. The role of an individual can be defined by a job description that states responsibilities, objectives and performance targets.

At one or more stages during the execution of a task it is common to assess performance through an appraisal system designed to evaluate progress, motivate future performance and set new targets. A similar procedure would apply to teamwork and team performance.

In this unit learners will develop the skills associated with setting job descriptions and targets for individuals and teams and then review their performance.

Learning outcomes

On successful completion of this unit a learner will:

1 Be able to establish the objectives of individuals

2 Be able to evaluate the performance of individuals

3 Be able to establish the roles and responsibilities of teams

4 Be able to review the performance of teams.

Unit content

1 Be able to establish the objectives of individuals

Job description: analysis of jobs; behaviour; responsibilities and tasks; pay; bonus; incentives

Employee: any person working in the applied science sector with responsibility to a line manager

Roles: any specific activity or group of activities within the applied science sector

Responsibilities: direct and indirect relationships; relations between personal and team responsibility

Performance targets: personal; financial; quantity and quality; incorporation within a job description; setting and monitoring performance targets

2 Be able to evaluate the performance of individuals

Employee appraisal system: reasons for using performance appraisals eg to determine salary levels and bonus payments, promotion, establish strengths and areas for improvement, training needs, communication; establishing appraisal criteria eg production data, personnel data, judgemental data; rating methods eg ranking, paired comparison, checklist, management by objectives

Staff appraisal schedule: conduct of performance reviews eg by supervisor, peers, committee, subordinates or self-appraisal

Feedback of results: comments on positive and negative aspects of performance related to targets, conduct and timekeeping; resolution of conflicts

Encouragement: as a motivator for the achievement of performance targets eg strengths, rewards

3 Be able to establish the roles and responsibilities of teams

Teams: management teams and peer groups eg focus groups, task groups, project groups, panels; purpose of teams eg long and short term, specific project or task, seeking views within the company and from external sources, communication

Team responsibilities: to superiors; subordinates; the business; each other and external groups eg meeting performance targets, communicating results, confidentiality, deadlines

Targets: realistic deadlines; new and or amended outcomes

Internal team management: hierarchical; functional

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4 Be able to review the performance of teams

Team performance: appraisal systems; reasons for appraising team performance eg team effectiveness, contribution to business, constitution of team, identifying individual contributions to the team effort and determining the need to establish other team criteria

Performance criteria: formulate appropriate criteria eg outcome data, achieved improvements, employee morale, value added

Performance review: conduct a team performance review eg as individual manager, outside person; team self-appraisal; feedback of results and resolution of conflicts within the team

Team motivation: encouragement of overall team performance as a motivator for the achievement of objectives

Learning outcomes and assessment criteria

Learning outcomes **On successful completion of this unit a learner will:**	Assessment criteria for pass **The learner can:**
LO1 Be able to establish the objectives of individuals	1.1 identify the essential elements of a job description 1.2 design a job description for an employee 1.3 produce a schedule of the roles and responsibilities of individuals 1.4 agree performance targets for an individual
LO2 Be able to evaluate the performance of individuals	2.1 explore the key factors in establishing an employee appraisal system 2.2 develop a staff appraisal schedule for use by a manager 2.3 provide feedback to an individual who has undergone an appraisal 2.4 encourage an individual to achieve performance targets
LO3 Be able to establish the roles and responsibilities of teams	3.1 identify teams suitable for a variety of purposes 3.2 determine the responsibilities of teams to different personnel within an organisation 3.3 set suitable targets for teams 3.4 compare various types of internal team management
LO4 Be able to review the performance of teams	4.1 identify the reasons for appraising team performance 4.2 formulate the criteria by which the performance of different types of teams can be measured 4.3 conduct a performance review of a team 4.4 produce a report on the factors that are likely to motivate a team to achieve its defined objectives.

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Guidance

Links

This unit has particular links with the following units within this qualification:

- Unit 7: Laboratory Management.

This unit also links with the following NOS:

- NVQ L4 Laboratory and Associated Technical Activities (LATA).

Essential requirements

Delivery

Learners are generally expected to work individually. However, certain criteria may lend themselves to teamwork and, where this occurs, tutors should ensure that they keep sufficiently detailed records to enable an External Examiner to audit assessment. Learners must provide sufficient evidence to meet the assessment criteria on an individual basis.

Assessment

It is essential that learners have some experience of supervisory or management roles to benefit fully from the unit. Ideally, learners should be employed or have experience in an occupation which relates to the unit. Alternatively, suitable work-based experience is appropriate.

Resources

Learners must have access to a range of textbooks relating to human resources management in applied science-based settings. Suitable guest speakers should be invited to provide an overview of relevant aspects of the unit, which might include applications of personnel/human resource management, motivation, organisational structures, management and appraisal techniques.

Employer engagement and vocational contexts

Wherever possible, learners must base their examples on specific tasks and teamwork within local applied science-related industries. They should study the structure and activities of the company and, where possible, visit the company to witness practices and procedures relating to individual and group work, target setting and evaluation.

Unit 29: Nanotechnology

Unit code: K/601/0311

Level: 4

Credit value: 15

Aim

This unit examines the role of nanotechnology at the interface of Chemistry, Biology, Physics and Engineering, especially its use in achieving effects not possible in individual atoms or bulk materials.

Unit abstract

This unit provides learners with an introduction to the fundamental principles and commercial use of nanotechnology and embraces the interdisciplinary nature of the subject. Scientific theory relevant to the nanoscale is covered. Learners will also cover key concepts in engineering, physics, chemistry and biology and their application in solving nanotechnology problems.

Learners will develop practical skills and techniques to evaluate current nanotechnology fabrication methods. Current, and potential future, applications in energy, medicinal engineering, physics, chemistry, biology, electronics and computing are covered.

Learners will gain an appreciation of the commercial applications of nanotechnology and the challenges for the future.

Learning outcomes

On successful completion of this unit a learner will:

1 Know how structure controls properties at the nanoscale dimension

2 Understand key concepts in engineering, physics, chemistry, and biology used to solve nanotechnology problems

3 Be able to evaluate current nanotechnology fabrication methods

4 Know current and potential future commercial nanotechnology applications.

Unit content

1 Know how structure controls properties at the nanoscale dimension

'There's plenty of room at the bottom': benefits of reducing a problem to the nanoscale; the nanoscale paradigm

Nanoscience: definitions; history; current commercial applications; nanoscale science; technology principles

Control of properties: Carbon Nanotube Technologies (CNT) eg from diamond to graphite to graphene to buckminster-fullerene to CNT, fabricating and key applications of carbon allotropes

Lengthscale controls of electronic properties: quantum devices; quantum dots; quantum wires; quantum wells; quantum computing

2 Understand key concepts in engineering, physics, chemistry, and biology used to solve nanotechnology problems

Surface and colloid chemistry: principles of surface/colloid chemistry; function of surfaces in nanotechnology devices; colloid chemistry and particles in nanotechnology

Thin film applications: thin film deposition and characterisation processes; plasma deposition/surface treatment; applications of thin film technology

Chemical templating: soft chemical fabrication; templating molecules; sol-gel synthesis; opals and photonic crystals; 3-DOM materials

Quality control in nanofabrication: failure analysis; analysis and measurement techniques in nanoscience; imaging techniques eg SEM, SPM-AFM; surface and bulk materials analysis

3 Be able to evaluate current nanotechnology fabrication methods

Nanofabrication: routes eg nanolithography, thin film processes, MEMS and semiconductors, physical limits to UV, X-ray and e-beam lithography, self-assembly, bottom-up fabrication and outline of Complex Adaptive Systems

Polymers and organic molecules: polymer chemistry applications in nanotechnology; organic molecules and supramolecular chemistry; liquid crystal and flat panel displays

Technology review: case study of the commercial application of nanotechnology; the company; how nanotechnology addresses a need, the technology; product and market

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4 Know current and potential future commercial nanotechnology applications

Commercial applications: consumer markets for nanomaterials eg electronics, photonics, optoelectronics, magnetic data storage, MEMS/NEMS, nano-bio applications, computing technologies (present and future), nano-medicine

Moore's Law: semiconductors; history and future 1950-2020; material requirements for silicon; quantum effects (desired or not); nanofabrication techniques in semiconductors

Nanotechnology challenges: challenges eg skilled workforce, public and private investment, enhanced material risks of nanoparticles, public perception

Career prospects: nanotechnology career prospects eg materials science and processing, nano-bio applications, bioinformatics, nanomagnetics, quantum computing, IT

Learning outcomes and assessment criteria

Learning outcomes **On successful completion of this unit a learner will:**	Assessment criteria for pass **The learner can:**
LO1 Know how structure controls properties at the nanoscale dimension	1.1 describe the benefits of reducing a problem to the nanoscale 1.2 outline the definitions, history and current commercial applications of nanoscience 1.3 describe the control of properties by structure in the carbon allotropes 1.4 define the lengthscale controls of electronic properties
LO2 Understand key concepts in engineering, physics, chemistry, and biology used to solve nanotechnology problems	2.1 explain the principles of surface/colloid chemistry 2.2 discuss thin film deposition and characterisation processes 2.3 explain chemical templating 2.4 compare imaging techniques for quality control in nanofabrication
LO3 Be able to evaluate current nanotechnology fabrication methods	3.1 carry out an assessment of different nanofabrication routes to an assigned device design 3.2 plan commercial nanofabrication routes for the assigned device 3.3 produce a report assessing cost, quality and safety of the planned route 3.4 present the findings and make recommendations
LO4 Know current and potential future commercial nanotechnology applications	4.1 describe commercial applications of nanomaterials 4.2 state Moore's Law and materials requirements for its continuation in silicon to 2020 4.3 outline current challenges to nanotechnology 4.4 describe future growth areas in nanotechnology including career prospects.

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Guidance

Links

This unit has particular links with the following units within this qualification:

- Unit 30: Bioinformatics.

Essential requirements

Delivery

It is assumed that nanotechnology experimentation is not possible in the learning environment. However, any nanoscience that facilities and/or health and safety permit will be hugely beneficial, for example colours of solutions of CdSe nanoparticles of different sizes. Visits to a nanofabrication facility would also add interest and context to the unit content.

Delivery of learning outcome 1 must focus on how property and function are controlled by dimensionality and lengthscale. A historical context starting with Feynman's famous 'there's plenty of room at the bottom' lecture would be of great benefit.

For learning outcome 2, appreciation of complex three-dimensional structures should be reinforced by the use of computer 3D imagery where possible.

Learning outcome 3 requires a project-based review of a commercial application of nanotechnology. This must be a product or technology that is being prepared for market, but it does not have to be on the market yet. Learners must review the technology, the product and how nanotechnology meets a specific need. The report must focus on four key areas; the company, the nanofabrication technology, the nano-aspects of the product and the market.

For learning outcome 4, emphasis must be placed on the safety implications of working with nanosized particles. Appropriate software and ICT facilities should be used to encourage independent learning.

Assessment

For learning outcome 1, learners must demonstrate knowledge of the role structure and dimensionality play in determining the physical properties of nanostructures, and outline the history and current state of nanotechnology.

For learning outcome 2, learners must explain the underlying chemical and physical concepts in surface/colloid science, chemical templating and thin film deposition. They must assess the use of the various imaging techniques for quality control and the characterisation of typical structures each technique produces.

For learning outcome 3, learners could work individually or in small groups to produce a report and presentation. If group work is selected, each learner must provide sufficient evidence to meet the assessment criteria on an individual basis. The relative merits of various possible fabrication strategies should be evaluated. One of these strategies must be selected on the basis of this evaluation and then related commercial and safety implications assessed.

For learning outcome 4, learners must demonstrate knowledge of the current challenges and potential future directions of nanotechnology, and the materials implications for the continuation of Moore's Law over the next 10 years.

Resources

Learners need access to library and ICT resources to support unit delivery.

Employer engagement and vocational contexts

Learners will benefit from visits to laboratories engaged in investigations or research into nanotechnological processes, for example in chip or hard-disk fabrication, agri-food research or nano-medicine. This would enable learners to observe the application of nanofabrication techniques within a particular context.

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Unit 30: Bioinformatics

Unit code: M/601/0312

Level: 4

Credit value: 15

Aim

This unit enables learners to explore bioinformatics to develop a structured approach to biological data and a detailed understanding of the software tools needed for analysis.

Unit abstract

This unit will enable learners to appreciate that, over the past few decades, advances in genomic technology, coupled with major advances in the field of molecular biology, have led to an explosive growth in the biological information generated in the scientific community.

This expansion of genomic information has led, in turn, to the need for biological databases to store, organise and index the data, and for specialised tools to view and analyse the data.

In this unit learners will review key methods, data sources and the aims of bioinformatics, including its use in medical diagnosis and the treatment and prevention of genetic diseases.

Learners will gain an understanding of computational biology, data collection and the computer procedures required by biologists. They will gain a knowledge and understanding of how to manage biological databases and how to analyse data using appropriate software tools.

Learning outcomes

On successful completion of this unit a learner will:

1 Understand the aims, methods, data sources and applications of bioinformatics

2 Understand the processes of computational biology

3 Understand key features involved in building biological databases

4 Be able to carry out data analysis within the field of bioinformatics.

Unit content

1 Understand the aims, methods, data sources and applications of bioinformatics

Bioinformatics aims: aims eg finding out how living things work, modelling biological systems, making advances in understanding basic biological processes, making advances in diagnosis, treatment and prevention of genetic diseases

Bioinformatics applications: applications eg hypothesising about functions of newly discovered genes, predicting how the protein folds, modelling protein and metabolite working together to make the cell function, developing predictive methods to model function and phenotype of an organism based on its genome sequence

Methods: types eg representation, storage, organisation, manipulation, distribution and maintenance of data, design of data formats and databases, creation of tools to query databases, development of tools to ask complex questions about the data

Sources of biological data: technologies and research initiatives that are making increased amounts of data available eg nucleotide sequences, amino acid sequences, protein domains, protein structures

Impact: on biological sciences eg from a purely laboratory-based science to an information science, greater global perspective of 'informed' design of genomic experiments, future developments for biomedical scientists and medicine

2 Understand the processes of computational biology

Computational biology: computer procedures required by biologists; the process of analysing and interpreting genomic data; use of specialised tools to view and analyse data

Data collection: new approaches to data collection; quality standards for new data sets; human genome and other genome projects; parallel computing; micro array technology; using search engines to find biological information; the key role of the worldwide web

Data warehousing: data from many sources gathered together in a consistent and useful way

Data analysis: analysis of biological data; use of software techniques for finding patterns and regularities in data sets; extracting relevant information for a specific (biological) question

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3 Understand key features involved in building biological databases

Design of biological databases: design eg data capture, file formats, typical records within files, ease of access to stored data, complex interfaces to access existing data and submit new or revised data, software for database building

Management of biological databases: management eg submitting new or revised data, management of various types of information, database management strategies, database management systems, flat file and relational databases

Records within a file: types eg contact name, input sequence, type of molecule, scientific name of the source organism, literature citations

Types of biological database: types eg sequence, structure and specialised databases, public biological databases

Database resources: resources eg familiarity with the Protein Data Bank and GenBank, depositing data into public databases

4 Be able to carry out data analysis within the field of bioinformatics

Mathematical and statistical modelling: applying mathematical and statistical methods to analyse biological data

Data analysis: methods eg spreadsheet programmes (such as Excel) to create simple plots, sequence and gene expression analysis, accuracy of predictions

Software tools: pattern detection eg using Practical Extraction and Reporting Language (PERL) for efficient pattern detection, automated data analysis, familiarity with an assortment of available software, writing own programmes

Present information: format eg communication, organisation of biological information within a multi-disciplinary field, type

Learning outcomes and assessment criteria

Learning outcomes **On successful completion of this unit a learner will:**	Assessment criteria for pass **The learner can:**
LO1 Understand the aims, methods, data sources and applications of bioinformatics	1.1 explain the aims and applications of bioinformatics 1.2 discuss methods employed in informatics 1.3 discuss the impact of bioinformatics in the biological sciences
LO2 Understand the processes of computational biology	2.1 discuss computational processes for the collection and manipulation of data 2.2 discuss the need to extract only the information relevant to a specific biological question
LO3 Understand key features involved in building biological databases	3.1 summarise the design and management of biological databases 3.2 identify a range of records within a file 3.3 discuss the need for biological databases to store, organise and index basic biological processes 3.4 discuss the nature of new data available and the types of database and resources that might be used
LO4 Be able to carry out data analysis within the field of bioinformatics	4.1 apply mathematical and statistical methods to analyse biological data 4.2 use software tools for efficient pattern detection 4.3 present information clearly.

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Guidance

Links

This unit has particular links with the following units within this qualification:

- Unit 6: Project for Applied Science
- Unit 11: Applied Genetics of Industry, Agriculture and Medicine
- Unit 24: Statistics for Experimental Design.

Essential requirements

Delivery

The development of appropriate computer skills, especially in the correct use of software, must be encouraged whenever possible. Where appropriate, analysis of experimentally derived data must be attempted.

A case-study approach could be used to unify a number of themes, for example searching for a nucleotide string contained in a block of sequence data.

Assessment

Evidence for this unit could be provided by reporting on experimental work, such as DNA sequences or a protein structure. Use of experimentally derived data in case studies and interpretation exercises, literature searches and reviews would also be appropriate.

Resources

Learners will need access to computer facilities, appropriate software and library resources. The use of computer teaching programmes and CD ROM simulations of experiments must be encouraged.

Employer engagement and vocational contexts

Learners will benefit from visiting speakers engaged in bioinformatics research or processes. This would enable learners to appreciate the application of bioinformatics within a particular context and the required equipment and personnel.

Unit 31: Work-based Experience

Unit code: D/601/0998

Level: 5

Credit value: 15

Aim

This unit aims to enable learners to experience the scope and depth of learning which may take place in a work-based context by planning, monitoring and evaluating the work experience.

Unit abstract

A significant amount of learning can be achieved by carrying out practical activities in a workplace. Learning may be enhanced by taking a more formal approach to work-based activities – by planning, carrying out the activities and reflecting on the benefits of the activities for the business and learner.

This unit is designed to allow flexibility of study for part-time and full-time learners. It is expected that learners will be supervised in the workplace in addition to their academic supervisor.

Learners will have the opportunity, supported by their supervisors, to negotiate and perform activities which will allow them to meet the assessment criteria for this unit. They will recognise the scope of what they have achieved by recording evidence from carrying out the activities. They will also gain maximum benefit by reflecting on and evaluating the work they undertake.

Learning outcomes

On successful completion of this unit a learner will:

1 Be able to negotiate industry experience

2 Understand the specific requirements of the placement

3 Be able to undertake work experience as identified

4 Be able to monitor and evaluate own performance and learning.

Unit content

1 Be able to negotiate industry experience

Suitable organisation and location: types of establishments for placement eg industry-related work for a client brief at college, existing work environment, different department within current employer's business

Negotiation: methods of contacting organisations; methods of undertaking negotiations

Nature of duties: type of undertaking eg routine duties and tasks, project work, development of new procedures/protocol

Supervisors: roles and responsibilities of academic and industrial mentors

Expectations of learning: aims eg proficiency in new tasks and procedures, time management and problem solving skills, reflection, discuss progress with others, teamwork

Business constraints: consideration of possible limitations eg need to be fully trained, adherence to quality systems, health and safety considerations, supervision time, workload, customer satisfaction, limited staffing, cost of materials

2 Understand the specific requirements of the placement

Tasks: details of activities eg specific hourly, daily, weekly routine and non-routine tasks; breakdown of a project into stages; new procedures/protocol

Prioritise: reasons for rationalisation of the order of tasks; methods of prioritising work

Plan for the work experience: methods used to develop detailed plan with schedule of tasks; proposed dates for reviews; expected input from supervisors

Benefits to organisation and learner: advantages to business eg allowing more routine tasks to be carried out, allowing procedures/techniques to be developed, increasing responsiveness, identifying cost saving measures; advantages to learner eg understanding how a business operates, understanding importance of teamwork, learning new techniques, development of problem-solving and time management skills

3 Be able to undertake work experience as identified

Carry out the planned activities: realisation eg carrying out tasks and project work according to relevant legislation, training and codes of practice; developing new procedures or protocol

Record activities in the appropriate manner: systematic and appropriate recording of relevant activities eg logbook, diary, portfolio, spreadsheets, databases; list of resources

Revise the initial plan as required: methods used to review activities at the appropriate time to see if they meet requirements; make alterations as needed

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4 Be able to monitor and evaluate own performance and learning

Evaluation of the quality of the work undertaken: meeting industry standards and evaluating own performance against original proposal; comments/testimony from supervisors

Account of learning during the work experience: details of experience gained eg new procedures, interpersonal skills, time management, problem solving, teamwork; details of evidence eg portfolio of evidence, scientific report, management report

Recommendations on how the learning experience could have been enhanced: alternative ideas eg different location, different brief, different time period, more/less support, better time management, better preparation

Learning outcomes and assessment criteria

Learning outcomes **On successful completion of this unit a learner will:**	Assessment criteria for pass **The learner can:**
LO1 Be able to negotiate industry experience	1.1 research and evaluate suitable organisations that could provide industry experience 1.2 negotiate with work and academic supervisors a proposal for the work experience 1.3 recognise the business constraints on the work experience offered
LO2 Understand the specific requirements of the placement	2.1 agree and prioritise the tasks and responsibilities involved in the work experience 2.2 produce a plan for the work experience 2.3 analyse the benefits of the proposed activities to the business and the learner
LO3 Be able to undertake work experience as identified	3.1 fulfil specified requirements of placement conforming to all related codes of practice 3.2 produce systematic records of work undertaken 3.3 revise the initial plan as required 3.4 make suggestions for improvement and review these with appropriate supervisor
LO4 Be able to monitor and evaluate own performance and learning	4.1 monitor progress against original proposal 4.2 evaluate the quality of own performance 4.3 analyse the learning which has taken place during the work experience using suitable reflections 4.4 make recommendations on how the experience could have been enhanced.

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Guidance

Links

This unit has particular links with the following units within this qualification:

- Unit 32: Personal and Professional Development
- Unit 33: Employability Skills.

This unit also links with the following NOS:

- NVQ L4 Laboratory and Associated Technical Activities (LATA).

Essential requirements

Delivery

This unit differs from *Unit 8: Work-based Investigation* in that a significant part of this unit relates to negotiating a placement and researching the activities of the company. In *Unit 8: Work-based investigation,* the intention is to give credit to learners who are already industry-based and routinely develop applied science practical skills and theoretical knowledge through everyday company-based activities. The work used for this unit must not be used for *Unit 6: Project for Applied Science* or *Unit 8: Work-based Investigation*.

Given the work-based nature of this unit, the majority of resources will be those available to learners in the workplace. Work will normally be planned to be achievable within the resource constraints of the employer. Therefore knowledge of company structures and daily routines and expectations is essential.

Assessment

Tutor support and guidance are essential. Learners must remain in touch with tutors during the work experience. Email is often the best way but some centres may have access to a virtual learning environment where learners can share information and experiences with each other and the tutor.

Resources

Where possible learners must negotiate a placement in a local applied science-related industry or negotiate an applied science-related scheme of work at their centre of learning. In either case they must fully appreciate the role of their placement within the context of the company's business or the centre's activity.

Employer engagement and vocational contexts

Evaluation of learners' performance against set targets is a key aspect of the unit and must be undertaken in conjunction with both academic and industrial supervisors.

Unit 32: Personal and Professional Development

Unit code: T/601/0943

Level: 5

Credit value: 15

Aim

This unit aims to help learners become effective and confident, self-directed employees. This helps learners become confident in managing their personal and professional skills to achieve personal and career goals.

Unit abstract

This unit is designed to enable learners to assess and develop a range of professional and personal skills in order to promote future personal and career development. It also aims to develop learners' ability to organise, manage and practise a range of approaches to improve their performance as self-directed learners in preparation for work or further career development.

The unit emphasises the needs of the individual but within the context of how the development of self-management corresponds with effective team management in meeting objectives.

Learners will be able to improve their own learning, be involved in teamwork and be more capable of problem solving through the use of case studies, role play and real-life activities.

Learning outcomes

On successful completion of this unit a learner will:

1 Understand how self-managed learning can enhance lifelong development

2 Be able to take responsibility for own personal and professional development

3 Be able to implement and continually review own personal and professional development plan

4 Be able to demonstrate acquired interpersonal and transferable skills.

Unit content

1 Understand how self-managed learning can enhance lifelong development

Self-managed learning: self-initiation of learning processes; clear goal setting eg aims and requirements, personal orientation achievement goals, dates for achievement, self-reflection

Learning styles: personal preferences; activist; pragmatist; theorist; reflector eg reflexive modernisation theory; Kolb's learning cycle

Approaches: learning through research; learning from others eg mentoring/coaching, seminars, conferences, secondments, interviews, use of the internet, social networks, use of bulletin boards, news groups

Effective learning: skills of personal assessment; planning, organisation and evaluation

Lifelong learning: self-directed learning; continuing professional development; linking higher education with industry, further education, Recognition of Prior Learning, Apprenticeships, Credit Accumulation and Transfer Schemes

Assessment of learning: improved ability range with personal learning; evidence of improved levels of skill; feedback from others; learning achievements and disappointments

2 Be able to take responsibility for own personal and professional development

Self-appraisal: skills audit (personal profile using appropriate self-assessment tools); evaluating self-management; personal and interpersonal skills; leadership skills

Development plan: current performance; future needs; opportunities and threats to career progression; aims and objectives; achievement dates; review dates; learning programme/activities; action plans; personal development plan

Portfolio building: developing and maintaining a personal portfolio

Transcripts: maintaining and presenting transcripts including curriculum vitae

3 Be able to implement and continually review own personal and professional development plan

Learning styles and strategies: types of styles; awareness of own personal style; impact of personal style and interactions with others

Learning from others: formal learning and training; observation; mentoring; supervision; tutorials; informal networks; team members; line managers; other professionals

Evaluation of progress: setting and recording of aims and objectives; setting targets; responding to feedback; re-setting aims and targets; establishing and recognising strengths and areas for improvement; directions for change; cycles of activity (monitoring, reflecting and planning)

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4 Be able to demonstrate acquired interpersonal and transferable skills

Transferable skills: personal effectiveness (ability to communicate effectively at all levels, initiative, self-discipline, reliability, creativity, problem solving)

Verbal and non-verbal communication: effective listening, respect for others' opinions; negotiation; persuasion; presentation skills; assertiveness; use of ICT

Delivery formats: ability to deliver transferable skills using a variety of formats

Working with others: team player; flexibility/adaptability; social skills

Time management: prioritising workloads; setting work objectives; using time effectively; making and keeping appointments; reliable estimates of task time

Learning outcomes and assessment criteria

Learning outcomes **On successful completion of this unit a learner will:**	Assessment criteria for pass **The learner can:**
LO1 Understand how self-managed learning can enhance lifelong development	1.1 evaluate approaches to self managed learning 1.2 propose ways in which lifelong learning in personal and professional contexts could be encouraged 1.3 evaluate the benefits of self-managed learning to the individual and organisation
LO2 Be able to take responsibility for own personal and professional development	2.1 evaluate own current skills and competencies against professional standards and organisational objectives 2.2 identify own development needs and the activities required to meet them 2.3 identify development opportunities to meet current and future defined needs 2.4 devise a personal and professional development plan based on identified needs
LO3 Be able to implement and continually review own personal and professional development plan	3.1 discuss the processes and activities required to implement the development plan 3.2 undertake and document development activities as planned 3.3 reflect critically on own learning against original aims and objectives set in the development plan 3.4 update the development plan based on feedback and evaluation
LO4 Be able to demonstrate acquired interpersonal and transferable skills	4.1 select solutions to work-based problems 4.2 communicate in a variety of styles and appropriate manner at various levels 4.3 evaluate and use effective time management strategies.

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Guidance

Links

This unit has particular links with the following units within this qualification:

- Unit 33: Employability Skills.

This unit also links with the following NOS:

- NVQ L4 Laboratory and Associated Technical Activities (LATA).

Essential requirements

Delivery

Activities carried out in this unit could be part of the mainstream academic activity and could be integrated into the whole programme of study. Learners would benefit from regular review meetings, and where appropriate, linking the delivery of learning outcomes from this unit to other units.

Assessment

A personal development portfolio or progress file must be put together for all information and personal records 'owned' by the learner, including the planning and monitoring of progress towards the achievement of personal objectives. The method for this could be web based, paper based or other. Potentially this could form the basis of an extended record of a lifelong record of learning and achievement.

Resources

There are no essential resource requirements for this unit.

Employer engagement and vocational contexts

In developing material for this unit, learners should consider any applied science industrial placements or work experience that they may have undertaken in the course of their studies.

Unit 33: Employability Skills

Unit code: A/601/0992

Level: 5

Credit value: 15

Aim

This unit provides learners with the opportunity to acquire honed employability skills required for effective employment.

Unit abstract

All learners at all levels of education and experience require honed employability skills as a prerequisite to entering the job market. This unit gives learners an opportunity to assess and develop an understanding of their own responsibilities and performance in, or when entering, the workplace.

It considers the skills required for general employment, such as interpersonal and transferable skills, and the dynamics of working with others in teams or groups including leadership and communication skills.

It also deals with the everyday working requirement of problem solving which includes the identification or specification of the 'problem', strategies for its solution and then evaluation of the results through reflective practices.

Learning outcomes

On successful completion of this unit a learner will:

1 Be able to determine own responsibilities and performance

2 Be able to develop interpersonal and transferable skills

3 Understand the dynamics of working with others

4 Be able to develop strategies for problem solving.

Unit content

1 Be able to determine own responsibilities and performance

Own responsibilities: personal responsibility; direct and indirect relationships and adaptability, decision-making processes and skills; ability to learn and develop within the work role; employment legislation, ethics, employment rights and responsibilities

Performance objectives: setting and monitoring performance objectives

Individual appraisal systems: uses of performance appraisals eg salary levels and bonus payments, strengths and areas for improvement, training needs; communication; appraisal criteria eg production data, personnel data, judgemental data; rating methods eg ranking, paired comparison, checklist, management by objectives

Motivation and performance: application and appraisal of motivational theories and techniques, rewards and incentives, manager's role, self-motivational factors

2 Be able to develop interpersonal and transferable skills

Effective communication: verbal and non-verbal eg awareness and use of body language, openness and responsiveness, formal and informal feedback to and from colleagues; ICT as an effective communication medium; team meetings

Interpersonal skills: personal effectiveness; working with others; use of initiative; negotiating skills; assertiveness skills; social skills

Time management: prioritising workload; setting work objectives; making and keeping appointments; working steadily rather than erratically; time for learning; reliable estimate of task time

Problem solving: problem analysis; researching changes in the workplace; generating solutions; choosing a solution

3 Understand the dynamics of working with others

Working with others: nature and dynamics of team and group work; informal and formal settings, purpose of teams and groups eg long-term corporate objectives/strategy; problem solving and short-term development projects; flexibility/adaptability; team player

Teams and team building: selecting team members eg specialist roles, skill and style/approach mixes; identification of team/work group roles; stages in team development eg team building, identity, loyalty, commitment to shared beliefs, team health evaluation; action planning; monitoring and feedback; coaching skills; ethics; effective leadership skills eg setting direction, setting standards, motivating, innovative, responsive, effective communicator, reliability, consistency

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4 Be able to develop strategies for problem solving

Specification of the problem: definition of the problem; analysis and clarification

Identification of possible outcomes: identification and assessment of various alternative outcomes

Tools and methods: problem-solving methods and tools

Plan and implement: sources of information; solution methodologies; selection and implementation of the best corrective action eg timescale, stages, resources, critical path analysis

Evaluation: evaluation of whether the problem was solved or not; measurement of solution against specification and desired outcomes; sustainability

Learning outcomes and assessment criteria

Learning outcomes **On successful completion of this unit a learner will:**	Assessment criteria for pass **The learner can:**
LO1 Be able to determine own responsibilities and performance	1.1 develop a set of own responsibilities and performance objectives 1.2 evaluate own effectiveness against defined objectives 1.3 make recommendations for improvement 1.4 review how motivational techniques can be used to improve quality of performance
LO2 Be able to develop interpersonal and transferable skills	2.1 develop solutions to work based problems 2.2 communicate in a variety of styles and appropriate manner at various levels 2.3 identify effective time management strategies
LO3 Understand the dynamics of working with others	3.1 explain the roles people play in a team and how they can work together to achieve shared goals 3.2 analyse team dynamics 3.3 suggest alternative ways to complete tasks and achieve team goals
LO4 Be able to develop strategies for problem solving	4.1 evaluate tools and methods for developing solutions to problems 4.2 develop an appropriate strategy for resolving a particular problem 4.3 evaluate the potential impact on the business of implementing the strategy.

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Guidance

Links

This unit has particular links with the following units within this qualification:

- Unit 6: Project for Applied Science
- Unit 31: Work-Based Experience
- Unit 32: Personal and Professional Development.

This unit also links with the following NOS:

- NVQ L4 Laboratory and Associated Technical Activities (LATA).

Essential requirements

Delivery

Access to a range of work-related exemplars (for example appraisal and development systems, team health checks, job descriptions, action plans, communication strategies) would help in delivering this unit. Case studies based on relevant sectors, workshops, career talks, and work-based mentors would also be useful in the teaching and learning aspect of the unit.

Assessment

Learners can generate assessment evidence through a range of possible activities including individual work placements, project management, research reports, development of case studies, working with others (for example employee – supervisor roles, teamwork, group work) and everyday communication within the workplace.

Resources

There are no essential resource requirements for this unit.

Employer engagement and vocational contexts

In developing material for this unit, learners must consider any applied science industrial placements or work experience that they may have undertaken in the course of their studies.

Unit 34: Pathology for the Laboratory Scientist

Unit code: L/616/9158

Level: 5

Credit value: 15

Aim

This unit provides an understanding of the fundamental principles of general pathology and the way biological specimens are investigated. Learners will develop knowledge of how cells and tissues react under pathological conditions. Furthermore, learners will develop skills and techniques relevant to the examination and analysis of pathological samples.

Unit abstract

This unit introduces the principles of general pathology for the laboratory scientist. It focuses on the way cells and tissues react to pathological processes, which includes cell injury and death, circulatory disturbances, inflammation and repair and disturbances of growth and neoplasia. This unit will enable learners to appreciate key principles in general pathology as well as aspects of systemic pathology. An introduction to cellular pathology will give the learner valuable insights into how cells and tissues change under pathological conditions. Mechanisms that lead to cell adaptation, cell growth and differentiate will be explored, using specific examples. Diseases of the cardiovascular system and the lymphatic system will be used to illustrate the processes that lead to pathological conditions. Learners will also gain insights into the way numerous factors can affect the results of pathological examinations.

Learners will gain knowledge of techniques used to analyse tissues and cells under pathological conditions. The unit will give an overview of biological specimen acquisition, handling, preparation and histological examination. Furthermore, an introduction into specialised methods, eg immunofluorescence and immunochemistry will be provided. Learners will learn how to perform and apply basic techniques in the analysis of biological samples. To this aim an introduction into analytical clinical pathology techniques like chromatography, colorimetry and electrophoresis will be given. Emphasis will be put on the analysis of key biological indicators, eg blood sugar or creatinine cholesterol, which are routinely used in clinical pathology to distinguish healthy from pathological states.

An important aspect of the unit is for learners to understand the need to work safely and accurately, adhering to established laboratory protocols and safety guidelines.

On successful completion of this unit a learner will:

1 Understand the principles of general pathology

2 Understand the key areas of systemic pathology

3 Understand key features of histopathology and its link with the major laboratory techniques

4 Understand the concepts of clinical and chemical pathology for the biologist

Unit content

1 Understand the principles of general pathology

Factors affecting different pathological results: eg age, gender, metabolic rate, race drugs taken

Concept of pathology: define concept of pathology; divisions of pathology; importance of pathology in biology

Cellular pathology: cellular adaptation; cellular growth; cell differentiation; hyperplasia; hypertrophy; atrophy; metaplasia

2 **Understand the key areas of systemic pathology**

Tissue changes: in cellular level and tissue level in various pathological conditions

Hypertensive vascular diseases: arthrosclerosis; arteriosclerosis; veins and lympathics; varicose veins

Heart failure: myocardial infarction; systemic hypertension; anemia; chronic lympocytic leukemia; acute lymphoblastic leukemia

3 **Understand key features of histopathology and its link with the major laboratory techniques**

Handling specimens: collection of specimens; labelling of specimens; documentation; fixation

Cutting and staining: cutting and staining the specimens

Staining techniques: use of special stains; immunochemistry; immunofluorescence

Cytological techniques: including FNAC – preparation, staining, reporting autopsy techniques, grossing

4 **Understand the concepts of clinical and chemical pathology for the biologist**

Examination: of urine, blood and other body fluids, stool

Fundamental techniques of clinical pathology: colorimetry; chromatography; electrophoresis

Estimation of the samples: blood sugar, urea, creatinine, proteins, bilirubin, cholesterol, uric acid, electrolytes, eg calcium, potassium and sodium ions

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Learning outcomes and assessment criteria

Learning outcomes **On successful completion of this unit a learner will:**	Assessment criteria for pass **The learner can:**
LO1 Understand the principles of general pathology	1.1 describe at least two factors that affect pathological results 1.2 define different divisions of pathology 1.3 appraise the importance of pathology in biological sciences 1.4 describe mechanisms by which cells adapt, grow and differentiate under pathological conditions
LO2 Understand the key areas of systemic pathology	2.1 describe, on a cellular and tissue level, the changes that occur under specific pathological conditions 2.2 describe pathological changes in the cardiovascular and lymphatic system 2.3 describe pathological changes in the blood
LO3 Be able to identify key features of histopathology and its link with the major laboratory techniques	3.1 describe procedures relevant to the acquisition, preparation and cataloguing of samples 3.2 describe techniques used for cutting, staining and examination of histological samples 3.3 describe procedures used in specific cytological techniques
LO4 Understand the concepts of clinical and chemical pathology for the biologist	4.1 describe procedures relevant to the examination of biological samples 4.2 apply basic techniques in the analysis of biological specimens 4.3 compare data for key biological and biochemical indicators under healthy and pathological conditions

Assessment guidance

Learning outcome 1 involves the understanding of principles of general pathology and factors that affect pathological results. Furthermore, the learner will need to describe, how cells grow, differentiate and adapt under pathological conditions.

Learning outcome 2 focuses on the changes that occur in cells and tissues under pathological conditions. Evidence will be mainly in written form and may involve general reviews or be integrated with evidence from outcome 3.

Learning outcome 3 involves the application of the knowledge and principles from outcomes 1 and 2 to a broad range of common laboratory techniques in the analysis of pathological samples. The evidence will be in written form and will include laboratory studies and use of case studies and laboratory based exercises.

Learning outcome 4 involves carrying out laboratory investigations, selecting appropriate methods in a laboratory situation, handling medical specimens safely, interpreting results from a range of laboratory methods and applying them to medical situations or case histories.

The use of patient case histories in either a tutorial or laboratory based exercise may allow learners to apply the knowledge gained from many aspects of the unit and allow generation of evidence covering several learning outcomes. Evidence must also include practical work carried out by the learners. The techniques used will depend on the equipment available in the learning centre but should encompass a range of identification and diagnostic techniques.

Resources

Textbooks

HARMENING, D.M. (2007) *Laboratory Management: Principles and Processes*. 2nd Ed. D.H. Pub. & Consulting.

HUDSON, J. (2003) *Principles of Clinical Laboratory Management: A Study Guide and Workbook*. 1st Ed. Pearson.

KINKUS, C.A. (2011) *Laboratory Management: Quality in Laboratory Diagnosis (Diagnostic Standards o f Care).* 1st Ed. Demos Medical Publishing.

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