BTEC

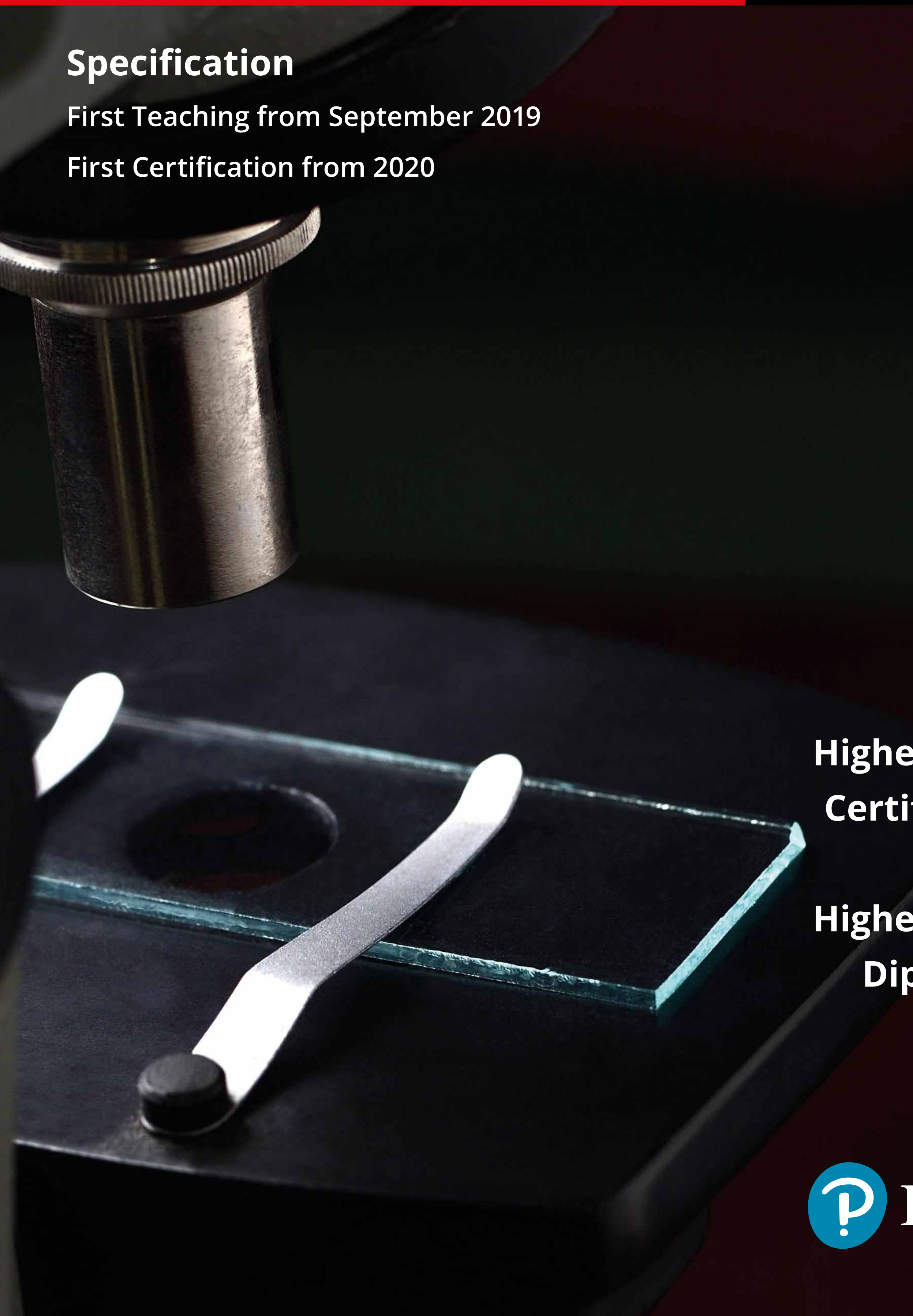
HIGHER NATIONALS

Applied Sciences

Specification

First Teaching from September 2019

First Certification from 2020



Higher National Certificate Lvl 4

Higher National Diploma Lvl 5

Pearson

About Pearson

We are the world's leading learning company operating in countries all around the world. We provide content, assessment and digital services to learners, educational institutions, employers, governments and other partners globally. We are committed to helping equip learners with the skills they need to enhance their employability prospects and to succeed in the changing world of work. We believe that wherever learning flourishes so do people.

References to third party material made in this specification are made in good faith. Pearson does not endorse, approve or accept responsibility for the content of materials, which may be subject to change, or any opinions expressed therein. (Material may include textbooks, journals, magazines and other publications and websites.)

All information in this specification is correct at time of publication.

Original image by recklessstudios/Shutterstock.com

ISBN 978 1 446 95965 7

Summary of changes in Pearson BTEC Higher Nationals in Applied Sciences Issue 6

Summary of changes made between previous issue and this current issue	Page number
Addition of specialist optional *Unit 73: Environmental Pollutants and Water Testing* to the qualification, including structure tables in Section 4.	772
10 Pearson BTEC Higher Nationals in Applied Sciences Units Revision of 1 existing unit: *Unit 70: Histology and Haematology* Addition of 1 new unit: *Unit 73: Environmental Pollutants and Water Testing*	 740 772
Appendix 2: HNC/HND Applied Sciences programme outcomes for students mapped to FHEQ level 5 descriptors Added mapping of *Unit 73: Environmental Pollutants and Water Testing*	 794
Appendix 5: Transferable skills mapping Added mapping of *Unit 73: Environmental Pollutants and Water Testing*	 807
Appendix 6: Pearson BTEC Level 5 Higher National Diploma in Applied Sciences Mapped to the Apprenticeship Standard Level 5 Technician Scientist Added mapping of *Unit 73: Environmental Pollutants and Water Testing*	 813

If you need further information on these changes or what they mean, contact us via our website at: qualifications.pearson.com/en/support/contact-us.html.

Contents

1 Introduction

BTEC is one of the world's most recognised applied learning brands, engaging students in practical, interpersonal and thinking skills for more than thirty years.

BTECs are work-related qualifications for students taking their first steps into employment, or for those already in employment and seeking career development opportunities. BTECs provide progression into the workplace, either directly or via study at university, and are also designed to meet employers' needs. Therefore, Pearson BTEC Higher National qualifications are widely recognised by industry and higher education as the principal career-related qualification at Levels 4 and 5.

When developing the Pearson BTEC Higher National qualifications in Applied Sciences, we collaborated with a wide range of students, employers, higher education providers, colleges and subject experts to ensure that the new qualifications meet their needs and expectations. We also worked closely with relevant professional bodies, to ensure alignment with recognised professional standards.

There is now a greater emphasis on employer engagement and work readiness. The new Pearson BTEC Higher National qualifications in Applied Sciences are designed to reflect this increasing need for high quality professional and technical education pathways at Levels 4 and 5, thereby providing students with a clear line of sight to employment and to progression to a degree at Level 6.

1.1 The student voice

Students are at the heart of what we do. That is why, from the outset, we consulted with students in the development of these qualifications. We involved them in writing groups, sought their feedback, and added their voices and views to those of other stakeholders.

The results, we believe, are qualifications that will meet the needs and expectations of students worldwide.

1.2 Why choose Pearson BTEC Higher Nationals?

Pearson BTEC Higher Nationals are designed to help students secure the knowledge skills and behaviours needed to succeed in the workplace. They represent the latest in professional standards and provide opportunities for students to develop behaviours for work, for example by undertaking a group project, or responding to a client brief. A student may even achieve exemption from professional or vendor qualifications, or student membership of selected professional bodies, to help them on their journey to professional competence.

At the same time, the Pearson BTEC Higher Nationals are intended to keep doors open for future study should a student wish to progress further in their education after their Level 5 study. They do this by allowing space for the development of higher education study skills, such as the ability to research. Clear alignment of level of demand with the Framework for Higher Education qualification descriptors at Level 4 and Level 5 means that students wishing to progress to Level 6 study should feel better prepared. The Pearson BTEC Higher Nationals address these various requirements by providing:

- a range of core, optional and specialist units, each with a clear purpose, so there is something to suit each student's choice of programme and future progression plans
- fully revised content that is closely aligned with the needs of employers, professional bodies, vendors and higher education for a skilled future workforce
- the opportunity to develop transferable skills useful for work and for higher education, including research skills, the ability to meet deadlines and communication skills'
- learning Outcomes mapped against the Technician Scientist apprenticeship standard requirements
- assessments and projects chosen to help students progress to the next stage (this means some are set by the centre to meet local needs, while others are set by Pearson); students are required to apply their knowledge to a variety of assignments and activities, with a focus on the holistic development of practical, interpersonal and higher-level thinking skills
- an approach to demand at Level 4 and Level 5 which is aligned with the Framework for Higher Education Qualifications (FHEQ)
- support for students and tutors, including Schemes of Work and Example Assessment Briefs.

1.3 HN Global

Pearson BTEC Higher Nationals are supported by a specially designed range of digital resources, to ensure that tutors and students have the best possible experience during their course. These are available from the HN Global website, www.highernationals.com

With HN Global, tutors can access Programme Specifications which contain useful information on programme planning and quality assurance processes. Tutors can also view Schemes of Work and Example Assessment Briefs, helping them create meaningful courses and assessments. HN Global also allows tutors to create and annotate reading lists for their students and keep up-to-date on the latest news regarding HN programmes.

1.4 Qualification titles

Pearson BTEC Level 4 Higher National Certificate in Applied Sciences

Specialist pathways are included within brackets in the qualification title:

- Pearson BTEC Level 4 Higher National Certificate in Applied Sciences (Biology)
- Pearson BTEC Level 4 Higher National Certificate in Applied Sciences (Forensic Science)
- Pearson BTEC Level 4 Higher National Certificate in Applied Sciences (Chemistry)
- Pearson BTEC Level 4 Higher National Certificate in Applied Sciences (Environmental Science)
- Pearson BTEC Level 4 Higher National Certificate in Applied Sciences (Food Science, Technology and Nutrition)
- Pearson BTEC Level 4 Higher National Certificate in Applied Sciences (Polymer Science and Technology).

Pearson BTEC Level 5 Higher National Diploma in Applied Sciences

Specialist pathways are included within brackets in the qualification title:

- Pearson BTEC Level 5 Higher National Diploma in Applied Sciences (Biology)
- Pearson BTEC Level 5 Higher National Diploma in Applied Sciences (Biotechnology)
- Pearson BTEC Level 5 Higher National Diploma in Applied Sciences (Forensic Science)
- Pearson BTEC Level 5 Higher National Diploma in Applied Sciences (Chemistry)
- Pearson BTEC Level 5 Higher National Diploma in Applied Sciences (Water and Wastewater)
- Pearson BTEC Level 5 Higher National Diploma in Applied Sciences (Environmental Sustainability)
- Pearson BTEC Level 5 Higher National Diploma in Applied Sciences (Food Science, Technology and Nutrition)
- Pearson BTEC Level 5 Higher National Diploma in Applied Sciences (Polymer Science and Technology)

1.5 Qualification codes

Ofqual Regulated Qualifications Framework (RQF) qualification numbers:

Pearson BTEC Level 4 Higher National Certificate in Applied Sciences: **603/4570/6**

Pearson BTEC Level 5 Higher National Diploma in Applied Sciences: **603/4574/3**

1.6 Awarding institution

Pearson Education Ltd.

1.7 Key features

Pearson BTEC Higher National qualifications in Applied Sciences offer the following:

- a stimulating and challenging programme of study that will be both engaging and memorable for students
- the essential subject knowledge that students need to progress successfully into further study or the world of work
- a simplified structure: students undertake a substantial core of learning in the Level 4 HNC and can build on this in the Level 5 HND, with specialist and optional units linked to their specialist area of study
- six specialist pathways in the Level 4 HNC and eight specialist pathways in the Level 5 HND, so there is something to suit each student's preference of study and future progression plans
- refreshed content that is closely aligned with professional body, employer and higher education needs
- assessments that consider cognitive skills (what students know) along with affective and applied skills (respectively how they behave and what they can do)
- unit-specific grading and Pearson-set assignments
- a varied approach to assessment that supports progression to Level 6 and also allows centres to offer assessment relevant to the local economy, thereby accommodating and enhancing different learning styles
- quality assurance measures – as outlined in Sections 6 and 7 of this Programme Specification – to ensure that all stakeholders (e.g. professional bodies, universities, colleges and students) can feel confident in the integrity and value of the qualifications
- A qualification designed to meet the needs and expectations of students aspiring to work in the Applied Sciences environment.

Qualification frameworks

Pearson BTEC Higher National qualifications are designated higher education qualifications in the UK. They are aligned to the Framework for Higher Education Qualifications (FHEQ) in England, Wales and Northern Ireland, and Quality Assurance Agency (QAA) Subject Benchmark Statements. These qualifications are part of the UK Regulated Qualifications Framework (RQF).

1.8 Collaborative development

Students completing their Pearson BTEC Higher Nationals in Applied Sciences will be aiming to go on to employment or progress to the second or final year at university. Therefore, it was essential that we developed these qualifications in close collaboration with experts from professional bodies and universities, and with the providers who will be delivering the qualifications.

We are very grateful to the university and further education tutors, employers, professional body representatives and other individuals who have generously shared their time and expertise to help us develop these new qualifications:

- Belfast Metropolitan College
- Brooklands College
- Coláiste Dhúlaigh College of Further Education
- Dudley College
- Efixis Consulting Ltd (higher education consultants)
- Gower College Swansea
- GxPpro Ltd (training and consultancy providers for the pharmaceutical industry)
- Institute of Materials, Minerals and Mining (IOM3)
- Kirklees College
- Leeds City College
- London Metropolitan University
- National Physical Laboratory (NPL)
- Open University
- Royal Society of Biology (RSB)
- Royal Society of Chemistry (RSC)
- Southern Regional College
- University College London
- University of Reading
- Westminster University
- Wirral Metropolitan College.

1.9 Professional body and apprenticeship alignment

The Pearson BTEC Level 5 Higher National Diploma in Applied Science has been developed to meet the mandatory qualification requirements of the Level 5 Technician Scientist Higher Apprenticeship Standard, which is recognised by the Science Council at registered Scientist (RSci) level. Students undertaking this qualification in a higher apprenticeship programme can progress to direct employment following successful completion.

Mapping to the Apprenticeship Standards can be found in *Appendix 6* of this specification.

2 Programming purpose and objectives

2.1 Purpose of the BTEC Higher Nationals in Applied Sciences

The purpose of Pearson BTEC Higher Nationals in Applied Sciences is to develop students as professional, self-reflecting individuals able to meet the demands of employers in the Applied Sciences sector and adapt to a constantly changing world. The qualifications aim to widen access to higher education and enhance the career prospects of those who undertake them.

2.2 Objectives of the BTEC Higher Nationals in Applied Sciences

The objectives of the Pearson BTEC Higher Nationals in Applied Sciences are as follows:

- to equip students with the Applied Sciences skills, knowledge and the understanding necessary to achieve high performance in the global Applied Sciences environment
- to provide education and training for a range of careers in Applied Sciences, including Laboratory Technician, Research Technician, Technical Support Chemist / Biologist, Quality Support Technician, Manufacturing Technician, Science Technician, Technologist, Instrumentation Technician and Product Development Technician
- to provide insight and understanding into the diversity of roles within the Applied Sciences sector, recognising the importance of collaboration at all levels
- to equip students with knowledge and understanding of culturally diverse organisations, cross-cultural issues, diversity and values
- to provide opportunities for students to enter or progress in employment in the Applied Sciences, or progress to higher education qualifications such as an Honours degree in Biology, Chemistry, Environmental Sciences, Polymers or a related area
- to provide opportunities for students to develop the skills, techniques and personal attributes essential for successful working lives
- to support students to understand the local, regional and global context of the Applied Sciences sector and, for those students with a global outlook, to aspire to international career pathways
- to provide students with opportunities to address contemporary Applied Science issues facing the sector, and society at large, with particular emphasis on environmental sustainability, food and nutrition and polymer recyclability

- to provide opportunities for students to achieve a nationally-recognised professional qualification within their chosen area of specialisation
- to offer students the chance of career progression in their chosen field, with particular emphasis on achieving management-level positions, professional recognition and beyond
- to allow flexibility of study and to meet local or specialist needs
- to offer a balance between employability skills and the knowledge essential for students with entrepreneurial, employment or academic aspirations
- to provide students with opportunities to engage in an industry-recognised higher apprenticeship scheme that aligns with their employer's needs and their own career aspirations
- to provide students with the context in which to consider professional ethics and their relation to personal, professional and statutory responsibilities within the industry.

We aim to meet these objectives by:

- providing a thorough grounding in Applied Sciences principles and a degree of specialism at Level 4 that leads the student to a range of specialist progression pathways at Level 5 relating to individual professions within the Applied Sciences sector
- equipping individuals with sector-relevant acumen, understanding and Applied Sciences skills for success in a range of supervisory or lower management roles in Applied Sciences
- enabling progression to a university degree by supporting the development of appropriate academic study skills.

Who is this qualification for?

The Pearson BTEC Higher National qualifications in Applied Sciences are aimed at students wanting to continue their education through applied learning. Higher Nationals provide a wide-ranging study of the Applied Sciences sector and are designed for students who wish to pursue or advance their career in Applied Sciences or related fields. In addition to the knowledge, understanding and skills that underpin the study of the Applied Sciences sector, Pearson BTEC Higher Nationals in Applied Sciences give students experience of the breadth and depth of the sector that will prepare them for further study or training in Applied Sciences related fields.

2.3 Aims of the Pearson BTEC Level 4 Higher National Certificate in Applied Sciences

The Pearson BTEC Level 4 Higher National Certificate in Applied Sciences offers students a broad introduction to the subject area via a mandatory core of learning, while allowing for the acquisition of skills and experience through specialist pathways and the selection of optional units across a range of occupationally-relevant subjects at Level 4. This effectively builds underpinning core and specialist skills while preparing the student for further subject specialisation at Level 5. Students will gain a wide range of sector knowledge tied to practical skills gained in evidence-based practice, personal research, self-study, directed study and workplace learning and experience.

At Level 4, students develop a broad knowledge and awareness of key aspects of the Applied Sciences sector through three core units, which includes one unit assessed by a Pearson-set assignment. The units are:

- Fundamentals of Laboratory Techniques
- Scientific Data Handling Approaches and Techniques
- Regulation and Quality in the Applied Sciences.

Depending on the 'specialist pathway', at Level 4, students will undertake a further three specialist units related to their Level 4 Pathway and also another two optional specialist units from:

- Cell Biology
- Fundamentals of Chemistry
- Anatomy and Human Physiology
- Inorganic Chemistry
- Organic Chemistry
- Physical Chemistry
- Principles of Ecology and their Applications
- Physiological Adaptation of Plants to Environmental Changes
- Managing Environmental Resources
- Human Health and Nutrition
- Food Technology
- Introduction to Polymer Materials and Properties
- Polymer Manufacturing Techniques
- Fundamentals of Biochemistry

- Microbiological Techniques
- Managing Food Preparation and Production Systems
- Introduction to Material Properties and Applications
- Criminal Investigation
- Theories and Causes of Crime
- Psychology in Forensic Science
- Sampling and Sample Preparation
- Volume Crime Scene Science
- Undertake Forensic Examinations at Scenes of Incidents.

The centre can also choose one further optional unit (pathway-independent) at Level 4 (in cases where the total number of core and specialist units chosen is 7), from the following:

- Personal and Professional Development
- Managing Scientific Projects.

Graduates successfully completing the Pearson BTEC Level 4 Higher National Certificate in Applied Sciences will be able to demonstrate a sound knowledge of the basic concepts, values and principles of Applied Sciences, and the skills to perform effectively as a support worker in a number of different settings in the Applied Sciences sector. They will be able to communicate accurately and appropriately, and they will have the behaviours and qualities needed for employment that requires some degree of personal responsibility. They will have developed a range of transferable skills to ensure effective team working, independent initiatives, organisational competence and problem-solving strategies. They will be adaptable and flexible in their approach to Applied Sciences, show resilience under pressure, and meet challenging targets within a given resource.

2.4 Aims of the Pearson BTEC Level 5 Higher National Diploma in Applied Sciences

The Pearson BTEC Level 5 Higher National Diploma in Applied Sciences offers students eight specialist pathways designed to support progression into relevant occupational areas or on to degree-level study.

All pathways in the Higher National Diploma are referenced against professional body standards, and meet the mandatory qualification requirements of the Level 5 Technician Scientist Higher Apprenticeship standard, providing apprenticeship status and progression to direct employment.

The Pearson BTEC Level 5 Higher National Diploma offers the following specialist pathways for students who wish to concentrate on a particular aspect of Applied Sciences:

- Biology
- Biotechnology
- Forensic Science
- Chemistry
- Water and Wastewater
- Environmental Sustainability
- Food Science, Technology and Nutrition
- Polymer Science and Technology
- Forensic Strategies for Serious and Complex Investigations
- Manage Forensic Investigations at Scenes.

Holders of the Pearson BTEC Level 5 Higher National Diploma in Applied Sciences will have developed a sound understanding of the principles in their field of study and will have learned to apply those principles more widely. They will have learned to evaluate the appropriateness of different approaches to solving problems. They will be able to perform effectively in their chosen field and will have the qualities necessary for employment in situations requiring the exercise of personal responsibility and decision-making.

2.5 What could these qualifications lead to?

The Pearson BTEC Level 4 Higher National Certificate in Applied Sciences provides a solid grounding in Applied Sciences, which students can build on should they decide to continue their studies beyond the Certificate stage. The Pearson BTEC Level 5 Higher National Diploma in Applied Sciences allows students to further specialise by committing to specific career paths and progression routes to degree-level study.

On successful completion of the Pearson BTEC Level 5 Higher National Diploma in Applied Sciences, students can develop their careers in the engineering sector through:

- entering employment
- continuing existing employment
- linking with the appropriate professional body
- linking with the appropriate vendor accredited certificates (if appropriate)
- committing to Continuing Professional Development (CPD)
- progressing to university.

2.5.1 Progression to university

The Pearson BTEC Level 5 Higher National Diploma in Applied Sciences is recognised by higher education providers as meeting admission requirements for many relevant engineering degree programmes in subject specialisms such as:

- BSc (Hons) Life Sciences
- BSc (Hons) Biology / Biological Sciences / Human Biology
- BSc (Hons) Biochemistry / Biotechnology
- BSc (Hons) Ecology and Environmental Biology
- BSc (Hons) Microbiology / Molecular Biology
- BSc (Hons) Wildlife Ecology and Conservation Science / Conservation Biology
- BSc (Hons) Chemistry / Biochemistry
- BSc (Hons) Environmental Science / Chemistry
- BSc (Hons) Medicinal Chemistry
- BSc (Hons) Pharmacology / Pharmaceutical Science
- BSc (Hons) Food Science / Technology / Studies
- BSc (Hons) Forensic Science / Chemistry / Biology
- BSc (Hons) Nutrition and Dietetics
- BSc (Hons) Hydrology / Water Science
- BSc (Hons) Environmental Science / Health.

University recognition and articulations

We work with a range of higher education institutions around the world that recognise and accept BTEC Higher Nationals as a qualification for entry onto an undergraduate degree. Many universities allow advanced entry onto the second or third year of a degree, and agreements can include credit transfer, articulation and case-by-case admission. Students should be aware that university admission criteria are always subject to change and remain at the discretion of the institution. Students should take time to understand the course entry requirements for subject, year and grade before applying.

For more information on entry requirements, including 2+1 articulations, please visit: https://www.highernationals.com/degree-finder.

2.5.2 Employment

After completing a Pearson BTEC Level 4 Higher National Certificate or Level 5 Higher National Diploma, students can also progress directly into employment. The skills offered as part of the Pearson BTEC Level 5 Higher National Diploma can provide graduates with the opportunity to work in many different areas of the Applied Sciences sector. Below are some examples of job roles each qualification could lead to.

Pathway	Job Roles
Biology	Technician Scientist Technician Scientist Laboratory Technician Research Technician Quality Support Technician Technologist Development Technician Manufacturing Technician Science Technician
Biotechnology	Technician Scientist Laboratory Technician Research Technician Quality Support Technician Technologist Development Technician Manufacturing Technician Science Technician
Forensic Science	Technician Scientist Laboratory Technician Research Technician Quality Support Technician Technologist Development Technician Manufacturing Technician Science Technician

Pathway	Job Roles
Chemistry	Technician Scientist Laboratory Technician Research Technician Quality Support Technician Technologist Development Technician Manufacturing Technician Science Technician
Water and Wastewater	Technician Scientist Laboratory Technician Research Technician Quality Support Technician Technologist Development Technician Manufacturing Technician Science Technician
Environmental Sustainability	Technician Scientist Laboratory Technician Research Technician Quality Support Technician Technologist Development Technician Manufacturing Technician Science Technician
Food Science, Technology and Nutrition	Technician Scientist Laboratory Technician Research Technician Quality Support Technician Technologist Development Technician Manufacturing Technician Science Technician

Pathway	Job Roles
Polymer Science and Technology	Technician Scientist Laboratory Technician Research Technician Quality Support Technician Technologist Development Technician Manufacturing Technician Science Technician

2.6 Use of maths and English within the curriculum

Those working within the Applied Sciences sector cannot just rely on their technical skills and must ensure they develop all relevant employability skills to increase employment opportunities. For example, they will be required to communicate appropriately with stakeholders throughout their career, so the ability to use maths and English in a professional context is an essential employability skill that must be developed at all levels of study.

Development of essential maths and English skills is embedded throughout these qualifications in accordance with industry requirements; below are some examples of how these skills are developed in the Pearson BTEC Higher National curriculum:

- written reports
- formal presentations
- informal conversations with a range of audiences including customers, other professionals and people accessing services in applied sciences
- use of professional, sector-specific language
- use of maths in developing the skills to manage and control the safe use of substances.
- use of mathematical methods to accurately record and present data for diagnostic or treatment purposes in an applied sciences context
- use of analytical and computational methods to solve problems, and assist with clinical trials, audits and research projects as required.

Many aspects of Applied Sciences require good maths skills and we strongly recommend all students complete diagnostic maths assessments preferably before beginning a Higher National course, as well as having an A* to C and/or 9 to 4 grade in GCSE Maths (or equivalent) prior to starting the course (see *3.2 Entry requirements and Admissions*).

2.7 How Pearson BTEC Higher Nationals in Applied Sciences provide both transferable employability skills and academic study skills

Students need both relevant qualifications and employability skills to enhance their career prospects and contribute to their personal development. Pearson BTEC Higher National Applied Sciences qualifications embed throughout the programme the development of key skills, attributes and strengths required by 21st-century employers.

Where employability skills are referred to in this specification, this generally refers to skills in five main categories:

- **Cognitive and problem-solving skills**: critical thinking, approaching non-routine problems by applying expert and creative solutions, use of systems and digital technology, generating and communicating ideas creatively.
- **Intrapersonal skills**: self-management, adaptability and resilience, self-monitoring and self-development, self-analysis and reflection, planning and prioritising.
- **Interpersonal skills**: effective communication and articulation of information, working collaboratively, negotiating and influencing, self-presentation.
- **Commercial skills**: sector awareness, budget management/monitoring.
- **Business skills**: awareness of types of companies, company formation, calculating fees, business management.

Pearson Example Assessment Briefs make recommendations for a range of real or simulated assessment activities, for example group work where appropriate, to encourage the development of collaborative and interpersonal skills or a solution-focused case study to provide the opportunity to develop cognitive skills. There are specific requirements for the assessment of these skills, as relevant, within the assessment grids for each unit. Example Assessment Briefs are for guidance and support only and **must** be customised and amended according to localised needs and requirements. All assignments must still be verified as per the internal verification process.

Students can also benefit from opportunities for deeper learning, where they are able to make connections between units and select areas of interest for detailed study. In this way Pearson BTEC Higher Nationals provide a career-related context in which students can develop the knowledge and academic study skills required for progression to university degree courses, including:

- active personal research skills
- effective writing skills
- analytical skills
- critical thinking and reflective practice
- evidence-based practice
- creative problem-solving
- decision-making
- team building
- exam preparation skills
- digital literacy
- competence and capability in practice-based skills in the workplace
- competence in assessment methods used in higher education.

To support you in developing these skills in your students, we have developed a map of higher education relevant transferable and academic study skills, available in *Appendix 5*.

3 Planning your programme

3.1 Delivering the Higher Nationals in Applied Sciences

You play a central role in helping your students to choose the right Pearson BTEC Higher National qualification.

You should assess your students very carefully to ensure that they take the right qualification and the right pathways or optional units, to allow them to progress to the next stage. You should check the qualification structures and unit combinations carefully when advising students.

You will need to ensure that your students have access to a full range of information, advice and guidance in order to support them in making the necessary qualification and unit choices. When students are recruited, you need to give them accurate information on the title and focus of the qualification for which they are studying.

3.2 Entry requirements and admissions

Although Pearson do not specify formal entry requirements, as a centre it is your responsibility to ensure that the students you recruit have a reasonable expectation of success on the programme.

For students who have recently been in education, the entry profile is likely to include one of the following:

- a BTEC Level 3 qualification in Applied Sciences (or a related subject)
- a GCE Advanced Level profile that demonstrates strong performance in a relevant subject or adequate performance in more than one GCE subject; this profile is likely to be supported by GCSE grades A* to C and/or 9 to 4 (or equivalent) in subjects such as maths and English
- other related Level 3 qualifications
- an Access to Higher Education Diploma awarded by an approved further education institution
- related work experience
- an international equivalent of the above.

Centres may wish to consider applicants' prior learning when assessing their acceptance on a Pearson BTEC Higher National, through Recognition of Prior Learning. (For further information please refer to *Section 8* of this document.)

3.2.1 English language requirements for Higher Nationals

Pearson's mission is to help people make more of their lives through learning. In order for students to be successful on Pearson BTEC Higher National qualifications which are **both** taught and assessed in English, it is critical that they have an appropriate level of English language skills.

The following clarifies the requirements for all centres when recruiting applicants on to new Pearson BTEC Higher National qualifications.

All centres delivering the new Pearson BTEC Higher National qualifications must ensure that all students who are non-native English speakers and who have not undertaken their final two years of schooling in English, can demonstrate capability in English at a standard equivalent to the levels identified below, before being recruited to the programme **where the programme is both taught and assessed in English**:

- Common European Framework of Reference (CEFR) level B2
- PTE **51**
- IELTS **5.5**; Reading and Writing must be at **5.5**
- or equivalent.

It is up to the centre to decide what proof will be necessary to evidence individual student proficiency.

The following clarifies the requirements for all centres when recruiting applicants on to new Pearson BTEC Higher National qualifications which are taught in a language other than English, but are assessed in English.

All centres delivering the new Pearson BTEC Higher National qualifications **wholly or partially** in a language other than English, but who are assessed in English, must ensure that all students can demonstrate capability in English at a standard equivalent to the levels identified below, on completion of the programme:

- Common European Framework of Reference (CEFR) level B2
- PTE **51**
- IELTS **5.5;** Reading and Writing must be at **5.5**
- or equivalent.

It is up to the centre to decide what proof will be necessary to evidence individual student proficiency.

3.2.2 Centre approval

To ensure that centres are ready to assess students and that we can provide the support that is needed, all centres must be approved before they can offer these qualifications. For more information about becoming a centre and seeking approval to run our qualifications, please visit the support section on our website (http://qualifications.pearson.com).

3.2.3 Level of sector knowledge required

We do not set any requirements for tutors, but we do recommend that centres assess the overall skills and knowledge of the teaching team, which should be relevant, up to date and at the appropriate level.

3.2.4 Resources required

As part of your centre approval, you will need to show that the necessary material resources and work spaces are available to deliver BTEC Higher Nationals. For some units, specific resources are required, this is clearly indicated in the unit descriptors.

3.2.5 HN Global support

HN Global is an online resource that supports centre planning and delivery of BTEC Higher Nationals by providing appropriate teaching and learning resources. For further information see *Sections 5 and 6* of this Programme Specification.

3.2.6 Modes of delivery

Subject to approval by Pearson, centres are free to deliver BTEC Higher Nationals using modes of delivery that meet the needs of their students. We recommend making use of a wide variety of modes, including:

- full-time
- part-time
- blended learning.

3.2.7 Recommendations for employer engagement

BTEC Higher Nationals are vocational qualifications and as an approved centre you are encouraged to work with employers on the design, delivery and assessment of the course. This will ensure that students enjoy a programme of study that is engaging and relevant, and which equips them for progression. There are suggestions in *Section 5.2* about how employers could become involved in delivery and/or assessment, but these are not intended to be exhaustive and there will be other possibilities at a local level.

3.2.8 Support from Pearson

We provide a range of support materials, including Schemes of Work and Example Assessment Briefs, with supporting templates. You will be allocated an External Examiner early in the planning stage, to support you with planning your assessments, and there will be training events and support from our Subject Leads.

3.2.9 Student employability

All Pearson BTEC Higher Nationals have been designed and developed with consideration of National Occupational Standards, where relevant, and have been aligned to professional body and higher apprenticeship standard (see *Section 1.9*).

Employability skills such as team working and entrepreneurialism as well as practical hands-on skills have been built into the design of the learning aims and content. This gives you the opportunity to use relevant contexts, scenarios and materials to enable students to develop a portfolio of evidence demonstrating the breadth of their skills and knowledge in a way that equips them for employment.

3.3 Access to study

This section focuses on the administrative requirements for delivering a Pearson BTEC Higher National qualification. It will be of value to Quality Nominees, Programme Leaders and Examinations Officers.

Our policy regarding access to our qualifications is that:

- they should be available to everyone who is capable of reaching the required standards
- they should be free from any barriers that restrict access and progression.

There should be equal opportunities for all those wishing to access the qualifications. We refer centres to our Pearson *Equality and Diversity Policy*. Centres are also required to recruit students to Higher National programmes with integrity. We refer centres to our Pearson *Recruiting with Integrity* guide. Both policies can be found in the support section of our website (http://qualifications.pearson.com).

Centres will need to make sure that applicants have relevant information and advice about the qualification, to make sure it meets their needs. Centres should review the applicant's prior qualifications and/or experience to consider whether this profile shows that they have the potential to achieve the qualification. For students with disabilities and specific needs, this review will need to take account of the support available to the student during the teaching and assessment of the qualification. For further guidance and advice please refer to *Section 9* on reasonable adjustments.

3.4 Student registration and entry

All students must be registered for the qualification, and appropriate arrangements made for internal and external verification. For information on making registrations for the qualification, you will need to refer to the information manual available in the support section of our website (http://qualifications.pearson.com).

Students can be formally assessed only for a qualification on which they are registered. If students' intended qualifications change (for example, if a student decides to choose a different specialist pathway), then the centre must transfer the student to the chosen pathway appropriately. Please note that student work cannot be sampled if the student is not registered or is registered on an incorrect pathway.

3.5 Access to assessments

Assessments need to be administered carefully, to ensure that all students are treated fairly, and that results and certification are issued on time, allowing students to move on to chosen progression opportunities.

Our equality policy requires that all students should have equal opportunity to access our qualifications and assessments, and that our qualifications are awarded in a way that is fair to every student. We are committed to making sure that:

- students with a protected characteristic (as defined in legislation) are not, when they are undertaking one of our qualifications, disadvantaged in comparison to students who do not share that characteristic
- students achieve the recognition they deserve for undertaking a qualification and that this achievement can be compared fairly to the achievement of their peers.

Further information on access arrangements can be found on the Joint Council for Qualifications website (www.jcq.org.uk).

3.6 Administrative arrangements for internal assessment

3.6.1 Records

You are required to retain records of assessment for each student. Records should include assessments taken, decisions reached and any adjustments or appeals. Further information on quality assurance and assessment can be found in our UK and international guides available in the support section on our website (http://qualifications.pearson.com).

We may ask to audit your records, so they must be retained as specified. All student work must be retained for a minimum of 12 weeks after certification has taken place.

3.6.2 Reasonable adjustments to assessment

A reasonable adjustment is one that is made before a student takes an assessment, to ensure that he or she has fair access to demonstrate the requirements of the assessments.

You are able to make adjustments to internal assessments to take account of the needs of individual students. In most cases this can be achieved through a defined time extension or by adjusting the format of evidence. We can advise you if you are uncertain as to whether an adjustment is fair and reasonable. You need to plan for time to make adjustments, if necessary.

Further details on how to make adjustments for students with protected characteristics are available on the support section of our website (http://qualifications.pearson.com).

3.6.3 Special consideration

Special consideration is given after an assessment has taken place for students who have been affected by adverse circumstances, such as illness, and require an adjustment of grade to reflect normal level of attainment. You must operate special consideration in line with Pearson policy (see previous paragraph). You can provide special consideration related to the period of time given for evidence to be provided, or for the format of the assessment (if it is equally valid). You may not substitute alternative forms of evidence to that required in a unit, or omit the application of any assessment criteria to judge attainment. Pearson can consider applications for special consideration in line with the policy, which can be found in the document linked above.

Please note that your centre must have a policy for dealing with mitigating circumstances, such as if students are affected by adverse situations, such as illness, which result in non-submission or late submission of assessment.

3.6.4 Appeals against assessment

Your centre must have a policy for dealing with appeals from students. These appeals may relate to assessment decisions being incorrect or assessment not being conducted fairly. The first step in such a policy could be a consideration of the evidence by a Programme Leader or other member of the programme team. The assessment plan should allow time for potential appeals after assessment decisions have been given to students. If there is an appeal by a student, you must document the appeal and its resolution. Students have a final right of appeal to Pearson, but only if the procedures that you have put in place have been followed.

Further details of our policy on enquiries and appeals is available on the support section of our website (http://qualifications.pearson.com).

If your centre is located in England or Wales and the student is still dissatisfied with the final outcome of their appeal he or she can make a further appeal to the Office of the Independent Adjudicator (OIA) by emailing: enquiries@oiahe.org.uk. In Northern Ireland a further appeal may be lodged with the Northern Ireland Public Service Ombudsman (NIPSO) by emailing: nipso@nipso.org.uk

3.7 Dealing with malpractice in assessment

'Malpractice' means acts that undermine the integrity and validity of assessment, the certification of qualifications and/or may damage the authority of those responsible for delivering the assessment and certification.

Pearson does not tolerate actual or attempted actions of malpractice by learners, centre staff or centres in connection with Pearson qualifications. Pearson may impose penalties and/or sanctions on learners, centre staff or centres where malpractice or attempted malpractice has been proven.

Malpractice may occur or be suspected in relation to any unit or type of assessment within a qualification. For further details on malpractice and advice on preventing malpractice by learners, please see Pearson's Centre Guidance: Dealing with Malpractice, available on our website.

The procedures we ask you to adopt vary between units that are internally assessed and those that are externally assessed.

Centres are required to take steps to prevent malpractice and to investigate instances of suspected malpractice. Learners must be given information that explains what malpractice is for internal assessment and how suspected incidents will be dealt with by the centre. The Centre Guidance: Dealing with Malpractice document gives full information on the actions we expect you to take.

Pearson may conduct investigations if we believe a centre is failing to conduct internal assessment according to our policies. The above document gives further information and examples, and details the penalties and sanctions that may be imposed.

In the interests of learners and centre staff, centres need to respond effectively and openly to all requests relating to an investigation into an incident of suspected malpractice.

3.7.1 Internally assessed units

Centres are required to take steps to prevent malpractice and to investigate instances of suspected malpractice. Students must be given information that explains what malpractice is for internal assessment and how suspected incidents will be dealt with by the centre. Full information on dealing with malpractice and the actions we expect you to take is available on the support section of our website (http://qualifications.pearson.com).

Pearson may conduct investigations if it is believed that a centre is failing to conduct internal assessment according to Pearson policies. The above document gives further information, provides examples, and details the penalties and sanctions that may be imposed.

3.7.2 Student malpractice

The head of centre is required to report incidents of suspected learner malpractice that occur during Pearson qualifications. We ask centres to complete *JCQ Form M1* (www.jcq.org.uk/malpractice) and email it with any accompanying documents (signed statements from the learner, invigilator, copies of evidence, etc) to the Investigations Processing team at candidatemalpractice@pearson.com. The responsibility for determining appropriate sanctions or penalties to be imposed on learners lies with Pearson.

Learners must be informed at the earliest opportunity of the specific allegation and the centre's malpractice policy, including the right of appeal. Learners found guilty of malpractice may be disqualified from the qualification for which they have been entered with Pearson.

Failure to report malpractice constitutes staff or centre malpractice.

3.7.3 Staff and centre malpractice

The head of centre is required to inform Pearson's Investigations team of any incident of suspected malpractice (which includes maladministration) by centre staff, before any investigation is undertaken. The head of centre is requested to inform the Investigations team by submitting a *JCQ M2 Form* (downloadable from www.jcq.org.uk/malpractice) with supporting documentation to pqsmalpractice@pearson.com. Where Pearson receives allegations of malpractice from other sources (for example Pearson staff, anonymous informants), the Investigations team will conduct the investigation directly or may ask the head of centre to assist.

Pearson reserves the right in cases of suspected malpractice to withhold the issuing of results/certificates while an investigation is in progress. Depending on the outcome of the investigation, results and/or certificates may not be released or they may be withheld.

We reserve the right to withhold certification when undertaking investigations, audits and quality assurance processes. You will be notified within a reasonable period of time if this occurs.

3.7.4 Sanctions and appeals

Where malpractice is proven, we may impose sanctions or penalties, such as:

- mark reduction for affected external assessments
- disqualification from the qualification
- debarment from registration for Pearson qualifications for a period of time.

If we are concerned about your centre's quality procedures we may impose sanctions such as:

- working with centres to create an improvement action plan
- requiring staff members to receive further training
- placing temporary suspensions on certification of learners
- placing temporary suspensions on registration of learners
- debarring staff members or the centre from delivering Pearson qualifications
- suspending or withdrawing centre approval status.

The centre will be notified if any of these apply.

Pearson has established procedures for centres that are considering appeals against penalties and sanctions arising from malpractice. Appeals against a decision made by Pearson will normally be accepted only from the head of centre (on behalf of learners and/or members or staff) and from individual members (in respect of a decision taken against them personally). Further information on appeals can be found in the *JCQ Appeals booklet* (https://www.jcq.org.uk/exams-office/appeals).

4 Programme structure

4.1 Units, Credits, Total Qualification Time (TQT) and Guided Learning (GL)

The Higher National Certificate (HNC) is a Level 4 qualification made up of 120 credits. It is usually studied full-time over one year, or part-time over two years.

The Higher National Diploma (HND) is a Level 4 and Level 5 qualification made up of 240 credits. It is usually studied full-time over two years, or part-time over four years.

Pearson would expect that an HND student would have achieved at least 90 credits at Level 4 before progressing to Level 5 units. This allows for the students to submit the remaining 30 credits at Level 4 while undertaking their Level 5 study.

Students undertaking an HND who fail to successfully complete the full qualification may be awarded an HNC, if their credit achievement permits.

Pearson BTEC Higher Nationals consist of core units, specialist units and optional units.

- Core units are mandatory.
- Specialist units are designed to provide a specific occupational focus to the qualification and are aligned to professional body and/or higher apprenticeship standards.
- Required combinations of units are clearly set out in the tables below.

Units are usually 15 credits in value, or a multiple thereof. These units have been designed from a learning time perspective, and are expressed in terms of **Total Qualification Time (TQT)**. TQT is an estimate of the total amount of time that could reasonably be expected to be required for a student to achieve and demonstrate the achievement of the level of attainment necessary for the award of a qualification. TQT includes undertaking each of the activities of Guided Learning, Directed Learning and Invigilated Assessment. Each 15-credit unit approximates to a Total Unit Time of 150 hours with 60 hours of Guided Learning.

Total Qualification Time (TQT) for Higher National Certificate (HNC) = 1,200 hours

Total Qualification Time (TQT) for Higher National Diploma (HND) = 2,400 hours

Examples of activities which can contribute to TQT include:

- guided Learning
- independent and unsupervised research/learning
- unsupervised compilation of a portfolio of work experience
- unsupervised e-learning
- unsupervised e-assessment
- unsupervised coursework
- watching a pre-recorded podcast or webinar
- unsupervised work-based learning.

Guided Learning (GL) is defined as the time when a tutor is present to give specific guidance towards the learning aim being studied on a programme. This definition includes lectures, tutorials and supervised study in, for example, open learning centres and learning workshops. Guided Learning includes any supervised assessment activity; this includes invigilated examination, observed assessment and observed work-based practice.

Total Guided Learning (GL) for Higher National Certificate (HNC) = 480 hours

Total Guided Learning (GL) for Higher National Diploma (HND) = 960 hours

Some examples of activities which can contribute to GL include:

- classroom-based learning supervised by a tutor
- work-based learning supervised by a tutor
- live webinar or telephone tutorial with a tutor in real time
- e-learning supervised by a tutor in real time
- all forms of assessment which take place under the immediate guidance or supervision of a tutor or other appropriate provider of education or training, including where the assessment is competence-based and may be turned into a learning opportunity.

4.2 Programme structures

The programme structures specify:

- the total credit value of the qualification
- the minimum credit to be achieved at the level of the qualification
- the core units
- the specialist mandatory units
- the specialist optional units
- the generic optional units
- the maximum credit value in units that can be centre-commissioned.

When combining units for a Pearson BTEC Higher National qualification, it is the centre's responsibility to make sure that the correct combinations are followed.

4.2.1 Pearson BTEC Level 4 Higher National Certificate in Applied Sciences

- Qualification credit value: a minimum of 120 credits. This is made up of eight units, each with a value of 15 credits.
- Total Qualification Time (TQT) = 1,200 hours
- Total Guided Learning (GL) = 480 hours
- There is a required mix of core, specialist and optional units totalling 120 credits. All units are at Level 4.
- In some cases, a maximum of 30 credits can be imported from another RQF Pearson BTEC Higher National qualification and/or from units designed by the centre and approved by Pearson. Core units may **not** be substituted and are **mandatory**. For more information please refer to Higher National Commissioned Qualifications.
- Please note that some specialist units are available as optional units.

Pearson BTEC Level 4 Higher National Certificate in Applied Sciences (Biology)		**Unit credit**	**Level**
Core unit *Mandatory*	**1 Fundamentals of Laboratory Techniques**	15	4
Core unit *Mandatory*	**2 Scientific Data Handling Approaches and Techniques**	15	4
Core unit *Mandatory*	**3 Regulation and Quality in the Applied Sciences (Pearson-set)**	15	4
Specialist unit *Mandatory*	**4 Cell Biology**	15	4
Specialist unit *Mandatory*	**5 Fundamentals of Chemistry**	15	4
Specialist unit *Mandatory*	**6 Anatomy and Human Physiology**	15	4
Plus TWO units, including a minimum of one specialist unit, from below.			
Minimum of ONE unit may be selected from the specialist units list:			
Specialist unit *Optional*	**10 Principles of Ecology and their Applications**	15	4
Specialist unit *Optional*	**12 Managing Environmental Resources**	15	4
Specialist unit *Optional*	**17 Fundamentals of Biochemistry**	15	4
Specialist unit *Optional*	**18 Microbiological Techniques**	15	4
Specialist unit *Optional*	**24 Sampling and Sample Preparation**	15	4
Specialist unit *Optional*	**64 Work-based Investigation**	15	4
Specialist unit *Optional*	**71 Medical Microbiology**	15	4
Maximum of ONE unit may be selected from the generic optional units list:			
Generic unit *Optional*	**25 Personal and Professional Development for Scientists**	15	4
Generic unit *Optional*	**26 Managing Scientific Projects**	15	4

Pearson BTEC Level 4 Higher National Certificate in Applied Sciences (Forensic Science)		Unit credit	Level
Core unit *Mandatory*	**1 Fundamentals of Laboratory Techniques**	15	4
Core unit *Mandatory*	**2 Scientific Data Handling Approaches and Techniques**	15	4
Core unit *Mandatory*	**3 Regulation and Quality in the Applied Sciences (Pearson-set)**	15	4
Specialist unit *Mandatory*	**4 Cell Biology**	15	4
Specialist unit *Mandatory*	**17 Fundamentals of Biochemistry**	15	4
Specialist unit *Mandatory*	**21 Criminal Investigation**	15	4
Plus TWO units, including a minimum of one specialist unit, from below.			
Minimum of ONE unit may be selected from the specialist units list:			
Specialist unit *Optional*	**6 Anatomy and Human Physiology**	15	4
Specialist unit *Optional*	**18 Microbiological Techniques**	15	4
Specialist unit *Optional*	**22 Theories and Causes of Crime**	15	4
Specialist unit *Optional*	**23 Psychology in the Forensic Setting**	15	4
Specialist unit *Optional*	**24 Sampling and Sample Preparation**	15	4
Specialist unit *Optional*	**35 Analytical Chemistry**	15	4
Specialist unit *Optional*	**64 Work-based Investigation**	15	4
Specialist unit *Optional*	**66 Volume Crime Scene Science**	15	4
Specialist unit *Optional*	**67 Undertake Forensic Examinations at Scenes of Incidents**	15	4
Maximum of ONE unit may be selected from the generic optional units list:			
Generic unit *Optional*	**25 Personal and Professional Development for Scientists**	15	4
Generic unit *Optional* unit	**26 Managing Scientific Projects**	15	4

Pearson BTEC Level 4 Higher National Certificate in Applied Sciences (Chemistry)		Unit credit	Level
Core unit *Mandatory*	**1 Fundamentals of Laboratory Techniques**	15	4
Core unit *Mandatory*	**2 Scientific Data Handling Approaches and Techniques**	15	4
Core unit *Mandatory*	**3 Regulation and Quality in the Applied Sciences (Pearson-set)**	15	4
Specialist unit *Mandatory*	**7 Inorganic Chemistry**	15	4
Specialist unit *Mandatory*	**8 Organic Chemistry**	15	4
Specialist unit *Mandatory*	**9 Physical Chemistry**	15	4
Plus TWO units, including a minimum of one specialist unit, from below.			
Minimum of ONE unit may be selected from the specialist units list:			
Specialist unit *Optional*	**15 Introduction to Polymer Materials and Properties**	15	4
Specialist unit *Optional*	**17 Fundamentals of Biochemistry**	15	4
Specialist unit *Optional*	**20 Introduction to Material Properties and Applications**	15	4
Specialist unit *Optional*	**24 Sampling and Sample Preparation**	15	4
Specialist unit *Optional*	**35 Analytical Chemistry**	15	4
Specialist unit *Optional*	**64 Work-based Investigation**	15	4
Specialist unit *Optional*	**73 Environmental Pollutants and Water Testing**	15	4
Maximum of ONE unit may be selected from the generic optional units list:			
Generic unit *Optional*	**25 Personal and Professional Development for Scientists**	15	4
Generic unit *Optional*	**26 Managing Scientific Projects**	15	4

Pearson BTEC Level 4 Higher National Certificate in Applied Sciences (Environmental Science)		Unit credit	Level
Core unit *Mandatory*	**1 Fundamentals of Laboratory Techniques**	15	4
Core unit *Mandatory*	**2 Scientific Data Handling Approaches and Techniques**	15	4
Core unit *Mandatory*	**3 Regulation and Quality in the Applied Sciences (Pearson-set)**	15	4
Specialist unit *Mandatory*	**5 Fundamentals of Chemistry**	15	4
Specialist unit *Mandatory*	**10 Principles of Ecology and their Applications**	15	4
Specialist unit *Mandatory*	**11 Physiological Adaptation of Plants to Environmental Changes**	15	4
Plus TWO units, including a minimum of one specialist unit, from below.			
Minimum of ONE unit may be selected from the specialist units list:			
Specialist unit *Optional*	**12 Managing Environmental Resources**	15	4
Specialist unit *Optional*	**18 Microbiological Techniques**	15	4
Specialist unit *Optional*	**24 Sampling and Sample Preparation**	15	4
Specialist unit *Optional*	**35 Analytical Chemistry**	15	4
Specialist unit *Optional*	**64 Work-based Investigation**	15	4
Maximum of ONE unit may be selected from the generic optional units list:			
Generic unit *Optional*	**25 Personal and Professional Development for Scientists**	15	4
Generic unit *Optional*	**26 Managing Scientific Projects**	15	4

Pearson BTEC Level 4 Higher National Certificate in Applied Sciences (Food Science, Technology and Nutrition)		Unit credit	Level
Core unit *Mandatory*	**1 Fundamentals of Laboratory Techniques**	15	4
Core unit *Mandatory*	**2 Scientific Data Handling Approaches and Techniques**	15	4
Core unit *Mandatory*	**3 Regulation and Quality in the Applied Sciences (Pearson-set)**	15	4
Specialist unit *Mandatory*	**5 Fundamentals of Chemistry**	15	4
Specialist unit *Mandatory*	**13 Human Health and Nutrition**	15	4
Specialist unit *Mandatory*	**14 Food Technology**	15	4
Plus TWO units, including a minimum of one specialist unit, from below.			
Minimum of ONE unit may be selected from the specialist units list:			
Specialist unit *Optional*	**6 Anatomy and Human Physiology**	15	4
Specialist unit *Optional*	**10 Principles of Ecology and their Applications**	15	4
Specialist unit *Optional*	**12 Managing Environmental Resources**	15	4
Specialist unit *Optional*	**19 Managing Food Preparation and Production Systems**	15	4
Specialist unit *Optional*	**18 Microbiological Techniques**	15	4
Specialist unit *Optional*	**24 Sampling and Sample Preparation**	15	4
Specialist unit *Optional*	**64 Work-based Investigation**	15	4
Maximum of ONE unit may be selected from the generic optional units list:			
Generic unit *Optional*	**25 Personal and Professional Development for Scientists**	15	4
Generic unit *Optional*	**26 Managing Scientific Projects**	15	4

Pearson BTEC Level 4 Higher National Certificate in Applied Sciences (Polymer Science and Technology)		**Unit credit**	**Level**
Core unit *Mandatory*	**1 Fundamentals of Laboratory Techniques**	15	4
Core unit *Mandatory*	**2 Scientific Data Handling Approaches and Techniques**	15	4
Core unit *Mandatory*	**3 Regulation and Quality in the Applied Sciences (Pearson-set)**	15	4
Specialist unit *Mandatory*	**5 Fundamentals of Chemistry**	15	4
Specialist unit *Mandatory*	**15 Introduction to Polymer Materials and Properties**	15	4
Specialist unit *Mandatory*	**16 Polymer Manufacturing Techniques**	15	4
Plus TWO units, including a minimum of one specialist unit, from below.			
Minimum of ONE unit may be selected from the specialist units list:			
Specialist unit *Optional*	**8 Organic Chemistry**	15	4
Specialist unit *Optional*	**12 Managing Environmental Resources**	15	4
Specialist unit *Optional*	**18 Microbiological Techniques**	15	4
Specialist unit *Optional*	**20 Introduction to Material Properties and Applications**	15	4
Specialist unit *Optional*	**24 Sampling and Sample Preparation**	15	4
Specialist unit *Optional*	**64 Work-based Investigation**	15	4
Maximum of ONE unit may be selected from the generic optional units list:			
Generic unit *Optional*	**25 Personal and Professional Development for Scientists**	15	4
Generic unit *Optional*	**26 Managing Scientific Projects**	15	4

4.2.2 Pearson BTEC Level 5 Higher National Diploma in Applied Sciences

- Qualification credit value: a minimum of 240 credits. This is made up of fifteen units, fourteen with a value of 15 credits, and one with a value of 30 credits.
- **Total Qualification Time (TQT)** Higher National Diploma (HND) = 2,400 hours
- **Total Guided Learning (GL)** Higher National Diploma (HND) = 960 hours
- There is a required mix of Core, Specialist and Optional units totalling 240 credits. Units are at Level 4 and Level 5.
- In some cases, a maximum of 60 credits can be imported from another RQF Pearson BTEC Higher National qualification and/or from units designed by the centre and approved by Pearson. Core units may **not** be substituted and are **mandatory**. For more information please refer to Higher National Commissioned Qualifications.
- Please note that some Specialist units are available as Optional units.
- The requirements of the HNC have to be met.

The Pearson BTEC Level 5 Higher National Diploma in Applied Sciences consists of the Pearson BTEC Level 4 Higher National Certificate in Applied Sciences (from a defined specialist pathway) plus an additional 120 credits at Level 5 delivered via one of eight corresponding specialist pathways. At Level 5, these pathways are:

- Biology
- Biotechnology
- Forensic Science
- Chemistry
- Water and Wastewater
- Environmental Sustainability
- Food Science, Technology and Nutrition
- Polymer Science and Technology

Students will typically progress within the pathways, as shown in Figure 1 (below). Where a centre may allow students to change pathways, from Level 4 to Level 5, they must undertake a suitable mapping of accredited prior experience or learning (APEL) in support of any potential review by an External Examiner.

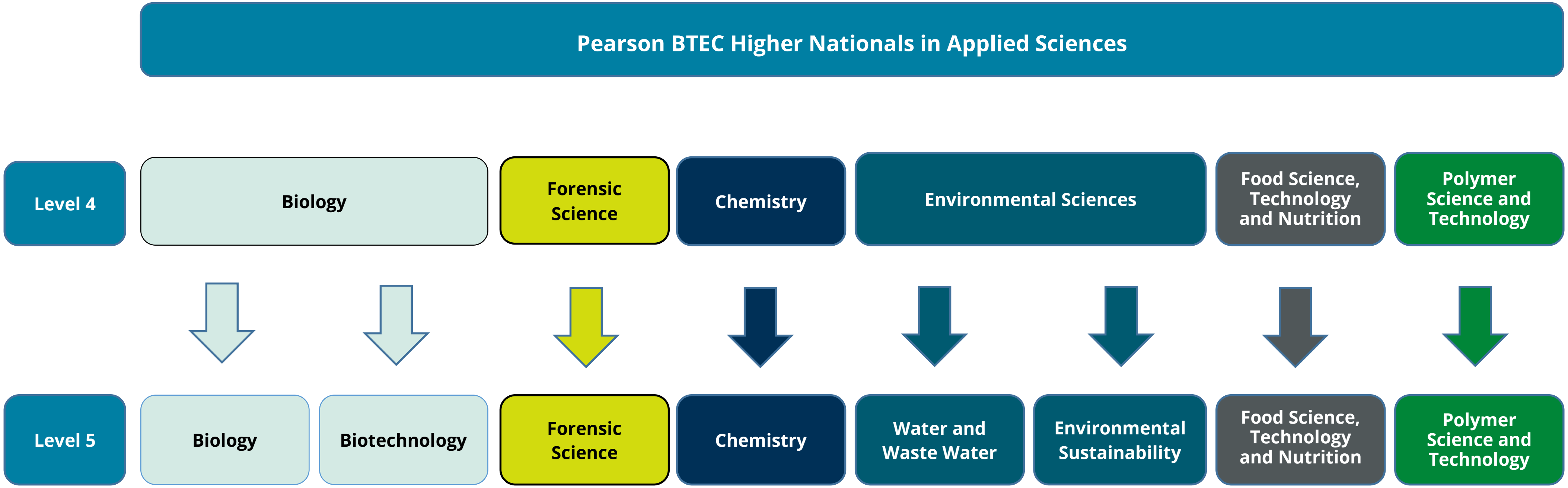


Figure 1: Typical Pathway Progression in Applied Sciences

Pearson BTEC Level 5 Higher National Diploma in Applied Sciences (Biology)		Unit credit	Level
Level 4 units:			
Core unit *Mandatory*	**1 Fundamentals of Laboratory Techniques**	15	4
Core unit *Mandatory*	**2 Scientific Data Handling Approaches and Techniques**	15	4
Core unit *Mandatory*	**3 Regulation and Quality in the Applied Sciences (Pearson-set)**	15	4
Specialist unit *Mandatory*	**4 Cell Biology**	15	4
Specialist unit *Mandatory*	**5 Fundamentals of Chemistry**	15	4
Specialist unit *Mandatory*	**6 Anatomy and Human Physiology**	15	4
Plus TWO units, including a minimum of one specialist unit, from below.			
Minimum of ONE unit may be selected from the specialist units list:			
Specialist unit *Optional*	**10 Principles of Ecology and their Applications**	15	4
Specialist unit *Optional*	**12 Managing Environmental Resources**	15	4
Specialist unit *Optional*	**17 Fundamentals of Biochemistry**	15	4
Specialist unit *Optional*	**18 Microbiological Techniques**	15	4
Specialist unit *Optional*	**24 Sampling and Sample Preparation**	15	4
Specialist unit *Optional*	**64 Work-based Investigation**	15	4
Specialist unit *Optional*	**71 Medical Microbiology**	15	4
Maximum of ONE unit may be selected from the generic optional units list:			
Generic unit *Optional*	**25 Personal and Professional Development for Scientists**	15	4
Generic unit *Optional*	**26 Managing Scientific Projects**	15	4

Level 5 units:			
Core unit *Mandatory*	**27 Analysis of Scientific Data and Information**	15	5
Core unit *Mandatory*	**28 Applied Sciences Research Project (Pearson-set)**	30	5
Specialist unit *Mandatory*	**29 Biochemistry of Macromolecules and Metabolic Pathways**	15	5
Specialist unit *Mandatory*	**30 Molecular Biology and Genetics**	15	5
Specialist unit *Mandatory*	**31 Immunology**	15	5
Plus TWO units, including a minimum of one specialist unit, from below.			
Minimum of ONE unit may be selected from the specialist units list:			
Specialist unit *Optional*	**39 Environmental Monitoring and Analysis**	15	5
Specialist unit *Optional*	**41 Conservation and Biodiversity**	15	5
Specialist unit *Optional*	**42 Materials Life Cycle and the Circular Economy**	15	5
Specialist unit *Optional*	**51 Specialist Scientific Techniques and Experimentation**	15	5
Specialist unit *Optional*	**55 Nanomaterials and their Technology**	15	5
Specialist unit *Optional*	**56 Stem Cell Biology**	15	5
Specialist unit *Optional*	**57 Infectious Diseases and Diagnosis**	15	5
Specialist unit *Optional*	**58 Epidemiology of Communicable Diseases**	15	5
Specialist unit *Optional*	**59 Genetic Analysis**	15	5
Specialist unit *Optional*	**70 Histology and Haematology**	15	5
Specialist unit *Optional*	**72 Clinical Chemistry**	15	5
Maximum of ONE unit may be selected from the generic optional units list:			
Generic unit *Optional*	**61 Science Laboratory Management**	15	5

Generic unit *Optional*	**62 Organisations and Change Management**	15	5
Generic unit *Optional*	**63 Entrepreneurship and New Business Development**	15	5

Pearson BTEC Level 5 Higher National Diploma in Applied Sciences (Biotechnology)		**Unit credit**	**Level**
Level 4 units:			
Core unit *Mandatory*	**1 Fundamentals of Laboratory Techniques**	15	4
Core unit *Mandatory*	**2 Scientific Data Handling Approaches and Techniques**	15	4
Core unit *Mandatory*	**3 Regulation and Quality in the Applied Sciences (Pearson-set)**	15	4
Specialist unit *Mandatory*	**4 Cell Biology**	15	4
Specialist unit *Mandatory*	**5 Fundamentals of Chemistry**	15	4
Specialist unit *Mandatory*	**6 Anatomy and Human Physiology**	15	4
Plus TWO units, including a minimum of one specialist unit, from below.			
Minimum of ONE unit may be selected from the specialist units list:			
Specialist unit *Optional*	**10 Principles of Ecology and their Applications**	15	4
Specialist unit *Optional*	**12 Managing Environmental Resources**	15	4
Specialist unit *Optional*	**17 Fundamentals of Biochemistry**	15	4
Specialist unit *Optional*	**18 Microbiological Techniques**	15	4
Specialist unit *Optional*	**24 Sampling and Sample Preparation**	15	4
Specialist unit *Optional*	**64 Work-based Investigation**	15	4
Maximum of ONE unit may be selected from the generic optional units list:			
Generic unit *Optional*	**25 Personal and Professional Development for Scientists**	15	4
Generic unit *Optional*	**26 Managing Scientific Projects**	15	4

Level 5 units:			
Core unit *Mandatory*	**27 Analysis of Scientific Data and Information**	15	5
Core unit *Mandatory*	**28 Applied Sciences Research Project (Pearson-set)**	30	5
Specialist unit *Mandatory*	**29 Biochemistry of Macromolecules and Metabolic Pathways**	15	5
Specialist unit *Mandatory*	**30 Molecular Biology and Genetics**	15	5
Specialist unit *Mandatory*	**32 Biotechnology Techniques**	15	5
Plus TWO units, including a minimum of one specialist unit, from below.			
Minimum of ONE unit may be selected from the specialist units list:			
Specialist unit *Optional*	**39 Environmental Monitoring and Analysis**	15	5
Specialist unit *Optional*	**41 Conservation and Biodiversity**	15	5
Specialist unit *Optional*	**42 Materials Life Cycle and the Circular Economy**	15	5
Specialist unit *Optional*	**51 Specialist Scientific Techniques and Experimentation**	15	5
Specialist unit *Optional*	**52 Drug Development for Production**	15	5
Specialist unit *Optional*	**53 Industrial Microbiology**	15	5
Specialist unit *Optional*	**55 Nanomaterials and their Technology**	15	5
Specialist unit *Optional*	**56 Stem Cell Biology**	15	5
Specialist unit *Optional*	**59 Genetic Analysis**	15	5
Maximum of ONE unit may be selected from the generic optional units list:			
Generic unit *Optional*	**61 Science Laboratory Management**	15	5
Generic unit *Optional*	**62 Organisations and Change Management**	15	5
Generic unit *Optional*	**63 Entrepreneurship and New Business Development**	15	5

Pearson BTEC Level 5 Higher National Diploma in Applied Sciences (Forensic Science)		Unit credit	Level
Level 4 units:			
Core unit *Mandatory*	**1 Fundamentals of Laboratory Techniques**	15	4
Core unit *Mandatory*	**2 Scientific Data Handling Approaches and Techniques**	15	4
Core unit *Mandatory*	**3 Regulation and Quality in the Applied Sciences (Pearson-set)**	15	4
Specialist unit *Mandatory*	**4 Cell Biology**	15	4
Specialist unit *Mandatory*	**17 Fundamentals of Biochemistry**	15	4
Specialist unit *Mandatory*	**21 Criminal Investigation**	15	4
Plus TWO units, including a minimum of one specialist unit, from below.			
Minimum of ONE unit may be selected from the specialist units list:			
Specialist unit *Optional*	**6 Anatomy and Human Physiology**	15	4
Specialist unit *Optional*	**18 Microbiological Techniques**	15	4
Specialist unit *Optional*	**22 Theories and Causes of Crime**	15	4
Specialist unit *Optional*	**23 Psychology in the Forensic Setting**	15	4
Specialist unit *Optional*	**24 Sampling and Sample Preparation**	15	4
Specialist unit *Optional*	**35 Analytical Chemistry**	15	4
Specialist unit *Optional*	**64 Work-based Investigation**	15	4
Specialist unit *Optional*	**66 Volume Crime Scene Science**	15	4
Specialist unit *Optional*	**67 Undertake Forensic Examinations at Scenes of Incidents**	15	4

Maximum of ONE unit may be selected from the generic optional units list:			
Generic unit *Optional*	**25 Personal and Professional Development for Scientists**	15	4
Generic unit *Optional*	**26 Managing Scientific Projects**	15	4

Level 5 units:			
Core unit *Mandatory*	**27 Analysis of Scientific Data and Information**	15	5
Core unit *Mandatory*	**28 Applied Sciences Research Project (Pearson-set)**	30	5
Specialist unit *Mandatory*	**30 Molecular Biology and Genetics**	15	5
Specialist unit *Mandatory*	**33 Analytical Techniques for Forensic Science**	15	5
Specialist unit *Mandatory*	**34 Forensic Evidence Collection and Preservation**	15	5
Plus TWO units, including a minimum of one specialist unit, from below.			
Minimum of ONE unit may be selected from the specialist units list:			
Specialist unit *Optional*	**32 Biotechnology Techniques**	15	5
Specialist unit *Optional*	**65 Further Analytical Chemistry**	15	5
Specialist unit *Optional*	**39 Environmental Monitoring and Analysis**	15	5
Specialist unit *Optional*	**42 Materials Life Cycle and the Circular Economy**	15	5
Specialist unit *Optional*	**50 Toxicology**	15	5
Specialist unit *Optional*	**51 Specialist Scientific Techniques and Experimentation**	15	5
Specialist unit *Optional*	**55 Nanomaterials and their Technology**	15	5
Specialist unit *Optional*	**59 Genetic Analysis**	15	5
Specialist unit *Optional*	**68 Forensic Strategies for Serious and Complex Investigations**	15	5
Specialist unit *Optional*	**69 Manage Forensic Investigations at Scenes**	15	5

Maximum of ONE unit may be selected from the generic optional units list:			
Generic unit *Optional*	**61 Science Laboratory Management**	15	5
Generic unit *Optional*	**62 Organisations and Change Management**	15	5
Generic unit *Optional*	**63 Entrepreneurship and New Business Development**	15	5

Pearson BTEC Level 5 Higher National Diploma in Applied Sciences (Chemistry)		**Unit credit**	**Level**
Level 4 units:			
Core unit *Mandatory*	**1 Fundamentals of Laboratory Techniques**	15	4
Core unit *Mandatory*	**2 Scientific Data Handling Approaches and Techniques**	15	4
Core unit *Mandatory*	**3 Regulation and Quality in the Applied Sciences (Pearson-set)**	15	4
Specialist Unit *Mandatory*	**7 Inorganic Chemistry**	15	4
Specialist unit *Mandatory*	**8 Organic Chemistry**	15	4
Specialist unit *Mandatory*	**9 Physical Chemistry**	15	4
Plus TWO units, including a minimum of one specialist unit, from below.			
Minimum of ONE unit may be selected from the specialist units list:			
Specialist unit *Optional*	**15 Introduction to Polymer Materials and Properties**	15	4
Specialist unit *Optional*	**17 Fundamentals of Biochemistry**	15	4
Specialist unit *Optional*	**20 Introduction to Material Properties and Applications**	15	4
Specialist unit *Optional*	**24 Sampling and Sample Preparation**	15	4
Specialist unit *Optional*	**35 Analytical Chemistry**	15	4
Specialist unit *Optional*	**64 Work-based Investigation**	15	4
Specialist unit *Optional*	**73 Environmental Pollutants and Water Testing**	15	4
Maximum of ONE unit may be selected from the generic optional units list:			
Generic unit *Optional*	**25 Personal and Professional Development for Scientists**	15	4
Generic unit *Optional*	**26 Managing Scientific Projects**	15	4

Level 5 units:			
Core unit *Mandatory*	**27 Analysis of Scientific Data and Information**	15	5
Core unit *Mandatory*	**28 Applied Sciences Research Project (Pearson-set)**	30	5
Specialist unit *Mandatory*	**65 Further Analytical Chemistry**	15	5
Specialist unit *Mandatory*	**36 Aromatic and Carbonyl Compounds**	15	5
Specialist unit *Mandatory*	**37 Solid State and Transition Metal Chemistry**	15	5
Plus TWO units, including a minimum of one specialist unit, from below.			
Minimum of ONE unit may be selected from the specialist units list:			
Specialist unit *Optional*	**29 Biochemistry of Macromolecules and Metabolic Pathways**	15	5
Specialist unit *Optional*	**32 Biotechnology Techniques**	15	5
Specialist unit *Optional*	**38 Spectroscopy, Surface Chemistry and Equilibria**	15	5
Specialist unit *Optional*	**39 Environmental Monitoring and Analysis**	15	5
Specialist unit *Optional*	**42 Materials Life Cycle and the Circular Economy**	15	5
Specialist unit *Optional*	**49 Principles of Pharmacology**	15	5
Specialist unit *Optional*	**51 Specialist Scientific Techniques and Experimentation**	15	5
Specialist unit *Optional*	**52 Drug Development for Production**	15	5
Specialist unit *Optional*	**55 Nanomaterials and their Technology**	15	5
Maximum of ONE unit may be selected from the generic optional units list:			
Generic unit *Optional*	**61 Science Laboratory Management**	15	5
Generic unit *Optional*	**62 Organisations and Change Management**	15	5
Generic unit *Optional*	**63 Entrepreneurship and New Business Development**	15	5

Pearson BTEC Level 5 Higher National Diploma in Applied Sciences (Water and Wastewater)		Unit credit	Level
Level 4 units:			
Core unit *Mandatory*	**1 Fundamentals of Laboratory Techniques**	15	4
Core unit *Mandatory*	**2 Scientific Data Handling Approaches and Techniques**	15	4
Core unit *Mandatory*	**3 Regulation and Quality in the Applied Sciences (Pearson-set)**	15	4
Specialist unit *Mandatory*	**5 Fundamentals of Chemistry**	15	4
Specialist unit *Mandatory*	**10 Principles of Ecology and their Applications**	15	4
Specialist unit *Mandatory*	**11 Physiological Adaptation of Plants to Environmental Changes**	15	4
Plus TWO units, including a minimum of one specialist unit, from below.			
Minimum of ONE unit may be selected from the specialist units list:			
Specialist unit *Optional*	**12 Managing Environmental Resources**	15	4
Specialist unit *Optional*	**18 Microbiological Techniques**	15	4
Specialist unit *Optional*	**24 Sampling and Sample Preparation**	15	4
Specialist unit *Optional*	**35 Analytical Chemistry**	15	4
Specialist unit *Optional*	**64 Work-based Investigation**	15	4
Maximum of ONE unit may be selected from the generic optional units list:			
Generic unit *Optional*	**25 Personal and Professional Development for Scientists**	15	4
Generic unit *Optional*	**26 Managing Scientific Projects**	15	4

Level 5 units:			
Core unit *Mandatory*	**27 Analysis of Scientific Data and Information**	15	5
Core unit *Mandatory*	**28 Applied Sciences Research Project (Pearson-set)**	30	5
Specialist unit *Mandatory*	**32 Biotechnology Techniques**	15	5
Specialist unit *Mandatory*	**39 Environmental Monitoring and Analysis**	15	5
Specialist unit *Mandatory*	**40 Water and Wastewater Management**	15	5
Plus TWO units, including a minimum of one specialist unit, from below.			
Minimum of ONE unit may be selected from the specialist units list:			
Specialist unit *Optional*	**65 Further Analytical Chemistry**	15	5
Specialist unit *Optional*	**42 Materials Life Cycle and the Circular Economy**	15	5
Specialist unit *Optional*	**50 Toxicology**	15	5
Specialist unit *Optional*	**51 Specialist Scientific Techniques and Experimentation**	15	5
Specialist unit *Optional*	**53 Industrial Microbiology**	15	5
Specialist unit *Optional*	**54 Materials' in Contact with Food**	15	5
Specialist unit *Optional*	**55 Nanomaterials and their Technology**	15	5
Maximum of ONE unit may be selected from the generic optional units list:			
Generic unit *Optional*	**61 Science Laboratory Management**	15	5
Generic unit *Optional*	**62 Organisations and Change Management**	15	5
Generic unit *Optional*	**63 Entrepreneurship and New Business Development**	15	5

Pearson BTEC Level 5 Higher National Diploma in Applied Sciences (Environmental Sustainability)		Unit credit	Level
Level 4 units:			
Core unit *Mandatory*	**1 Fundamentals of Laboratory Techniques**	15	4
Core unit *Mandatory*	**2 Scientific Data Handling Approaches and Techniques**	15	4
Core unit *Mandatory*	**3 Regulation and Quality in the Applied Sciences (Pearson-set)**	15	4
Specialist unit *Mandatory*	**5 Fundamentals of Chemistry**	15	4
Specialist unit *Mandatory*	**10 Principles of Ecology and their Applications**	15	4
Specialist unit *Mandatory*	**11 Physiological Adaptation of Plants to Environmental Changes**	15	4
Plus TWO units, including a minimum of one specialist unit, from below.			
Minimum of ONE unit may be selected from the specialist units list:			
Specialist unit *Optional*	**12 Managing Environmental Resources**	15	4
Specialist unit *Optional*	**18 Microbiological Techniques**	15	4
Specialist unit *Optional*	**24 Sampling and Sample Preparation**	15	4
Specialist unit *Optional*	**35 Analytical Chemistry**	15	4
Specialist unit *Optional*	**64 Work-based Investigation**	15	4
Maximum of ONE unit may be selected from the generic optional units list:			
Generic unit *Optional*	**25 Personal and Professional Development for Scientists**	15	4
Generic unit *Optional*	**26 Managing Scientific Projects**	15	4

Level 5 units:			
Core unit *Mandatory*	**27 Analysis of Scientific Data and Information**	15	5
Core unit *Mandatory*	**28 Applied Sciences Research Project (Pearson-set)**	30	5
Specialist unit *Mandatory*	**39 Environmental Monitoring and Analysis**	15	5
Specialist unit *Mandatory*	**41 Conservation and Biodiversity**	15	5
Specialist unit *Mandatory*	**42 Materials Life Cycle and the Circular Economy**	15	5
Plus TWO units, including a minimum of one specialist unit, from below.			
Minimum of ONE unit may be selected from the specialist units list:			
Specialist unit *Optional*	**32 Biotechnology Techniques**	15	5
Specialist unit *Optional*	**50 Toxicology**	15	5
Specialist unit *Optional*	**51 Specialist Scientific Techniques and Experimentation**	15	5
Specialist unit *Optional*	**54 Materials' in Contact with Food**	15	5
Specialist unit *Optional*	**55 Nanomaterials and their Technology**	15	5
Specialist unit *Optional*	**60 Renewable Energy Resources and Technology**	15	5
Maximum of ONE unit may be selected from the generic optional units list:			
Generic unit *Optional*	**61 Science Laboratory Management**	15	5
Generic unit *Optional*	**62 Organisations and Change Management**	15	5
Generic unit *Optional*	**63 Entrepreneurship and New Business Development**	15	5

Pearson BTEC Level 5 Higher National Diploma in Applied Sciences (Food Science, Technology and Nutrition)		Unit credit	Level
Level 4 units:			
Core unit *Mandatory*	**1 Fundamentals of Laboratory Techniques**	15	4
Core unit *Mandatory*	**2 Scientific Data Handling Approaches and Techniques**	15	4
Core unit *Mandatory*	**3 Regulation and Quality in the Applied Sciences (Pearson-set)**	15	4
Specialist unit *Mandatory*	**5 Fundamentals of Chemistry**	15	4
Specialist unit *Mandatory*	**13 Human Health and Nutrition**	15	4
Specialist unit *Mandatory*	**14 Food Technology**	15	4
Plus TWO units, including a minimum of one specialist unit, from below.			
Minimum of ONE unit may be selected from the specialist units list:			
Specialist unit *Optional*	**6 Anatomy and Human Physiology**	15	4
Specialist unit *Optional*	**10 Principles of Ecology and their Applications**	15	4
Specialist unit *Optional*	**12 Managing Environmental Resources**	15	4
Specialist unit *Optional*	**18 Microbiological Techniques**	15	4
Specialist unit *Optional*	**19 Managing Food Preparation and Production Systems**	15	4
Specialist unit *Optional*	**24 Sampling and Sample Preparation**	15	4
Specialist unit *Optional*	**64 Work-based Investigation**	15	4
Maximum of ONE unit may be selected from the generic optional units list:			
Generic unit *Optional*	**25 Personal and Professional Development for Scientists**	15	4
Generic unit *Optional*	**26 Managing Scientific Projects**	15	4

Level 5 units:			
Core unit *Mandatory*	**27 Analysis of Scientific Data and Information**	15	5
Core unit *Mandatory*	**28 Applied Sciences Research Project (Pearson-set)**	30	5
Specialist unit *Mandatory*	**29 Biochemistry of Macromolecules and Metabolic Pathways**	15	5
Specialist unit *Mandatory*	**43 Investigating the Properties of Food Molecules**	15	5
Specialist unit *Mandatory*	**45 Nutritional Diseases and Disorders**	15	5
Plus TWO units, including a minimum of one specialist unit, from below.			
Minimum of ONE unit may be selected from the specialist units list:			
Specialist unit *Optional*	**42 Materials Life Cycle and the Circular Economy**	15	5
Specialist unit *Optional*	**44 Advanced Health and Nutrition**	15	5
Specialist unit *Optional*	**51 Specialist Scientific Techniques and Experimentation**	15	5
Specialist unit *Optional*	**53 Industrial Microbiology**	15	5
Specialist unit *Optional*	**54 Materials' in Contact with Food**	15	5
Specialist unit *Optional*	**55 Nanomaterials and their Technology**	15	5
Maximum of ONE unit may be selected from the generic optional units list:			
Generic unit *Optional*	**61 Science Laboratory Management**	15	5
Generic unit *Optional*	**62 Organisations and Change Management**	15	5
Generic unit *Optional*	**63 Entrepreneurship and New Business Development**	15	5

Pearson BTEC Level 5 Higher National Diploma in Applied Sciences (Polymer Science and Technology)		**Unit credit**	**Level**
Level 4 units:			
Core unit *Mandatory*	**1 Fundamentals of Laboratory Techniques**	15	4
Core unit *Mandatory*	**2 Scientific Data Handling Approaches and Techniques**	15	4
Core unit *Mandatory*	**3 Regulation and Quality in the Applied Sciences (Pearson-set)**	15	4
Specialist unit *Mandatory*	**5 Fundamentals of Chemistry**	15	4
Specialist unit *Mandatory*	**15 Introduction to Polymer Materials and Properties**	15	4
Specialist unit *Mandatory*	**16 Polymer Manufacturing Techniques**	15	4
Plus TWO units, including a minimum of one specialist unit, from below.			
Minimum of ONE unit may be selected from the specialist units list:			
Specialist unit *Optional*	**8 Organic Chemistry**	15	4
Specialist unit *Optional*	**12 Managing Environmental Resources**	15	4
Specialist unit *Optional*	**18 Microbiological Techniques**	15	4
Specialist unit *Optional*	**20 Introduction to Material Properties and Applications**	15	4
Specialist unit *Optional*	**24 Sampling and Sample Preparation**	15	4
Specialist unit *Optional*	**64 Work-based Investigation**	15	4
Maximum of ONE unit may be selected from the generic optional units list:			
Generic unit *Optional*	**25 Personal and Professional Development for Scientists**	15	4
Generic unit *Optional*	**26 Managing Scientific Projects**	15	4

Level 5 units:			
Core unit *Mandatory*	**27 Analysis of Scientific Data and Information**	15	5
Core unit *Mandatory*	**28 Applied Sciences Research Project (Pearson-set)**	30	5
Specialist unit *Mandatory*	**46 Polymer Processing and Manufacture**	15	5
Specialist unit *Mandatory*	**47 Polymer Materials and Properties**	15	5
Specialist unit *Mandatory*	**48 Polymer Testing**	15	5
Plus TWO units, including a minimum of one specialist unit, from below.			
Minimum of ONE unit may be selected from the specialist units list:			
Specialist unit *Optional*	**42 Materials Life Cycle and the Circular Economy**	15	5
Specialist unit *Optional*	**51 Specialist Scientific Techniques and Experimentation**	15	5
Specialist unit *Optional*	**54 Materials' in Contact with Food**	15	5
Specialist unit *Optional*	**55 Nanomaterials and their Technology**	15	5
Maximum of ONE unit may be selected from the generic optional units list:			
Generic unit *Optional*	**61 Science Laboratory Management**	15	5
Generic unit *Optional*	**62 Organisations and Change Management**	15	5
Generic unit *Optional*	**63 Entrepreneurship and New Business Development**	15	5

4.2.3 Meeting local needs (MLN)

Centres should note that Pearson BTEC Higher National qualifications have been developed in consultation with centres, employers and relevant professional organisations. The units were designed to meet the skill needs of the sector and thereby allow coverage of the full range of employment within the sector. Centres should make maximum use of the choices available to them within the specialist pathways to meet the needs of their students, as well as the local skills and training needs.

Where centres identify a specific need that cannot be addressed using the units in this specification, centres can seek approval to use units from other RQF Pearson BTEC Higher National qualifications, through the MLN process (refer to *Commissioned qualification design and validation service* of our website http://qualifications.pearson.com or get in touch your Pearson regional contact for application details. Centres will need to justify the rationale for importing units from other RQF Pearson BTEC Higher National specifications. **Meeting local need applications must be made in advance of delivery and before 31 January in the year of student registration.**

The flexibility to import standard units from other RQF Pearson BTEC Higher National specifications is **limited to a maximum of 30 credits in a BTEC HNC qualification and a maximum of 60 credits in a BTEC HND qualification (30 credits at Level 4 and 30 credits at Level 5)**. This is an overall maximum of units that can be imported. MLN units cannot be used at the expense of the mandatory units in any qualification nor can the qualification's rules of combination, as detailed in the specification, be compromised. It is the responsibility of the centre requesting the MLN to ensure that approved units are used only in eligible combinations.

For the **Pearson BTEC Level 4 Higher National Certificate in Applied Sciences** and **Pearson BTEC Level 5 Higher National Diploma in Applied Sciences**, the maximum number of credits that can be imported by pathway are as follows:

Qualification	Pathway	Import at Level 4	Import at Level 5
Pearson BTEC Level 4 Higher National Certificate in Applied Sciences	**Biology**	30	-
	Forensic Science	30	-
	Chemistry	30	-
	Environmental Sciences	30	-
	Food Science, Technology and Nutrition	30	-
	Polymer Science and Technology	30	-
Pearson BTEC Level 5 Higher National Diploma in Applied Sciences	**Biology**	30	30
	Biotechnology	30	30
	Forensic Science	30	30
	Chemistry	30	30
	Water and Wastewater	30	30
	Environmental Sustainability	30	30
	Food Science, Technology and Nutrition	30	30
	Polymer Science and Technology	30	30

4.2.4 Pearson BTEC Higher National Commissioned Development

Where MLN does not provide enough flexibility in terms of qualification structure, centres can request design and development of units by Pearson to meet their specific needs. This is offered by the following types of developments; full commission or partial commission.

We would be pleased to discuss your ideas for a Pearson BTEC Higher National Commissioned Development. For more information please refer to the *Commissioned qualification design and validation service* on our website http://qualifications.pearson.com

Once the centre is ready to proceed with a commissioned development, an application must be made, which provides a clear rationale for the development request. Pearson will review the application and may confirm or deny the request. The commissioned unit(s) will be authored by Pearson, in full consultation within the commissioning centre. Applications must be made one year in advance of the first year of commissioned unit(s) delivery.

4.3 Pearson-set assignments

There are Pearson-set assignments, as part of core units. Each year, Pearson will issue a *theme* and (for Level 4) a set of related *topics.* Centres will develop an assignment, to be internally assessed, to engage students in work related to the Pearson-set theme.

At Level 4, tutor will select a topic to further define their approach to the theme and assignment. At Level 5, it is expected that students will define their own topic, in negotiation with tutors, based on the Pearson-set theme.

For example, from the Higher Nationals in Applied Science:

Theme: Recycling commercial waste and its importance to environmental sustainability

Level 4 topics:

- Strategically planning the recycling process
- Damage to the environment if commercial waste is not recycled
- Implementing the recycling strategy through educating employees.

Centres can find relevant support in the *Pearson-set Assignment Guidance* for the units, and the theme and topic release documentation which will be provided for each level.

The aim of the Pearson-set assignments is to provide a common framework for centres to develop work that will allow cross-sector benchmarking, through the standardisation of student work, and identification and sharing of 'best practice' in higher education teaching and learning. Pearson will share the 'best practice' results with all centres. For further information about Pearson-set assignments and assessment, see *Section 6* of this document.

4.4 The Unit Descriptor

The Unit Descriptor is how we define the individual units of study that make up a Higher National qualification. Students will study and complete the units included in the programme offered at your centre.

We have described each part of the unit, as below. You may refer to any of the Unit Descriptors in *Section 10* of this programme specification.

Unit Title	A broad statement of what the unit will cover.
Unit Code	The Ofqual unit designation
Unit Type	There are three unit types: core (mandatory to all pathways); specialist (mandatory to specific pathways); and optional (available to most pathways)
Unit level	All Higher National Certificate units are at Level 4 and all Higher National Diploma are at Level 5
Credit value	The credit value is related to total qualification time (TQT) and unit learning hours (ULH), and is easy to calculate. 1 credit is equal to 10 ULH, so 15 credits are equal to 150 ULH. To complete a Higher National Certificate or Diploma students are expected to achieve the appropriate number of credits
Introduction	Some general notes on the unit, setting the scene, stating the purpose, outlining the topics and skills gained on completion of the unit
Learning Outcomes	The Learning Outcomes are explicit statements that clearly express what students will be able to do after the completion of the unit. There are, typically, four Learning Outcomes for each unit.
Essential Content	This section covers the content that students can expect to study as they work towards achieving their Learning Outcomes.

Learning Outcomes and Assessment Criteria	Each unit sets out the 'Pass', 'Merit' and 'Distinction' criteria for that unit. When assignments are graded, a tutor will refer to this table, which connects the unit's Learning Outcomes with the student's work. This assignment may be graded at 'Pass', 'Merit' or 'Distinction level, depending on the quality of the students work.
Recommended Resources	Lists the resources appropriate to support the study of this unit. This includes books, journals and online material to support learning. The programme tutor may suggest alternatives and additions, usually with a local application or relevance.

Web resources – referencing:

Some units have web resources as part of their recommended resources lists. Hyperlinking to these resources directly can be problematic as locations and addresses of resources can change over time. To combat this we have referenced web resources as follows:

[1] A link to the main page of the website

[2] The title of the site

[3] The name of the section or element of the website where the resource can be found

[4] The type of resource it is, which may be one of the following –

- research
- general reference
- tutorials
- training
- e-books
- report
- wiki
- article
- datasets
- development tool
- discussion forum

Web

[1] sdbs.db.aist.go.jp	[2] National Institute for Advanced Industrial Science and Technology (AIST) [3] Spectral Database for Organic Compounds, SDBS [4] (General reference)
[1] rsc.org	[2] Royal Society of Chemistry [3] Learn Chemistry [4] (General reference)

5 Teaching and learning

The aim of this section is to provide guidance to centres so that they can engage students in a dynamic, interactive and reflective learning experience. This experience should effectively prepare students to successfully engage in the assessments, which will measure depth, as well as breadth of knowledge. Teaching should stimulate academic engagement, develop challenging yet constructive discourse and encourage students to reflect on their own performance in preparation for a professional career. Additionally, centres are encouraged to expose students to autonomous and independent learning, which will facilitate the development of the academic skills, experiences and techniques required as they progress from one level of study to the next.

Centres are encouraged to develop programmes that have a distinctive focus on entry into work, delivering a curriculum that embeds employability, has a strong commitment to ethics and diversity, and introduces students to contemporary as well as seminal research. All teaching and learning should reflect the expectations of employers and society, and be informed and guided by external benchmarks such as professional and statutory bodies. In so doing, students completing a Pearson BTEC Higher National in Applied Sciences will have the attributes, skills, principles and behaviours that will enable them to make a valuable contribution to local, national and international healthcare service provision.

The contributions students make to their own experiences, alongside the experience of their peers, is invaluable. Student engagement and the student voice should form a significant aspect of a student's life. Centres are encouraged to gather student opinions on a range of teaching and learning matters, which would be used to inform and enhance future practice within a programme of study and within a centre.

5.1 Delivering quality and depth

A high-quality teaching and learning experience should include qualified and experienced lecturers, an interactive and engaging curriculum, motivated and inspired students, and a support system that caters for the pastoral as well as academic interests of students.

In addition to delivering a quality learning experience, centres must also encourage students to have a deeper understanding of the subject where they are able to go beyond the fundamentals of explaining and describing. Students are expected to show they can analyse data and information, make sense of this and then reach evaluative judgements. At the higher levels of study, there is an expectation that students will be able to apply a degree of criticality to their synthesis of knowledge. This criticality would come from exposure to appropriate and relevant theories, concepts and models.

One of the reasons for delivering a quality learning experience, which has depth as well as breadth, is the benchmarking of the qualification to the Framework for Higher Education Qualifications (FHEQ). It also meets requirements set by the Regulated Qualifications Framework (RQF). The first stage of a Pearson BTEC Higher National in Applied Sciences is the Higher National Certificate (HNC), which is aligned with Level 4 of both frameworks, with the Higher National Diploma (HND) aligned with Level 5. This means that the HNC has the same level of demand and expectations as the first year of a degree programme, with the HND having the same level of demand and expectations as the second year of a degree programme.

Centres are expected to provide a broadly similar experience for students to that which they would have if they attended a similar programme at a university. This could mean:

- providing access to library facilities which have, as a minimum, available copies (physically and/or electronically) of all required reading material
- access to research papers and journals
- utilising a virtual learning environment (VLE) to support teaching
- working with local employers (see below) to present real-life case studies
- creating Schemes of Work that embrace a range of teaching and learning techniques
- listening to the student voice.

Irrespective of the type of programme on which a student is enrolled, it is highly advisable that students are inducted onto their Higher National programme. This induction should include an introduction to the course programme and academic study skills that will be essential in supporting their research and studies and, therefore, enhance the learning experience.

An induction programme should consist of the following:

- a course programme overview
- preparing for lessons
- effective engagement in lectures and seminars
- making the most out of the tutor
- assignment requirements
- referencing and plagiarism
- centre policies
- academic study skills.

Pearson offer Higher National Global Study Skills to all students − an online toolkit that supports the delivery, assessment and quality assurance of BTECs in centres. This is available on the HN Global website, www.highernationals.com. HN Global provides a wealth of support to ensure that tutors and students have the best possible experience during their course. With HN Global, students can search, share, comment, rank and sort a vast a vast range of learning resources via an online digital library and tutors can create and annotate reading lists for students.

5.2 Engaging with employers

Just as the student voice is important, so too is the employer's. Employers play a significant role in the design and development of all regulated qualifications, including the Higher Nationals in Applied Sciences. This input should extend into the learning experience, where engagement with employers will add value to students, particularly in transferring theory into practice. Work placement is an important element of the students' programme and development, and is integrated throughout the qualification. Centres are encouraged to actively engage employers in the delivery and assessment of aspects of the programme as relevant.

Centres should consider a range of employer engagement activities. These could include:

- field trips to local businesses, the industry, research labs
- inviting local Applied Sciences employers, specialists, researchers, service users and deliverers to present guest lectures
- using specialists, employers, researchers, to judge the quality of assessed presentations and/or products
- (for the more entrepreneurial) establishing a panel of experts to whom students can present their research and recommendations for service improvement or product development.

While detailed guidance on assessment has been provided in this specification *(*see *Section 6)*, it is worth considering the involvement of employers when determining assessment strategies and the use of different assessment vehicles. This enables centres to design assessments that are more closely related to what students would be doing in the workplace. Employers are able to comment on relevance and content, as well as the challenge presented by an assessment. Notwithstanding this, ultimately it is the centre's responsibility to judge the extent to which any employer contributes to teaching and learning.

5.3 Engaging with students

Students are integral to teaching and learning. As such, it is important that they are involved as much as possible with most aspects of the programme onto which they are enrolled. This input could include taking into account their views on how teaching and learning will take place, their role in helping to design a curriculum, or on the assessment strategy that will test their knowledge and understanding.

There are many ways in which to capture the student voice and student feedback, both formal and informal. Formal mechanisms include the nomination of student representatives to act as the collective student voice for each student cohort, student representation at course team meetings, and an elected Higher Education representative as part of the Student Union. Student forums should also take place periodically throughout the year with minutes and action plans updated and informing the overall annual course monitoring process. Unit-specific feedback can also be collated by students completing unit feedback forms, end-of-year course evaluations, and scheduled performance review meetings with their tutor.

However, this should not be the only time when feedback from students is sought. Discourse with students should be constant, whereby teachers adopt a 'reflection on action' approach to adjust teaching, so that students are presented with an environment that is most supportive of their learning styles. Just as employers could have input into assessment design, so too could students. This will support the development of assignments that are exciting and dynamic, and fully engage students in meaningful and informative assessment.

The biggest advantage of consulting students on their teaching, learning and assessment is securing their engagement in their own learning. Students are likely to feel empowered and develop a sense of ownership of all matters related to teaching, learning and assessment, not just their own experiences. Students could also view themselves as more accountable to their lecturers, ideally seeing themselves as partners in their own learning and not just part of a process.

5.4 Planning and structuring a programme

Learning should be challenging yet exciting; teaching should be motivating and inspirational. Consequently, both teaching and learning should form part of a programme structure that is active, flexible and progressive, and has an industry focus wherever possible.

It is important for a programme structure to be effectively planned, taking into account the nature of the student cohort, the primary mode of delivery (face-to-face or distance learning) and the level of study. It is also advisable to consider the student voice (whether that voice is heard through end-of-programme feedback, or through ongoing dialogue) when planning how and when students will be exposed to a particular subject. One other vital source of information that centres would do well to embrace is the feedback from tutors who have been and/or will be delivering learning.

It is recommended that centres establish a programme planning forum where various stakeholders are represented. This forum could consider different perspectives of teaching and learning and how these are planned into an effective programme structure. Consideration could be given to, for example, the holistic and consistent use of Virtual Learning Environments (VLEs), a programme of field trips, a strategy for engaging with employers, and how and when to assess learning.

Consideration should be given to a number of factors when planning a programme structure. These include:

- the sequencing of units (possibly around related units)
- whether to have condensed or expanded delivery
- teaching and learning techniques.

5.4.1 Sequencing units

The level of demand embedded within a unit is benchmarked to recognised standards. This applies to all units within a level of study, and this means that all Level 4 units have similar demands, as do all Level 5 units. However, this does not mean that units can, or should, be delivered in any order. For example, in the Pearson BTEC Higher National Diploma in Applied Sciences it is strongly advised that Level 4 units are delivered, and achieved, by students before progression to Level 5. However, students are able to progress to level 5 with a minimum of 90 credits at Level 4.

Within each level it is advisable, in fact the centres are encouraged, to sequence units so that those providing fundamental knowledge and understanding are scheduled early in the programme. It may also be advisable to schedule the assessment of units requiring the practice and application of more advanced skills later in the programme.

5.4.2 Condensed and expanded delivery

The next consideration is whether to deliver a unit in a condensed format alongside other units, or to deliver units over an extended period. The following tables provide examples of this, based on four units being delivered in one teaching block.

Condensed version:

Weeks 1 to 6	Week 7	Weeks 8 to 13	Week 14
Unit 1	Assessment	Unit 3	Assessment
Unit 2		Unit 4	

Expanded version:

Weeks 1 to 12	Weeks 13 and 14
Unit 1	**Assessment**
Unit 2	
Unit 3	
Unit 4	

Mixed version:

<table>
<tr><th>Week 1</th><th>Week 2</th><th>Week 3</th><th>Week 4</th><th>Week 5</th><th>Week 6</th><th>Week 7</th><th>Week 8</th><th>Week 9</th><th>Week 10</th><th>Week 11</th><th>Week 12</th><th>Week 13</th><th>Week 14</th></tr>
<tr><td colspan="13">Unit 1</td><td rowspan="3">Assessment</td></tr>
<tr><td colspan="5">Unit 2</td><td colspan="2">Assessment</td><td colspan="6">Unit 3</td></tr>
<tr><td colspan="13">Unit 4</td></tr>
</table>

The decision to deliver a condensed, expanded or mixed programme would depend on a number of factors, including availability of resources, when placements are planned, the subjects to be taught and the requirements of students. Each version has advantages: the condensed version would provide an opportunity for students to gain early success and achievement. This will enhance their self-efficacy, sense of belief in their ability to succeed, and self-confidence, with tutors being able to identify and respond to less able students early in the teaching and learning cycle. The advantages of the expanded version include providing a longer timescale for students to absorb new knowledge and, therefore, potentially improve success, and giving tutors an opportunity to coach and support less able students over a longer period of time. The mixed version, with some units spanning over the entire period and others lasting for shorter periods, provides opportunities for learning in some units to support development in others. This format may be particularly suited to a combination of practical and theoretical units. In all cases, the choice of which type of unit sequence must consider student opportunities as well as staff and physical resources of the centre.

As there are pros and cons to all approaches, the use of a planning forum would help to ensure the most suitable approach is taken. For example, centres could choose to deliver the first teaching block using the expanded version, with the subsequent teaching block being delivered through a condensed approach.

It should be noted that the above consideration would apply equally to programmes that are being delivered face-to-face or through distance learning.

5.4.3 Drawing on a wide range of delivery techniques

As part of planning the range of delivery techniques that will be used to deliver the syllabus, centres should also consider an appropriate combination of techniques for the subject.

The table below lists, with explanation, some techniques that centres could introduce into a planned programme structure.

Technique	Face-to-face	Distance learning
Lectures and seminars	These are the most common techniques used by tutors. They offer an opportunity to engage with a large number of students, where the focus is on sharing knowledge through the use of presentations.	Delivery would be through video conferencing and/or pre-recorded audio and/or visual material, available through an online platform. Synchronous discussion forums could also be used.
Laboratory Experiment-ation	Laboratory work focuses on experiential learning of scientific theories in a controlled environment. Experiments are designed to test various scientific theories and establish relationships from the effects that independent variables may have on dependent ones.	Video conferencing would be the primary form of delivery where the students will be observing experiments taking place in laboratories. These would also be supported by pre-recorded material, synchronous discussion forums and analysis of experimental results obtained.
Workshops	These are used to build on knowledge shared via tutors and seminars. Teaching can be more in-depth where knowledge is applied, for example to case studies or real-life examples. Workshops could be student-led, where students present, for example, findings from independent study.	While more challenging to organise than for face-to-face delivery, workshops should not be dismissed. Smaller groups of three or four students could access a forum simultaneously and engage in the same type of activity as for face-to-face.

Technique	Face-to-face	Distance learning
Tutorials	These present an opportunity for focused one-to-one support, where teaching is led by an individual student's requirements. These can be most effective in the run-up to assessment, where tutors can provide more focused direction, perhaps based on a formative assessment.	Other than not necessarily being in the same room as a student, tutors could still provide effective tutorials. Video conferencing tools provide the means to see a student, which makes any conversation more personal.
Virtual Learning Environments (VLEs)	These are invaluable to students studying on a face-to-face programme. Used effectively, VLEs not only provide a repository for taught material such as presentation slides or handouts, but could be used to set formative tasks such as quizzes. Further reading could also be located on a VLE, along with a copy of the programme documents, such as the handbook and assessment timetable.	A VLE is a must if students are engaged with online delivery through distance or blended learning, as this would be the primary or the key source of learning. Where distance learning is primarily delivered through hard copies of workbooks, etc., the same principle would apply as for face-to-face learning.
Blended learning	The combination of traditional face-to-face learning and online learning. This can enable students to gain personalised support, instruction and guidance while completing assigned activities and tasks remotely.	Offline learning enables students to develop autonomy and self-discipline by completing set activities and tasks with limited direction and traditional classroom-based constraints.
Work-based learning	Any opportunity to integrate work-based learning into the curriculum should be taken. This adds realism and provides students with an opportunity to link theory to practice in a way in which case studies do not. Many full-time students are involved in some form of employment, either paid or voluntary, which could be used, where appropriate, as part of their learning e.g. when assignments require students to contextualise a response to a real organisation.	It is likely that the majority of distance learning students would be employed and possibly classed as mature students. Bringing theory to life through a curriculum, which requires work based application of knowledge, would make learning for these students more relevant and meaningful. Perhaps more importantly, assessment should be grounded in a student's place of work, wherever possible.

Technique	Face-to-face	Distance learning
Guest speakers	These could be experts from industry or visiting academics in the subject area that is being studied. They could be used to present a lecture/seminar, a workshop or to contribute to assessment. The objective is to make the most effective use of an expert's knowledge and skill by adding value to the teaching and learning experience.	As long as the expert has access to the same platform as the students then the value-added contribution would still be very high. Consideration would need to be given to timings and logistics, but with some innovative management this technique would still have a place in distance learning programmes.
Field trips	Effectively planned field trips, which have a direct relevance to the syllabus, would add value to the learning experience. Through these trips students could relate theory to practice, have an opportunity to experience organisations in action, and potentially open their minds to career routes.	The use of field trips could be included as part of a distance learning programme. They will add the same value and require the same planning. One additional benefit of field trips for distance learning is that they provide an opportunity for all students in a cohort to meet, which is a rare occurrence for distance-learning students.

5.4.4 Assessment considerations

Centres should design assessment for learning. This is where an assessment strategy requires students to engage with a variety of assessment tools that are accessible, are appropriately challenging, and support the development of student self-efficacy and self-confidence. To ensure that assignments are valid and reliable, centres must implement robust quality assurance measures and monitor the effectiveness of their implementation (see *Section 6*). This includes ensuring that all students engage in assessment positively and honestly.

Assessment also provides a learning opportunity for all stakeholders of the assessment to have access to feedback that is both individual to each student and holistic to the cohort. Feedback to students should be supportive and constructive. Student self-efficacy (and, therefore, self-confidence) can be significantly enhanced where feedback not only focuses on areas for improvement but recognises the strengths a student has. At the cohort level, similar trends could be identified that inform future approaches to assessment and teaching. Assessment is an integral part of the overall learning process and assessment strategy must be developed to support effective, reflective, thinking Applied Sciences practitioners for the future. Assessment can be formative, summative or both.

5.4.5 Formative assessment

Formative assessment is primarily developmental in nature and designed to give feedback to students on their performance and progress. It takes place before the summative assessment and as such it does not confirm achievement of grades. Assessment designed formatively should develop and consolidate knowledge, understanding, skills and competencies. It is a key part of the learning process and can enhance learning and contribute to raising standards.

Through formative assessment tutors can identify students' differing learning needs early on in the programme and so make timely corrective interventions. Tutors can also reflect on the results of formative assessment to measure how effective the planned teaching and learning is at delivering the syllabus. Each student should receive one set of written formative feedback, otherwise some students may feel that others are being given more than their share of verbal feedback.

5.4.6 Summative assessment

Summative assessment is where students are provided with the assignment grades contributing towards the overall unit grade. For summative assessment to be effective it should also give students additional feedback to support ongoing development and improvement in subsequent assignments. All formative assessment feeds directly into the summative assessment for each unit and lays the foundations on which students develop the necessary knowledge and skills required for the summative assessment.

5.4.7 Assessment feedback

Effective assessment feedback is part of continuous guided learning which promotes learning and enables improvement. It also allows students to reflect on their performance and helps them understand how to make effective use of feedback. Constructive and useful feedback should enable students to understand the strengths and limitations of their performance, providing positive comments where possible as well as explicit comments on how improvements can be made. Feedback should reflect the learning outcomes and assessment criteria to also help students understand how these inform the process of judging the overall grade.

The timing of the provision of feedback and of the returned assessed work also contributes to making feedback effective. Specific turnaround time for feedback should be agreed and communicated with both tutors and students. Timing should allow students the opportunity to reflect on the feedback and consider how to make use of it in forthcoming assessments, taking into account the tutor's workload and ability to provide effective feedback.

5.4.8 Designing valid and reliable assessments

To help ensure valid and reliable assignments are designed and are consistent across all units, centres could consider a number of actions.

Use of language

The first aspect of an assignment that a centre could focus on is ensuring that language makes tasks/questions more accessible to students.

Due consideration must be given to the command verbs (i.e. the verbs used in unit assessment criteria) when considering the learning outcomes of a unit. Assignments must use appropriate command verbs that equate to the demand of the learning outcome. If the outcome requires 'analysis' then 'evaluative' requirements within the assignment must not be set when testing that outcome. This would be viewed as over-assessing. Similarly, it is possible to under-assess where analytical demands are tested using, for example, explanatory command verbs.

The following can be used as a guide to support assignment design.

- Ensure there is a holistic understanding (by tutors and students) and use of command verbs.
- Set assignment briefs that use a single command verb, focusing on the highest level of demand expected for the learning outcome(s) that is (are) being tested.
- Assignments should be supported by additional guidance that helps students to interpret the demand of the assessment criteria.

- Time-constrained assessments should utilise the full range of command verbs (or acceptable equivalents) appropriate to the academic level. Modes of time-constrained assessments include in-class tests and examinations that could be both open- or closed-book. Centres should pay close consideration to ensuring tests and exams are not replicated during the course of the year.

Consistency

This relates to the consistency of presentation and structure, the consistent use of appropriate assessment language, and the consistent application of grading criteria. Where assignments are consistent, reliability is enhanced. Where validity is present in assignments, this will result in assignments that are fit for purpose and provide a fair and equitable opportunity for all students to engage with the assignment requirements.

Employing a range of assessment tools

Just as variation in teaching methods used is important to the planning of a programme structure, so too is the use of a range of assessment tools appropriate to the unit and its content. Centres should consider taking a holistic view of assessment, ensuring a balanced assessment approach with consideration given to the subject being tested and what is in the best interests of students. As mentioned above, consultation with employers could add a sense of realism to an assessment strategy. (A comprehensive list of assessment tools is provided in *Section 6.2*.

No matter what tool is used, assignments should have a sector focus (whether this is in a workplace context or through a case study), and be explicitly clear in their instructions. In the absence of a case study, a scenario should be used to provide some context. Finally, students should be clear on the purpose of the assignment and which elements of the unit it is targeting.

6 Assessment

Pearson BTEC Higher Nationals in Applied Sciences are assessed using a combination of internally assessed **centre-devised internal assignments** (which are set and marked by centres) and internally assessed **Pearson-set assignments** (which are set by Pearson and marked by centres). Pearson-set assignments are mandatory and target particular industry-specific skills. The number and value of these units are dependent on qualification size.

- For the HNC, one core, 15-credit, unit at Level 4 will be assessed by a mandatory Pearson-set assignment targeted at particular skills.
- For the HND, two core units − one core, 15-credit, unit at Level 4 and one core, 30-credit unit at Level 5 − will be assessed by a mandatory Pearson-set assignment targeted at particular skills.

All other units are assessed by centre-devised internal assignments.

The purpose and rationale of having Pearson-set units on Higher Nationals is as follows.

Standardisation of student work – Assessing the quality of student work, that it is meeting the level and the requirements of the unit across all centres, that grade decisions and assessor feedback are justified, and that internal verification and moderation processes are picking up any discrepancies and issues.

Sharing of good practice – We will share good practice in relation to themes such as innovative approaches to delivery, the use of digital literacy, enhancement of student employability skills and employer engagement. **These themes will align to those for QAA Higher Education Reviews**.

An appointed External Examiner (EE) for the centre will ask to sample the Pearson-set assignment briefs in advance of the external examination visit. Although this is not a mandatory requirement for centres we strongly advise that centres seek guidance and support from their EE on the Pearson-set assignment. The EE may also include the Pearson-set units in the centre visit sample of student work.

We have taken great care to ensure that the assessment method chosen is appropriate to the content of the unit and in line with requirements from professional bodies, employers and higher education.

In developing an overall plan for delivery and assessment for the programme, you will need to consider the order in which you deliver units, whether delivery will take place over short or long periods of time, and when assessment can take place.

6.0.1 Example Assessment Briefs

Each unit has supporting Example Assessment Briefs that are available to download from the course materials section on our website (http://qualifications.pearson.com). The Example Assessment Briefs are there to give you an example of what the assessment will look like in terms of the feel and level of demand of the assessment.

The Example Assessment Briefs, with the exception of the mandatory Pearson-set unit, provide tutors with suggested types of assignment and structure that can be adopted and, if so, **must** be adapted accordingly.

6.1 Principles of internal assessment

This section gives an overview of the key features of internal assessment and how you, as an approved centre, can offer it effectively. The full requirements and operational information are given in the *Pearson Quality Assurance Handbook* available in the support section of our website (http://qualifications.pearson.com). All of the assessment team will need to refer to this document.

For Pearson BTEC Higher Nationals it is important that you can meet the expectations of stakeholders and the needs of students by providing a programme that is practical and applied. Centres can tailor programmes to meet local needs and should use links with local employers and the wider Applied Sciences sector.

When internal assessment is operated effectively, it is challenging, engaging, practical and up to date. It must also be fair to all students and meet national standards.

6.1.1 Assessment through assignments

For internally assessed units, the format of assessment is an assignment taken after the content of the unit, or part of the unit if several assignments are used, has been fully delivered. An assignment may take a variety of forms, including practical and written types. An assignment is a distinct activity completed independently by students (either alone or in a team). An assignment is separate from teaching, practice, exploration and other activities that students complete with direction from, and formative assessment by, tutors.

An assignment is issued to students as an **assignment brief** with a hand-out date, a completion date and clear requirements for the evidence that students are expected to provide. There may be specific observed practical components during the assignment period. Assignments can be divided into separate parts and may require several forms of evidence. A valid assignment will enable a clear and formal assessment outcome based on the assessment criteria.

6.1.2 Assessment decisions through applying unit-based criteria

Assessment decisions for Pearson BTEC Higher Nationals are based on the specific criteria given in each unit and set at each grade level. The criteria for each unit have been defined according to a framework to ensure that standards are consistent in the qualification and across the suite as a whole. The way in which individual units are written provides a balance of assessment of understanding, practical skills and career-related attributes appropriate to the purpose of the qualifications.

The assessment criteria for a unit are hierarchical and holistic. For example, if an M criterion requires the student to show 'analysis' and the related P criterion requires the student to 'explain', then to satisfy the M criterion a student will need to cover both 'explain' and 'analyse'. The unit assessment grid shows the relationships among the criteria so that assessors can apply all the criteria to the student's evidence at the same time. In *Appendix 3* we have set out a definition of terms that assessors need to understand.

Assessors must show how they have reached their decisions using the criteria in the assessment records. When a student has completed all the assessment for a unit then the assessment team will give a grade for the unit. This is given simply according to the highest level for which the student is judged to have met all the criteria. Therefore:

- **To achieve a Pass**, a student must have satisfied all the Pass criteria for the learning outcomes, showing coverage of the unit content and, therefore, attainment at Level 4 or 5 of the National Framework.
- **To achieve a Merit**, a student must have satisfied all the Merit criteria (and, therefore, the Pass criteria) through high performance in each learning outcome.
- **To achieve a Distinction**, a student must have satisfied all the Distinction criteria (and, therefore, the Pass and Merit criteria), and these define outstanding performance across the unit as a whole.

The award of a Pass is a defined level of performance and cannot be given solely on the basis of a student completing assignments. Students who do not satisfy the Pass criteria should be reported as Unclassified.

6.1.3 The assessment team

It is important that there is an effective team for internal assessment. There are three key roles involved in implementing assessment processes in your centre, each with different interrelated responsibilities, and these roles are listed below. Full information is given in the *Pearson Quality Assurance Handbook* available in the support section of our website (http://qualifications.pearson.com).

- **The Programme Leader** has overall responsibility for the programme, its assessment and internal verification to meet our requirements, record-keeping and liaison with the External Examiner. The Programme Leader registers annually with Pearson and acts as an assessor, supports the rest of the assessment team, makes sure they have the information they need about our assessment requirements, and organises training, making use of our guidance and support materials.
- **Internal Verifiers** (IVs) oversee all assessment activity in consultation with the Programme Leader. They check that assignments and assessment decisions are valid and that they meet our requirements. IVs will be standardised by working with the Programme Leader. Normally, IVs are also assessors, but they do not verify their own assessments.
- **Assessors** set or use assignments to assess students to national standards. Before taking any assessment decisions, assessors participate in standardisation activities led by the Programme Leader. They work with the Programme Leader and IVs to ensure that the assessment is planned and carried out in line with our requirements. Placement assessments must be carried out by appropriately qualified assessors.
- Your **EE** will sample student work across assessors. Your EE will also want to see evidence of internal verification of assignments and assessment decisions.

6.1.4 Effective organisation

Internal assessment needs to be well organised so that student progress can be tracked and so that we can monitor that assessment is being carried out in line with national standards. We support you in this through, for example, providing training materials and sample documentation. Our online HN Global service can also help support you in planning and record-keeping.

It is particularly important that you manage the overall assignment programme and deadlines to make sure that all your students are able to complete assignments on time.

6.1.5 Student preparation

To ensure that you provide effective assessment for your students, you need to make sure that they understand their responsibilities for assessment and the centre's arrangements. From induction onwards, you will want to ensure that students are motivated to work consistently and independently to achieve the requirements of the qualifications. They need to understand how assignments are used, the importance of meeting assignment deadlines, and that all the work submitted for assessment must be their own.

You will need to give your students a guide that explains:

- how assignments are used for assessment
- how assignments relate to the teaching programme
- how they should use and reference source materials, including what would constitute plagiarism.

The guide should also set out your Centre's approach to operating assessments, such as how students must submit assignments/work and the consequences of submitting late work, and the procedure for requesting extensions for mitigating circumstances.

6.2 Setting effective assessments

6.2.1 Setting the number and structure of assessments

In setting your assessments you need to work with the structure of assessments shown in the relevant section of a unit. This shows the learning aims and outcomes and the criteria that you are expected to follow.

Pearson provide online Example Assessment Briefs for each unit to support you in developing and designing your own assessments.

In designing your own assignment briefs you should bear in mind the following points.

- The number of assignments for a unit must not exceed the number of learning outcomes listed in the unit descriptor. However, you may choose to combine assignments, either to cover a number of learning outcomes or to create a single assignment for the entire unit.
- You may also choose to combine all or parts of different units into single assignments, provided that all units and all their associated learning outcomes are fully addressed in the programme overall. If you choose to take this approach you need to make sure that students are fully prepared, so that they can provide all the required evidence for assessment, and that you are able to track achievement in assessment records.
- A learning outcome must always be assessed as a whole and must not be split into two or more elements.
- The assignment must be targeted to the learning outcomes but the learning outcomes and their associated criteria are not tasks in themselves. Criteria are expressed in terms of the outcome shown in the evidence.

You do not have to follow the order of the learning outcomes of a unit in setting assignments, but later learning outcomes often require students to apply the content of earlier learning outcomes, and they may require students to draw their learning together.

Assignments must be structured to allow students to demonstrate the full range of achievement at all grade levels. Students need to be treated fairly by being given the opportunity to achieve a higher grade, if they have the ability.

As assignments provide a final assessment, they will draw on the specified range of teaching content for the learning outcomes. **The specified unit content must be taught/delivered**. The evidence for assessment need not cover every aspect of the teaching content, as students will normally be given particular examples, case studies or contexts in their assignments. For example, if a student is carrying out one practical performance, or an investigation of one organisation, then they will address all the relevant range of content that applies in that instance.

6.2.2 Providing an assignment brief

A good assignment brief is one that, through providing challenging and authentic sector/work-related tasks, motivates students to provide appropriate evidence of what they have learned.

An assignment brief should have:

- a career-related scenario; this could be a simple situation or a full, detailed set of career-related requirements that motivates the student to apply their learning through the assignment
- clear instructions to the student about what they are required to do, normally set out through a series of tasks
- an audience or purpose for which the evidence is being provided
- an explanation of how the assignment relates to the unit(s) being assessed.

6.2.3 Forms of evidence

Pearson BTEC Higher Nationals have always allowed for a variety of forms of assessment evidence to be used, provided they are suited to the type of learning outcomes being assessed. For many units, the practical demonstration of skills is necessary and, for others, students will need to carry out their own research and analysis, working independently or as part of a team.

The Example Assessment Briefs give you information on what would be suitable forms of evidence to give students the opportunity to apply a range of employability or transferable skills. Centres may choose to use different suitable forms of evidence to those proposed. Overall, students should be assessed using varied forms of evidence.

These are some of the main types of assessment:

- written reports, essays
- in-class tests or examinations
- creation of planning documents

- work-based projects and portfolios
- academic posters, displays, leaflets
- slide presentations
- recordings of interviews/role plays
- work placement logbooks and reflective journals
- workplace observation of practice and assessment records
- presentations with assessor questioning
- professional discussions
- time-constrained assessment.

(Full definitions of different types of assessment are given in *Appendix 4*.)

The form(s) of evidence selected must:

- allow the student to provide all the evidence required for the learning outcomes and the associated assessment criteria at all grade levels
- allow the student to produce evidence that is their own independent work
- allow a verifier to independently reassess the student to check the assessor's decisions.

For example, when you are using performance evidence, you need to think about how supporting evidence can be captured through recordings, photographs or task sheets.

Centres need to take particular care that students are enabled to produce independent work. For example, if students are asked to use real examples, then best practice would be to encourage them to use examples of their own or to give the group a number of examples that can be used in varied combinations.

6.3 Making valid assessment decisions

6.3.1 Authenticity of student work

An assessor must assess only student work that is authentic, i.e. students' own independent work. Students must authenticate the evidence that they provide for assessment through signing a declaration stating that it is their own work. A student declaration must state that:

- evidence submitted for that assignment is the student's own
- the student understands that false declaration is a form of malpractice.

Assessors must ensure that evidence is authentic to a student through setting valid assignments and supervising them during the assessment period. Assessors must also take care not to provide direct input, instructions or specific feedback that may compromise authenticity.

Centres may use Pearson templates or their own templates to document authentication.

During assessment an assessor may suspect that some or all of the evidence from a student is not authentic. The assessor must then take appropriate action, using the centre's policies for malpractice. (See *section 3.7* in this Programme Specification for further information.)

6.3.2 Making assessment decisions using criteria

Assessors make judgements using the criteria. The evidence from a student can be judged using all the relevant criteria at the same time. The assessor needs to make a judgement against each criterion that evidence is present and sufficiently comprehensive. For example, the inclusion of a concluding section may be insufficient to satisfy a criterion requiring 'evaluation'.

Assessors should use the following information and support in reaching assessment decisions:

- the explanation of key terms in *Appendix 3* of this document
- examples of verified assessed work
- your Programme Leader and assessment team's collective experience.

6.3.3 Dealing with late completion of assignments

Students must have a clear understanding of the centre's policy on completing assignments by the deadlines that you give them. Students may be given authorised extensions for legitimate reasons, such as illness, at the time of submission, in line with your centre's policies (see also *Section 3.6*).

For assessment to be fair, it is important that students are all assessed in the same way and that some students are not advantaged by having additional time or the opportunity to learn from others. Centres should develop and publish their own regulations on late submission; this should make clear the relationship between late submission and the centre's mitigating circumstances policy.

Centres may apply a penalty to assignments that are submitted beyond the published deadline. However, if a late submission is accepted, then the assignment should be assessed normally, when it is submitted, using the relevant assessment criteria, with any penalty or cap applied after the assessment. Where the result of assessment may be capped, due to late submission of the assignment, the student should be given an indication of their uncapped grade, in order to recognise the learning that has been achieved, and assessment feedback should be provided in relation to the uncapped achievement.

As with all assessment results, both the uncapped and capped grades should be recorded and ratified by an appropriate assessment board, taking into account any mitigating circumstances that may have been submitted.

6.3.4 Issuing assessment decisions and feedback

Once the assessment team has completed the assessment process for an assignment, the outcome is a formal assessment decision. This is recorded and reported to students. The information given to the student:

- must show the formal decision and how it has been reached, indicating how or where criteria have been met
- may show why attainment against criteria has not been demonstrated
- must not provide feedback on how to improve evidence but can suggest how to improve in the future.

6.3.5 Resubmission opportunity

An assignment provides the final assessment for the relevant learning outcomes, and is normally a final assessment decision. A student who, for the first assessment opportunity, has failed to achieve a Pass for that unit specification **shall be expected to undertake a reassessment**.

- Only one opportunity for reassessment of the unit will be permitted.
- Reassessment for coursework, project or portfolio-based assessments shall normally involve the reworking of the original task.
- For examinations, reassessment shall involve completion of a new task.
- A student who undertakes a reassessment will have their grade capped at a Pass for that unit.
- A student will not be entitled to be reassessed in any component of assessment for which a Pass grade or higher has already been awarded.

6.3.6 Repeat Units

In cases of students who, for the first assessment opportunity and resubmission opportunity, still fail to achieve a Pass for that unit specification:

- at the discretion of the centre and Assessment Board, decisions can be made to permit a repeat of a unit
- the student must study the unit again with full attendance and payment of the unit fee
- the overall unit grade for a successfully completed repeat unit is capped at a Pass for that unit
- units can be repeated only once.

6.3.7 Assessment Boards

Each centre is expected by Pearson to hold Assessment Boards for all of its BTEC Higher National programmes. The main purpose of an Assessment Board is to make recommendations on:

- the grades achieved by students on the individual units
- extenuating circumstances
- cases of cheating and plagiarism
- progression of students on to the next stage of the programme
- the awards to be made to students
- referrals and deferrals.

Assessment Boards may also monitor academic standards. The main boards are normally held at the end of the session, although if your centre operates on a semester system there may be (intermediate) boards at the end of the first semester. There may also be separate boards to deal with referrals.

Where a centre does not currently have such a process then the External Examiner (EE) should discuss this with the Quality Nominee and Programme Leader, stressing the requirement for Assessment Boards by both Pearson and QAA, and that Assessment Board reports and minutes provide valuable evidence for QAA's Review of College Higher Education process.

6.4 Planning and record keeping

For internal processes to be effective, an assessment team needs to be well organised and keep effective records. The centre will also work closely with us so that we can quality assure that national standards are being satisfied. This process gives stakeholders confidence in the assessment approach.

The Programme Leader should have an assessment plan. When producing a plan, the assessment team will wish to consider:

- the time required for training and standardisation of the assessment team
- the time available to undertake teaching and carrying out of assessment, taking account of when students may complete external assessments and when quality assurance will take place
- the completion dates for different assignments
- who is acting as Internal Verifier (IV) for each assignment, and the date by which the assignment needs to be verified
- setting an approach to sampling assessor decisions though internal verification that covers all assignments, assessors and a range of students

- how to manage the assessment and verification of students' work, so that they can be given formal decisions promptly
- how resubmission opportunities can be scheduled.

The Programme Leader will also maintain records of assessment undertaken. The key records are:

- Verification of assignment briefs
- Student authentication declarations
- Assessor decisions on assignments, with feedback given to students
- Verification of assessment decisions.

Examples of records and further information are available in the *Pearson Quality Assurance Handbook* available in the support section of our website (http://qualifications.pearson.com).

6.5 Calculation of the final qualification grade

6.5.1 Conditions for the award

Conditions for the award of the HND

To achieve a Pearson BTEC Level 5 Higher National Diploma qualification a student must have:

- completed units equivalent to 120 credits at level 5
- achieved at least a pass in 105 credits at level 5
- completed units equivalent to 120 credits at level 4
- achieved at least a pass in 105 credits at level 4.

Conditions for the award of the HNC

To achieve a Pearson BTEC Level 4 Higher National Certificate qualification a student must have:

- completed units equivalent to 120 credits at level 4
- achieved at least a pass in 105 credits at level 4.

6.5.2 Compensation provisions

Compensation provisions for the HND

Students can still be awarded an HND if they have attempted but not achieved a Pass in one of the 15-credit units completed at level 4, and similarly if they have attempted but not achieved a Pass in one of the 15-credit units at level 5. However, they must complete and pass the remaining units for an HNC or HND as per the unit rules of combination of the required qualification.

Compensation provisions for the HNC

Students can still be awarded an HNC if they have attempted but not achieved a Pass in one of the 15-credit units completed, but have completed and passed the remaining units.

6.5.3 Calculation of the overall qualification grade

The calculation of the **overall qualification grade** is based on the student's performance in all units. Students are awarded a Pass, Merit or Distinction qualification grade, using the points gained through all 120 credits, at Level 4 for the HNC or Level 5 for the HND, based on unit achievement. The overall qualification grade is calculated in the same way for the HNC and for the HND.

All units in valid combination must have been attempted for each qualification. The conditions of award and the compensation provisions will apply as outlined above. All 120 credits count in calculating the grade (at each level, as applicable).

The overall qualification grade for the HND will be calculated based on student performance in Level 5 units only.

Units that have been attempted but not achieved, and subsequently granted compensation, will appear as 'Unclassified', i.e. a 'U' grade, on the student's Notification of Performance, that is issued with the student certificate.

Points per credit

Grade	Points
Pass	4
Merit	6
Distinction	8

Point boundaries

Grade	Point boundaries
Pass	420−599
Merit	600−839
Distinction	840 +

6.5.4 Modelled student outcomes

Pearson BTEC Level 4 Higher National Certificate

				STUDENT 1		STUDENT 2		STUDENT 3		STUDENT 4		STUDENT 5	
	Credits	Level	Grade point	Grade	Unit points	Grade	Unit points	Grade	Unit points	Grade	Unit points	Grade	Unit points
Core 1	15	4	4	P	60	P	60	P	60	D	120	D	120
Core 2	15	4	4	P	60	P	60	P	60	D	120	M	90
Core 3	15	4	4	P	60	P	60	P	60	D	120	M	90
Core 4	15	4	4	P	60	P	60	M	90	M	90	M	90
Core 5	15	4	6	M	90	P	60	M	90	M	90	M	90
Core 6	15	4	6	M	90	P	60	M	90	M	90	M	90
Opt 1	15	4	6	M	90	M	90	D	120	D	120	D	120
Opt 2	15	4	6	M	90	M	90	D	120	D	120	D	120
TOTAL	120				600		540		690		870		810
GRADE					M		P		M		D		M

Pearson BTEC Level 5 Higher National Diploma

				STUDENT 1		STUDENT 2		STUDENT 3		STUDENT 4		STUDENT 5	
	Credits	Level	Grade point	Grade	Unit points	Grade	Unit points	Grade	Unit points	Grade	Unit points	Grade	Unit points
Core 1	15	4	0	P	0	P	0	P	0	D	0	P	0
Core 2	15	4	0	P	0	P	0	P	0	D	0	M	0
Core 3	15	4	0	P	0	P	0	P	0	D	0	M	0
Core 4	15	4	0	P	0	P	0	M	0	M	0	M	0
Core 5	15	4	0	M	0	P	0	M	0	M	0	P	0
Core 6	15	4	0	M	0	P	0	M	0	D	0	U	0
Opt 1	15	4	0	M	0	P	0	D	0	D	0	D	0
Opt 2	15	4	0	M	0	P	0	D	0	D	0	D	0
Core 7	30	5	6	M	180	M	180	M	180	P	120	D	240
Core 8	15	5	6	M	90	M	90	M	90	P	60	D	120
Opt 3	15	5	6	M	90	M	90	D	120	P	60	D	120
Opt 4	15	5	6	M	90	P	60	D	120	P	60	D	120
Opt 5	15	5	6	M	90	P	60	D	120	M	90	M	90
Opt 6	15	5	6	M	90	P	60	M	90	M	90	P	60
Opt 7	15	5	6	M	90	P	60	M	90	M	90	M	90
TOTAL	240				720		600		810		570		840
GRADE					M		M		M		P		D

7 Quality assurance

Pearson's quality assurance system for all Pearson BTEC Higher National programmes is benchmarked to Level 4 and Level 5 on the UK Quality Assurance Agency's (QAA) Framework for Higher Education Qualifications (FHEQ). This will ensure that centres have effective quality assurance processes to review programme delivery. It will also ensure that the outcomes of assessment are to national standards.

The quality assurance process for centres offering Pearson BTEC Higher National programmes comprises five key components:

1 The approval process
2 Monitoring of internal centre systems
3 Independent assessment review
4 Annual programme monitoring report
5 Annual student survey

7.1 The approval process

Centres new to the delivery of Pearson programmes will be required to seek approval through the centre approval process that includes the programme approval process (refer to '*Becoming a centre*' section on our website http://qualifications.pearson.com). Programme approval for centres new to Higher Nationals are only considered in one way:

- desk-based approval review
- review and approval visit to the centre.

Prior to approval being given, centres will be required to submit documentary evidence to demonstrate that they:

- have the human and physical resources required for effective delivery and assessment
- understand the implications for independent assessment and agree to abide by these
- have a robust internal assessment system supported by 'fit-for-purpose' assessment documentation
- have a system to internally verify assessment decisions, to ensure standardised assessment decisions are made across all assessors and sites.

Applications for approval must be supported by the head of the centre (Principal or Chief Executive, etc.) and include a declaration that the centre will operate the programmes strictly, as approved and in line with Pearson requirements.

Centres seeking to renew their programme approval upon expiry of their current approval period may be eligible for the automatic approval process (refer to *Pearson BTEC Higher National Approval Guidance 2019* available at http://qualifications.pearson.com), subject to the centre meeting the eligibility criteria set out by Pearson.

Regardless of the type of centre, Pearson reserves the right to withdraw either qualification or centre approval when it deems there is an irreversible breakdown in the centre's ability to quality assure either its programme delivery or its assessment standards.

7.2 Monitoring of internal centre systems

Centres will be required to demonstrate ongoing fulfilment of the centre approval criteria over time and across all Higher National programmes. The review of these systems are either done through a Quality Management Review or and Academic Management Review (QMR or AMR) in the UK or by your External Examiner for international centres. Centres will be given the opportunity to present evidence of the ongoing suitability and deployment of their systems to carry out the required functions. This includes the consistent application of policies affecting student registrations, appeals, effective internal examination and standardisation processes. Where appropriate, centres may present evidence of their operation within a recognised code of practice, such as that of the *'UK Quality Assurance Agency for Higher Education quality code'* (refer to www.qaa.ac.uk/quality-code) . Pearson reserves the right to confirm independently that these arrangements are operating to Pearson's standards.

Pearson will affirm, or not, the ongoing effectiveness of such systems. Where system failures are identified, sanctions (appropriate to the nature of the problem) will be applied, in order to assist the centre in correcting the problem.

7.3 Independent assessment review

The internal assessment outcomes reached for all Pearson BTEC Higher National programmes benchmarked to Level 4 and Level 5 of the Quality Assurance Agency (QAA) Framework for Higher Education Qualifications (FHEQ) are subject to a visit from a Pearson-appointed External Examiner (known as Standards Verifiers for lower level BTEC programmes). The outcomes of this process will be:

- to confirm that internal assessment is to UK national standards and allow certification, **or**
- to make recommendations to improve the quality of assessment outcomes before certification is released, **or**
- to make recommendations about the centre's ability to continue to be approved for the Pearson BTEC Higher National qualifications in question.

7.4 Annual Programme Monitoring Report (APMR)

The APMR is a strategic overview of a centre's Higher National programmes which is writ that provides an opportunity for centres to analyse and reflect on the most recent teaching year. By working in collaboration with centres, the information can be used by Pearson to further enhance the quality assurance of the Pearson BTEC Higher National programmes. An overview report is produced to outline the findings of the APMR each year. This can be accessed on HigherNationals.com at http://monitoring-report.highernationals.com.

7.5 Annual student survey

Pearson will conduct an annual survey of Pearson BTEC Higher National students. The purpose of the survey is to enable Pearson to gain a snapshot of every Higher National student's experience as part of the quality assurance process, by engaging with students studying on these programmes. Each centre that has sufficient students engage with the survey will get their own bespoke report about their results. The report can be accessed on HN Global at http://hnglobal.highernationals.com

7.6 Centre and qualification approval

As part of the approval process, your centre must make sure that the resource requirements listed below are in place before offering the qualification.

Centres must have appropriate physical resources (for example equipment, IT, learning materials, teaching rooms) to support the delivery and assessment of the qualifications.

- Staff involved in the assessment process must have relevant expertise and/or occupational experience.
- There must be systems in place to ensure continuing professional development for staff delivering the qualification.
- Centres must have in place appropriate health and safety policies relating to the use of equipment by staff and students.
- Centres must deliver the qualification in accordance with current equality legislation.
- Centres should refer to the individual unit descriptors to check for any specific resources required.

The result, we believe, is qualifications that will meet the needs and expectations of students worldwide.

7.7 Continuing quality assurance and standards verification

We produce annually the latest version of the Pearson Quality Assurance Handbook, available in the support section of our website (http://qualifications.pearson.com). It contains detailed guidance on the quality processes required to underpin robust assessment and internal verification.

The key principles of quality assurance are that:

- a centre delivering Pearson BTEC Higher National programmes must be an approved centre, and must have approval for the programmes or groups of programmes that it is delivering
- the centre agrees, as part of gaining approval, to abide by specific terms and conditions around the effective delivery and quality assurance of assessment; it must abide by these conditions throughout the period of delivery
- Pearson makes available to approved centres a range of materials and opportunities through the assessment checking service. This is intended to exemplify the processes required for effective assessment and provide examples of effective standards. Approved centres must use the materials and services to ensure that all staff delivering BTEC qualifications keep up to date with the guidance on assessment
- an approved centre must follow agreed protocols for standardisation of assessors and verifiers, for the planning, monitoring and recording of assessment processes, and for dealing with special circumstances, appeals and malpractice.

The approach of quality-assured assessment is through a partnership between an approved centre and Pearson. We will make sure that each centre follows best practice and employs appropriate technology to support quality assurance processes where practicable. We work to support centres and seek to make sure that our quality-assurance processes do not place undue bureaucratic processes on centres. We monitor and support centres in the effective operation of assessment and quality assurance.

The methods we use to do this for Pearson BTEC Higher Nationals include:

- making sure that all centres complete appropriate declarations at the time of approval
- undertaking approval visits to centres
- making sure that centres have effective teams of assessors and verifiers who are trained to undertake assessment
- assessment sampling and verification through requested samples of assessments, completed assessed student work and associated documentation
- an overarching review and assessment of a centre’s strategy for assessing and quality-assuring its BTEC programmes.

An approved centre must make certification claims only when authorised by us and strictly in accordance with requirements for reporting. Centres that do not fully address and maintain rigorous approaches to quality assurance cannot seek certification for individual programmes or for all Pearson BTEC Higher National qualifications.

Centres that do not comply with remedial action plans may have their approval to deliver qualifications removed.

8 Recognition of Prior Learning and attainment

Recognition of Prior Learning (RPL) is a method of assessment (leading to the award of credit) that considers whether students can demonstrate that they can meet the assessment requirements for a unit through knowledge, understanding or skills they already possess, and so do not need to develop through a course of learning.

Pearson encourages Centres to recognise students' previous achievements and experiences whether at work, home or at leisure, as well as in the classroom. RPL provides a route for the recognition of the achievements resulting from continuous learning. RPL enables recognition of achievement from a range of activities using any valid assessment methodology. Provided that the assessment requirements of a given unit or qualification have been met, the use of RPL is acceptable for accrediting a unit, units or a whole qualification. Evidence of learning must be valid and reliable.

For full guidance on RPL please refer to the *Recognition of Prior Learning* policy document available in the support section of our website (https://qualifications.pearson.com).

The QCF Pearson BTEC Level 4 Higher National Certificate in Applied Biology, QCF Pearson BTEC Level 4 Higher National Certificate in Applied Chemistry, QCF Pearson BTEC Level 4 Higher National Certificate in Biological Sciences for Industry and QCF Pearson BTEC Level 4 Higher National Certificate in Biological Sciences for Industry unit content mapped to the Level 4 units available in the Pearson BTEC Higher National Applied Sciences programmes (RQF) can be found in Appendix 7 of this programme specification.

9 Equality and diversity

Equality and fairness are central to our work. The design of these qualifications embeds consideration of equality and diversity as set out in the qualification regulators' General Conditions of Recognition. Promoting equality and diversity involves treating everyone with equal dignity and worth, while also raising aspirations and supporting achievement for people with diverse requirements, entitlements and backgrounds. An inclusive environment for learning anticipates the varied requirements of students, and aims to ensure that all students have equal access to educational opportunities. Equality of opportunity involves enabling access for people who have differing individual requirements as well as eliminating arbitrary and unnecessary barriers to learning. In addition, students with and without disabilities are offered learning opportunities that are equally accessible to them, by means of inclusive qualification design.

Pearson's equality policy requires all students to have equal opportunity to access our qualifications and assessments. It also requires our qualifications to be designed and awarded in a way that is fair to every student. We are committed to making sure that:

- Students with a protected characteristic (as defined in legislation) are not, when they are undertaking one of our qualifications, disadvantaged in comparison to students who do not share that characteristic.
- All students achieve the recognition they deserve from undertaking a qualification and that this achievement can be compared fairly to the achievement of their peers.

Pearson's policy regarding access to its qualifications is that:

- They should be available to everyone who is capable of reaching the required standards
- They should be free from any barriers that restrict access and progression
- There should be equal opportunities for all those wishing to access the qualifications.

Centres are required to recruit students to Higher National qualifications with integrity. This will include ensuring that applicants have appropriate information and advice about the qualifications, and that the qualification will meet their needs. Centres will need to review the entry profile of qualifications and/or experience held by applicants, considering whether this profile shows an ability to progress to a higher level qualification. Centres should take appropriate steps to assess each applicant's potential and make a professional judgement about their ability to successfully complete the programme of study and achieve the qualification. This assessment will need to take account of the support available to the student within the centre during their programme of study and any specific support that might be necessary to allow the student to access the assessment for the qualification. Centres should consult our policy documents on students with particular requirements.

Access to qualifications for students with disabilities or specific needs

Students taking a qualification may be assessed in a **recognised regional sign language**, where it is permitted for the purpose of reasonable adjustments. Further information on access arrangements can be found in the Joint Council for Qualifications (JCQ) document Access Arrangements, Reasonable Adjustments and Special Consideration for General and Vocational Qualifications. Details on how to make adjustments for students with protected characteristics are given in the document Pearson Supplementary Guidance for Reasonable Adjustment and Special Consideration in Vocational Internally Assessed Units . See the support section of our website for both documents (http://qualifications.pearson.com/).

10 Pearson BTEC Higher Nationals in Applied Sciences Units

Unit 1: Fundamentals of Laboratory Techniques

Unit code	**A/617/5358**
Unit type	**Core**
Unit level	**4**
Credit value	**15**

Introduction

This general science laboratory techniques' unit is designed to ensure that all students use the same range of basic techniques, irrespective of pathway. Students will undertake chromatography, qualitative infrared spectroscopy, titration, quantitative spectroscopy, microscopy, aseptic technique and synthetic chemistry techniques. The unit will allow students to develop confidence in writing laboratory reports in a standard format and in carrying out risk assessments of practical work.

Where possible, tutors should ensure that practical activities reflect the students' pathways. Practical work should involve laboratory method sheets in a standardised format. The skills developed in following standard laboratory methods will be transferable to other pathways.

Students should be encouraged to reflect on the quality of the practical work carried out and to justify how they may improve their levels of skill. Students should be encouraged to adopt good practice, reflective of industrial and clinical standards when working in the laboratory. Visits to external laboratories would be useful in highlighting best practice.

Learning Outcomes

By the end of this unit, a student will be able to:

1 Carry out qualitative and quantitative analysis

2 Carry out synthetic chemistry techniques

3 Demonstrate use of microscopy and aseptic technique

4 Demonstrate good practice with respect to reporting, health and safety and laboratory organisation.

Essential Content

LO1 **Carry out qualitative and quantitative analysis**

Qualitative or quantitative analysis, using chromatography and relevant to the pathway:

Basic chromatography principles in relation to technique(s) carried out: mobile phase; stationary phase; locating agents; retention time; basis of separation, e.g. interactions between analyte and mobile/stationary phase, polarity, hydrophobicity, size, exclusion, ion-exchange, adsorption, partition

Examples of chromatography techniques: planar chromatography, e.g. thin layer chromatography (TLC) and paper chromatography; column chromatography, e.g. gas chromatography, high performance liquid chromatography (HPLC), ion-exchange, size exclusion

Qualitative analysis: use of a standard substance/standard substances; use of retention time

Quantitative analysis: use of a calibration curve; relation of peak area to amount of analyte present; use of an internal standard

Quantitative analysis, using titration and spectroscopy:

Calculations involving: number of moles; molar mass; mass; concentration; volume

Alternative ways of expressing concentration: mol dm^{-3}; mmol dm^{-3}; parts per million (ppm) or mg dm^{-3}; parts per billion (ppb) or mg dm^{-3}; percentage

Preparation of solutions, using quantitative technique

Titration (as appropriate to the pathway). Examples of titration techniques: acid-base; precipitation; complexometric; redox; titrations, using an indicating electrode, e.g. pH; Karl Fischer

Beer-Lambert Law applications of ultraviolet-visible spectroscopy

LO2 Carry out synthetic chemistry techniques

Examples of techniques that may be used in syntheses:

Reflux

Distillation

Filtration

Vacuum filtration

Recrystallisation

Solvent extraction, using a separating funnel

Use of a rotary evaporator

Examples of confirmatory techniques: boiling point; melting point; TLC; infrared spectroscopy; spot tests for functional groups.

Examples of syntheses (list not exhaustive):

Preparation of cyclohexene from cyclohexanol

Preparation of ethyl butanoate

Preparation of antifibrin

Preparation of paracetamol.

LO3 Demonstrate use of microscopy and aseptic technique

Microscopy:

Component parts of a light microscope

Prepared tissue slides

Slide preparation

Use of a calibrated eyepiece graticule

Production of labelled drawings showing magnification.

Aseptic technique:

For a purpose, e.g. microbiology or cell culture

Minimising environmental contamination: disinfection of surfaces; good experimental technique

Decontamination, e.g. sterilisation; autoclaving; disinfection; safe disposal of contaminated waste.

LO4 **Demonstrate good practice with respect to reporting, health and safety and laboratory organisation.**

Reporting:

Typical report format, e.g. aim, introduction (including underpinning theory), method/procedure (including materials used), results, discussion, conclusion

Reflection on validity of results in terms of the method used and the level of student proficiency.

Health and safety assessments:

Globally Harmonised System of Classification and Labelling of Chemicals (GHS) pictograms

Chemical hazards

Non-chemical hazards

Risk assessment methodology: likelihood and severity; hierarchy of control measures; recording significant findings

Checking that the portable appliance testing (PAT) label is current.

Examples of laboratory organisation practices:

Ensuring that the workstation is in an appropriate condition for commencing practical work

Carrying out laboratory tasks in a methodical manner, following standard operating procedures (SOP)

Checking the condition of glassware and equipment

Handling and storing materials appropriately

Following standard practices in cleaning equipment

Disposing of waste appropriately

Restoring the workstation to an appropriate standard at the end of practical work.

Calibrating equipment and checking that equipment is within calibration limits as appropriate to the task. Examples of this include:

Checking that balances are within calibration

Checking the calibration of volumetric glassware, using water as a standard

Calibration of pH meters

Calibration of Karl Fischer instruments

Construction of a calibration curve in ultraviolet visible spectroscopy

Running an infrared spectrum of a standard polymer sample to check the position of peaks

Running chromatograms of standard substances

Checking that thermometers used to find melting points and boiling points are calibrated correctly

Calibration of an eyepiece graticule, using a standard graduated slide.

Learning Outcomes and Assessment Criteria

Pass	Merit	Distinction
LO1 Carry out qualitative and quantitative analysis		**D1** Evaluate the validity of the results obtained from the analytical techniques
P1 Carry out a chromatographic technique **P2** Carry out titration and Beer Lambert Law applications to determine the concentrations of solutions	**M1** Explain the theory underpinning each technique	
LO2 Carry out synthetic chemistry techniques		**D2** Evaluate the success of the syntheses
P3 Undertake a procedure to synthesise and purify an organic liquid **P4** Undertake a procedure to synthesise and purify an organic solid	**M2** Explain the reasons for carrying out the steps in the syntheses	

<table>
<tr><td colspan="2">LO3 Demonstrate use of microscopy and aseptic technique</td><td rowspan="4">LO3 and LO4
D3 Justify an action plan for improving the level of skill demonstrated in microscopy, aseptic technique, risk assessment and compliance with standards of good practice in the laboratory</td></tr>
<tr><td>P5 Create labelled diagrams from tissue slides
P6 Carry out practical work that involves the use of aseptic technique</td><td>M3 Explain the purposes of the component steps in the procedure(s) that use aseptic technique</td></tr>
<tr><td colspan="2">LO4 Demonstrate good practice with respect to reporting, health and safety, and laboratory organisation</td></tr>
<tr><td>P7 Report on each of the practical exercises undertaken
P8 Carry out risk assessments for a minimum of three of the techniques undertaken
P9 Carry out relevant calibration and checks on calibration</td><td>M4 Evaluate the quality of the practical work carried out with respect to good laboratory practice, health and safety and laboratory organisation</td></tr>
</table>

Recommended Resources

Textbooks

AHMED, N., GLENCROSS, H., WANG, Q. (Eds.) (2016) *Biomedical Science Practice: Experimental and Professional Skills.* 2nd ed. Oxford: Oxford University Press.

BOYLE, J., RAMSAY, S. (2017) *Writing for Science Students.* London: Palgrave.

CHRISTIAN, G.D., DASGUPTA, P.K., SCHUG, K.A. (2013) *Analytical Chemistry.* 7th ed. Hoboken, NJ: John Wiley & Sons Inc.

CRANWELL, P.B., HARWOOD, L.M., MOODY, C.J. (2017) *Experimental Organic Chemistry.* Chichester: John Wiley & Sons Ltd.

DEAN, J.R., JONES, A.M., HOLMES, D., REED, R., WEYERS, J., JONES, A. (2017) *Practical Skills in Chemistry.* 3rd ed. Harlow: Pearson Education Ltd.

EVANS, E.H., FOULKES, M.E. (2018) *Analytical Chemistry: A Practical Approach.* Oxford: Oxford University Press.

GOLDMAN, E., GREEN, L.H. (Eds.) (2015) *Practical Handbook of Microbiology.* 3rd ed. Boca Raton, FL: CRC Press.

HARRIS, D.C., CHUCK, L. (2015) *Quantitative Chemical Analysis.* 9th ed. New York: W. H. Freeman and Co. Ltd.

JOHNSON, S., SCOTT, J. (2019) *Study and Communication Skills for the Biosciences.* 3rd ed. Oxford: Oxford University Press.

JONES, A., REED, R., WYERS, J. (2016) *Practical Skills in Biology.* 6th ed. Harlow: Pearson Education Ltd.

MCPHERSON, P. (2015) *Practical Volumetric Analysis.* Cambridge: The Royal Society of Chemistry.

OVERTON, T., JOHNSON, S., SCOTT, J. (2019) *Study and Communication Skills for the Chemical Sciences*. 3rd ed. Oxford: Oxford University Press.

ROBBINS, S. (2009) *Science Study Skills*. Basingstoke: Palgrave Macmillan.

SASTRY, A.S., BHAT, K.S. (2018) *Essentials of Practical Microbiology.* New Delhi: Jaypee Brothers Medical Publishers (P) Ltd.

SKOOG, D.A., WEST, D.M., HOLLER, F.J., CROUCH, S.R. (2014) *Fundamentals of Analytical Chemistry.* 9th ed. Belmont: Brooks/Cole.

Web

microbiologicalsociety.org	Microbiological Society
hse.gov.uk	Health and Safety Executive
rsb.org	Royal Society of Biology
rsc.org	Royal Society of Chemistry Learn Chemistry (General reference)
sdbs.db.aist.go.jp	National Institute for Advanced Industrial Science and Technology (AIST) Spectral Database for Organic Compounds, SDBS (General reference)

Links

This unit links to the following related units:

Unit 3: Regulation and Quality in the Applied Sciences

Unit 4: Cell Biology

Unit 7: Inorganic Chemistry

Unit 8: Organic Chemistry

Unit 18: Microbiological Techniques

Unit 24: Sampling and Sample Preparation

Unit 29: Biochemistry of Macromolecules and Metabolic Pathways

Unit 32: Biotechnology Techniques

Unit 33: Analytical Techniques for Forensic Science

Unit 35: Analytical Chemistry

Unit 51: Specialist Scientific Techniques and Experimentation

Unit 2: Scientific Data Handling Approaches and Techniques

Unit code	**F/617/5359**
Unit type	**Core**
Unit level	**4**
Credit value	**15**

Introduction

The data handling approaches and techniques, as well as the supporting mathematics that is delivered in this unit, are directly applicable to the scientific sector of industry, and will help to increase students' knowledge of the broad underlying principles within this discipline. The students will also develop their numerical abilities and increase their confidence in handling data in order to create information and knowledge.

The aim of this unit is to develop students' skills in data handling approaches and techniques and the underlying mathematical principles and theories that underpin the scientific curriculum. Students will be introduced to data collection and handling techniques, data representation, mathematical methods and statistical techniques in order to analyse and solve problems within a scientific context.

On successful completion of this unit, students will be able to employ mathematical methods within a variety of contextualised examples, interpret data using statistical techniques, and use analytical and computational methods to evaluate and solve scientific problems. Furthermore, abilities such as data collection, handling and interpretation of data, and logical approach to problem analysis and solving, will enhance the employability skills of the students.

Learning Outcomes

By the end of this unit, a student will be able to:

1 Demonstrate handling of data and information to scientific standards

2 Identify the relevance of mathematical methods to a variety of conceptualised scientific examples

3 Explore raw scientific data using statistical methods

4 Solve problems using differential and integral calculus.

Essential Content

LO1 Demonstrate handling of data and information to scientific standards

International system (SI) of units:

The basic dimensions in the physical world and the corresponding SI base units

SI derived units with special names and symbols

SI prefixes and their representation with scientific notation.

Collecting data and information:

Collecting primary data: e.g. through measurement, observation, interrogation, participation

Collecting secondary data: e.g. data published in books, journals, newspapers, magazines, online portals

Quantitative data collection: based on mathematical calculations in various formats; on hard facts; objective

Qualitative data collection: based on opinions, perspectives, feelings; subjective.

Interpreting data:

Classification and categorisation of data

Summarising quantitative and qualitative data with appropriate software

Test procedures for physical (destructive and non-destructive) tests and statistical tests that might be used in gathering information.

Presenting data:

Considerations: target audience; appropriateness of media used; clarity of information; communication of work carried out

Using presentation software to present data to an audience

Displaying data: e.g. using tables; graphs/charts; bullet points

Graphical methods: linear axes; non-linear axes, e.g. logarithmic, exponential; curve fitting; error bars; linear regression, e.g. least squares method

Graphical representations: e.g. indicators, line charts, bar charts, column charts, pie charts, area charts, frequency polygons, pivot tables, scatter charts, ogives, histograms, bubble charts, treemaps, polar charts, funnel charts, Fisheye/Cartesian Distortion.

LO2 **Identify the relevance of mathematical methods to a variety of conceptualised scientific examples**

Algebraic methods:

BODMAS

Equations: transposing of equations; linear equations; simultaneous linear equations; quadratic equations; roots of quadratic equations

The law of straight line; coordinates; identifying regions

Multiplying algebraic expressions; factors; fractions

Functions: quadratic, exponential, logarithmic, circular and hyperbolic.

Trigonometry:

Trigonometric ratios; relations between them

Ratios of angles in the second quadrant

Trigonometric identities

Relations between the sides and angles of a triangle

Circular measures.

Mathematical concepts:

Dimensional analysis

Arithmetic and geometric progressions.

Errors in data:

Classification of sources of errors, e.g. random, systematic, gross; difference between accuracy and precision; handling errors in data processing, e.g. absolute, relative, compound.

LO3 **Explore raw scientific data using statistical methods**

Handling data using statistical methods:

Differences between qualitative and quantitative raw data analysis

Descriptive statistics:

Measures of central tendency (e.g. mean, median)

Measures of variability (e.g. range, standard deviation)

Application to scientific data (e.g. finding tendencies, measuring variability in processes outputs).

Inferential statistics:

The difference between sample and population

Different sampling techniques and methods.

Measuring association:

Use of scatter plots, correlation and regression analysis, simple forecasting

Association between variables and outputs in applications of science

Evaluating use of software, such as Excel, SAS and SPSS, to perform raw data analysis

Applying the appropriate methods and tools for evaluation of raw data.

LO4 **Solve problems using differential and integral calculus**

Differential calculus:

Introduction to methods for differentiating mathematical functions

The use of stationary points to determine maxima and minima

Using differentiation to assess the rate of change in a quantity.

Integral calculus:

Introducing definite and indefinite integration for known functions

Using integration to determine the area under a curve

Formulating models of exponential growth and decay, using integration methods.

Learning Outcomes and Assessment Criteria

Pass	Merit	Distinction
LO1 Demonstrate handling of data and information to scientific standards		
P1 Describe SI units and prefix notation **P2** Examine the collection and handling of quantitative and qualitative data with appropriate graphical representations	**M1** Explain the impact on the visual clarity of data if inappropriate graphs are used with appropriate examples	**D1** Present an analysis of scientific data using both computational and qualitative methods
LO2 Identify the relevance of mathematical methods to a variety of conceptualised scientific examples		
P3 Construct graphs for quadratic, exponential, logarithmic and circular functions **P4** Determine and interpret solutions of functional equations to scientific examples	**M2** Illustrate the use of mathematical functions in applied science by the use of examples	**D2** Justify why logarithms are highly regarded in science giving real world examples in the process

Pass	Merit	Distinction
LO3 Explore raw scientific data using statistical methods		**D3** Make valid recommendations and judgements for improving data handling and evaluation through the application of statistical methods
P5 Assess qualitative and quantitative raw scientific data from a range of examples using appropriate statistical methods **P6** Assess the use of appropriate statistical methods supported by specific scientific examples	**M3** Evaluate the differences in application between descriptive statistics, inferential statistics and measuring association	
LO4 Solve problems using differential and integral calculus		**D4** Research applications of calculus to real world scientific problems
P7 Solve practical problems by using differential calculus and by determining rate of change graphically **P8** Use integral calculus to solve practical problems	**M4** Analyse the nature of stationary points on the graphs of functions by using first and second derivatives	

Recommended Resources

Textbooks

AITKEN, M., BROADHURST, B., HLADKY, S. (2009) *Mathematics for Biological Scientists*. New York: Garland Science (Taylor & Francis Group).

FRANCIS, P.G. (2013) *Mathematics for Chemists*. New York: Springer.

HOLMES, S., HUBER, W. (2019) *Modern Statistics for Modern Biology*. Cambridge: Cambridge University Press.

MONK, P., MUNRO, L.J. (2010) *Maths for Chemistry: A Chemist's Toolkit of Calculations*. 2nd ed. Oxford: Oxford University Press.

MOORE, D.S., MCCABE, G.P., CRAIG, B.A. (2017) *Introduction to the Practice of Statistics*. 9th ed. New York: W.H. Freeman (Macmillan Publishers).

SINGH, K. (2011) *Engineering Mathematics Through Applications*. 2nd ed. Basingstoke: Palgrave Macmillan.

STEINER, E. (2008) *The Chemistry Maths Book*. 2nd ed. New York: Oxford University Press USA.

STROUD, K.A. (2009) *Foundation Mathematics*. Basingstoke: Palgrave Macmillan.

STROUD, K.A., BOOTH, D.J. (2013) *Engineering Mathematics*. 7th ed. Basingstoke: Palgrave Macmillan.

Web

mathcentre.ac.uk	Mathcentre (Tutorials)
mathtutor.ac.uk	Mathtutor (Tutorials)

Links

This unit links to the following related units:

Unit 1: Fundamentals of Laboratory Techniques

Unit 5: Fundamentals of Chemistry

Unit 14: Food Technology

Unit 21: Criminal Investigation

Unit 26: Managing Scientific Projects

Unit 27: Analysis of Scientific Data and Information

Unit 28: Applied Sciences Research Project

Unit 33: Analytical Techniques for Forensic Science

Unit 51: Specialist Scientific Techniques and Experimentation

Unit 59: Genetic Analysis

Unit 3: Regulation and Quality in the Applied Sciences (Pearson-set)

Unit code	**T/617/5360**
Unit type	**Core**
Unit level	**4**
Credit value	**15**

Introduction

All employees, including apprentices, must recognise the importance of regulation and quality in their organisation. This unit allows students to investigate legislative compliance, external regulatory bodies, internal regulatory and quality management systems and international standards.

All organisations must comply with relevant health and safety, environmental legislation and other legislation specific to the sectors in which they operate. The task of complying with legislation may be large and complex for some sectors and relatively straightforward for others. For example, complying with environmental legislation may be as simple as disposing of waste appropriately for some organisations whereas for others there may also be permits and consents to consider. The Health and Safety Executive and the Environment Agency are likely to be the main external regulators for many organisations.

Some organisations, for example pharmaceutical manufacturers, are audited regularly by other external agencies such as the Medicines and Healthcare products Regulatory Agency (MHRA) to ensure that they are following their stated procedures, and to ensure that the planned methodologies ensure patient safety. Laboratories that carry out tests on customers' samples (for example for the food, water and oil industries, or for forensic analysis or in pathology labs) may choose to gain accreditation with the external bodies such as the United Kingdom Accreditation Service (UKAS). UKAS audits these laboratories and having UKAS accreditation can help them present a good image to their customers.

There are various standards related to quality management systems and being accredited to a standard is a way of demonstrating that the quality management system is fit for purpose. Implementing a quality management system will involve an organisation having internal regulation. That is likely to include use of management systems including a system for recording information. In some cases, organisations will be implementing good documentation practice (GDP) and/or good laboratory practice (GLP). The cycle of audit and implementing resulting actions is an example of a continuous improvement cycle. Generally all employees are likely to be involved in continuous improvement.

Tutors should tailor programmes towards the pathway studied and workplace activities of the students. Specific legislation covered must be recent and specific to the country, in which the student is based (even within the United Kingdom, specific pieces of legislation may only be specific to a country). Appropriate case studies must be used to provide examples of regulation and quality issues to support learning.

The unit is assessed by a Pearson-set assignment. Students will focus on a theme provided by Pearson (this will change annually) that also relates to their specialist pathway of study. This will enable students to explore and examine the handling of relevant and current data within their field of study.

Learning Outcomes

By the end of this unit, a student will be able to:

1 Review health, safety, environmental and other legislation relevant to a particular sector or pathway

2 Analyse how a specific sector is externally regulated

3 Illustrate the links between quality standards, continuous improvement cycles and quality systems

4 Explore internal regulation and relevant responsibilities of individuals in relation to a particular sector or pathway.

Essential Content

LO1 **Review health, safety, environmental and other legislation relevant to a particular sector or pathway**

Specific and current health and safety legislation relevant to the context and country.

For example, in the UK:

Health and Safety at Work Act (1974)

Management of Health and Safety at Work Regulations (1999)

Health and Safety (Display Screen Equipment) Regulations 1992 (amended 2002)

Control of Substances Hazardous to Health (COSHH) Regulations (2014)

Reporting of Injuries, Diseases and Dangerous Occurrences Regulations (2013) (RIDDOR 2013)

Control of Major Accident Hazards (COMAH) Regulations (2015)

Dangerous Substances and Explosive Atmosphere Regulations (DSEAR) (2002).

Consequences of health and safety legislation, e.g.:

Risk assessment methodology

COSHH assessment

Risk control measures: e.g. safe systems of work, extraction, safety cabinets, personal protective equipment

Duties of employers and employees.

Current environmental legislation relevant to the context and country:

For example, in the UK:

Environmental Protection Act (1990)

Environment Act (1995)

Water Industry Act (1991)

Water Act (2014)

Environmental Permitting (England and Wales) Regulations (2016).

Examples of environmental topics that may be relevant to the workplace:

Disposal of waste

Hazardous waste

Emissions

Discharges to controlled waters

Discharges to sewers

Contaminated land

Packaging waste.

Examples of other topics to consider:

Registration, Evaluation, Authorisation and Restriction of CHemicals (REACH)

CLP Regulation

Consumer rights

Nitrate Vulnerable Zones

Fisheries.

LO2 **Analyse how a specific sector is externally regulated**

Regulators relevant to the context and country:

For example, in the UK:

Health and Safety Executive (HSE)

Environment Agency (EA)

Water treatment companies

Food and Drugs Agency (FDA)

Medicines and Healthcare products Regulatory Agency (MHRA)

European Food Standards Agency (EFSA)

United Kingdom Accreditation Service (UKAS).

Benefits of regulation relevant to the context and country:

For example, in the UK:

Legal compliance (e.g. health, safety and environmental) − mandatory

Unable to sell products without proven regulation by an external body (e.g. FDA/MHRA/EFSA)

Customer confidence from accreditation by an external body (UKAS).

Consequences of external regulation, e.g.:

Documented and systems of work

Internal regulation

Customer, stakeholder, employee confidence in the organisation.

LO3 **Illustrate the links between quality standards, continuous improvement cycles and quality systems**

Relevant quality standards, e.g.:

ISO 9001 − requirements for a quality management system (QMS)

ISO 14001 − requirements for an environmental management system (EMS)

ISO 45001 − requirements for an occupational health and safety (OH&S) management system − will be replacing British Standard OHSAS 18001

ISO 17025 − requirements for a laboratory quality management system

ISO 15189 − requirements for a medical quality management system.

Elements of a quality system, e.g.:

Quality objectives

Quality manual

Organisational structure and responsibilities

Documentation

Data management

Processes

Product quality or quality of results for testing laboratories

Audit

Continuous improvement including Corrective And Preventive Action (CAPA).

Continuous improvement cycles e.g.:

Audit − triangulate observation/documentation/interviews

Identify actions and prioritise

Implement actions

Re-audit and further cycles.

LO4 **Explore internal regulation and relevant responsibilities of individuals in relation to a particular sector or pathway.**

An organisation's own regulatory systems may include:

Policies

Key performance indicators

Allocation of responsibilities

Documentation systems

Good documentation practice (GDP)

Standard procedures

Good laboratory practice (GLP)

Staff handbooks and guidelines

Training

Self-directed learning

Appraisal

Audit/self-assessment/risk assessment (in a wide context rather than in relation to health and safety).

Examples of responsibilities of individuals in relation to internal regulation:

Responsible for own actions

Taking part in audits

Undertaking required training and self-directed learning

Identifying own training needs

Undertaking continuous improvement projects

Taking part in 5S activities

Involvement in six sigma

Following GLP, GMP, GDP practices

Identifying procedures that could be updated

Identifying unsafe acts and near misses

Identifying incidents where product quality may be compromised

Working safely

Disposing of waste correctly

Keeping the workplace tidy

Informing contractors of expected standards

Attending meetings associated with work role

Taking part in shift hand over procedures.

Learning Outcomes and Assessment Criteria

Pass	Merit	Distinction
LO1 Review health, safety, environmental and other legislation relevant to a particular sector or pathway		**LO1 and LO2**
P1 Identify the legislation relevant to the selected sector or pathway **P2** Outline actions that an organisation and its employees must take in order to comply with the identified legislation	**M1** Explain why the legislation identified is relevant to the sector or pathway	**D1** Evaluate the level of regulation within the selected sector/pathway in comparison to other sectors/pathways
LO2 Analyse how a specific sector is externally regulated		
P3 Analyse how relevant bodies carry out external regulation in a specific sector **P4** Analyse the impact of external regulation on the roles of a range of individuals in a specific sector and on the organisation as a whole	**M2** Differentiate between external regulation in relation to compliance with legislation and in relation to customer confidence	

Pass	Merit	Distinction
LO3 Illustrate the links between quality standards, continuous improvement cycles and quality systems		**LO3 and LO4**
P5 Describe the benefits of accreditation against a quality standard for a particular organisation **P6** Using suitable examples, show how maintaining accreditation against a quality standard involves quality systems and continuous improvement	**M3** Analyse whether it is possible to implement a quality system and engage in continuous improvement without accreditation to a quality standard	**D2** Evaluate how internal regulatory systems are, or may be, continuously improved for a specific organisation
LO4 Explore internal regulation and relevant responsibilities of individuals in relation to a particular sector or pathway		
P7 Describe how an organisation carries out internal regulation of its activities **P8** Describe examples of actions taken by an individual in an organisation in relation to internal regulation	**M4** Explain how internal regulatory systems relate to external regulation	

Recommended Resources

Textbooks

AHMED, N., GLENCROSS, H., WANG, Q. (Eds.) (2016) *Biomedical Science Practice: Experimental and Professional Skills.* 2nd ed. Oxford: Oxford University Press.

BELL, S., MCGILLIVRAY, D., PEDERSEN, O.W., LEES, E., STOKES, E. (2017) *Environmental Law*. 9th ed. Oxford: Oxford University Press.

BLOKDYK, G. (2018) *Good Laboratory Practice.* 3rd ed. Australia: Emereo Pty Limited.

BOYLE, T. (2017) *Health and Safety: Risk Management*. Abingdon: Routledge.

CATALANO, T. (2014) *Good Laboratory Practices for Forensic Chemistry (Springer Briefs in Pharmaceutical Science and Drug Development).* New York: Springer Cham Heidelberg.

DOYLE, S. (2018) *Quality Management in Forensic Science.* Amsterdam: Elsevier Science.

FLOYD, R.C. (2010) *Liquid Lean: Developing Lean Culture in the Process Industries.* Boca Raton, FL: CRC.

FUNK, W., DAMMANN, V. (2007) *Quality Assurance in Analytical Chemistry: Applications in Environmental, Food and Materials Analysis, and Medical Engineering.* 2nd ed. Weinheim: WILEY-VCH Verlag GmbH & Co KGaA.

HIRANO, H. (1996) *5S for Operators: 5 Pillars of the Visual Workplace (The Shopfloor Series)*. Portland, OR: The Productivity Press.

HUGHES, P., FERRETT, E. (2015) *Introduction to Health and Safety at Work: for the NEBOSH National General Certificate in Occupational Health and Safety.* 6th ed. Abingdon: Routledge.

HYDE, P., REEVE, P. (2015) *Essentials of Environmental Management*. 4th ed. Wigston: IOSH Services Ltd.

INSPECTION, ENFORCEMENT AND STANDARDS DIVISION, MEDICINES AND HEALTHCARE PRODUCTS REGULATORY AGENCY (MHRA) (2017*) Rules and Guidance for Pharmaceutical Manufacturers and Distributors 2017 (Orange Guide)*. London: Pharmaceutical Press.

MOLLAH, A.H., LONG, M., BASEMAN, H. (2013) *Risk Management Applications in Pharmaceutical and Biopharmaceutical Manufacturing*. Hoboken, NJ: John Wiley & Sons Inc.

OAKLAND, J.S. (2014) *Total Quality Management and Operational Excellence: Text with Cases.* 4th ed. Abingdon: Routledge.

OSARO, E., ADIAS, T.C. (2012) *Laboratory Total Quality Management for Practitioners and Students of Medical Laboratory Science.* Bloomington: AuthorHouse.

PRICHARD, E., BARWICK, V. (2007) *Quality Assurance in Analytical Chemistry*. Chichester: John Wiley & Sons Ltd.

SANDLE, T. (2016) *Pharmaceutical Microbiology: Essentials for Quality Assurance and Quality Control*. Cambridge: Woodhead Publishing Ltd.

SCOTCHMER, A. (2008) *5S Kaizen in 90 Minutes.* Oxford: Management Books 2000 Ltd.

WATERS, B. (2013) *Introduction to Environmental Management For the NEBOSH National Certificate in Environmental Management.* Abingdon: Routledge.

WENCLAWIAK, B.W., KOCH, M. (2013) *Quality Assurance in Analytical Chemistry: Training and Teaching*. Heidelberg: Springer-Verlag.

WORLD HEALTH ORGANIZATION (2011) *Laboratory Quality Management System: Handbook.* Geneva: World Health Organization.

Web

fda.gov	US Food and Drug Administration
	(General reference)
gov.uk	UK Government
	Environmental Management
	(General reference)
gov.wales	Welsh Government
	Environment Protection and Quality
	(General reference)
hse.gov.uk	Health and Safety Regulation
	(General reference)
iso.org	International Organization for Standardization
	(General reference)
netregs.org.uk	Environmental regulation with respect to Scotland and Northern Ireland
	(General reference)
UKAS.com	United Kingdom Accreditation Service
	(General reference)

Links

This unit links to the following related units:

Unit 1: Fundamentals of Laboratory Techniques

Unit 19: Managing Food Preparation and Production Systems

Unit 25: Personal and Professional Development for Scientists

Unit 39: Environmental Monitoring and Analysis

Unit 40: Water and Wastewater Management

Unit 52: Drug Development for Production

Unit 53: Industrial Microbiology

Unit 61: Science Laboratory Management

Unit 62: Organisations and Change Management

Unit 4: Cell Biology

Unit code	**A/617/5361**
Unit level	**4**
Credit value	**15**

Introduction

The cell is the fundamental unit of life. All living things are cells or are composed of cells. Groups of cells can become organized and function as multicellular organisms. All cells arise from pre-existing cells. Cells contain the hereditary information, DNA, which they pass from generation to generation during cell division. Because all cells come from pre-existing cells, scientists can study cells to learn about growth, reproduction and all other functions that living cells perform. A cell is a chemical system that is able to maintain its structure. All biochemical processes are carried out by cells. Understanding the cell and the role and function of the cell in a multicellular organism is of fundamental importance in understanding biology and its related disciplines.

This unit will enable students to develop an appreciation of the cell as the basic unit of life. Students will become familiar with the structure and function of the organelles of the cell. Familiarity with the internal structure of the cell 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 will be emphasised. DNA and RNA will be introduced, and the ways they are stored in the cell, as well as the relationship between them, will also be discussed.

Students will examine the life cycle of a cell and how a cell divides. They will develop knowledge of how the hereditary information is passed on during cell division. The unit will also enable the students to develop an understanding of the processes of gamete formation that make embryos genetically unique. Students will also learn how a single zygote divides and how its daughter cells arrange themselves, in order to start the process of becoming multicellular organisms.

Learning Outcomes

By the end of this unit, a student will be able to:

1 Describe the structural and functional features of eukaryotic cells

2 Describe the organisation of DNA and RNA in eukaryotic cells

3 Explain the events of the cell cycle, mitosis and meiosis

4 Explain how cleavage and gastrulation result in germ layer formation.

Essential Content

LO1 **Describe the structural and functional features of eukaryotic cells**

Structural features of plant and animal cells and their associated organelles:

Function of the cell organelles:

Plant cells (cell wall, vacuole, chloroplast)

Animal cells (cytoplasm, nucleus, endoplasmic reticulum, golgi apparatus, mitochondria, lysosomes, peroxisomes)

Lipid bilayers

Cell membrane

Vesicles

Microtubules, microfilaments, intermediate filaments

Preparation of slides of plant and animal cells

Examination of electron micrographs of cell organelles.

Nucleus

Endoplasmic reticulum

Golgi apparatus

Mitochondria

Chloroplast

Lysosomes

Peroxisomes

Vacuole

Fluidity of lipid bilayers

Function of the cell membrane in maintaining the internal environment of the cell

Transport across the cell membrane.

LO2 **Describe the organisation of DNA and RNA in eukaryotic cells**

Outline structures of DNA and RNA (use the letters A, G, C, T and U to denote nitrogen bases):

Detailed chemical structures of nucleotides, riboses, purines and pyrimidines

Uracil in RNA

The phosphodiester linkage

Base pairing

The structure of the DNA double helix.

Ways that DNA and RNA are stored within the cell:

Histones

Chromosomes

The nucleus

The nucleolus

Ribosomal RNA

Messenger RNA

Transfer RNA.

LO3 **Explain the events of the cell cycle, mitosis and meiosis**

Events of the cell cycle and its control:

Diagram of the cell cycle

Generation time

G1 phase, S phase, G2 phase, G0 phase

Cyclin dependent protein kinases

Cyclin B

Mitosis promoting factor

Phosphorylation

Cyclin B degradation.

Mitosis and Meiosis:

Homologous chromosomes and their origin

Diploid and haploid

Kinetochores

Stages of mitosis

Cytokinesis

Stages of meiosis

Crossing over

Why only one egg is produced for every cell that enters meiosis.

LO4 **Explain how cleavage and gastrulation result in germ layer formation.**

Determining the pattern of cleavage by the amount of yolk in the embryo:

Zygote, blastomeres, morula, blastula

Holoblastic cleavage

Meroblastic cleavage, to include the reptilian embryo and the blastodisc of the chick

Human blastocyst (trophoblast and inner cell mass).

Gastrulation process of the seastar, amphibian chick and human:

Ectoderm, Mesoderm and Endoderm

Blastula, Blastocoel, Gastrula, Archenteron, chorda, Neural Plate

Gastrulation of the sea star

Gastrulation of the amphibian

Gastrulation of the chick embryo (epiblast, hypoblast, primitive streak, primitive groove, formation of a trilaminar disk, extraembryonic membranes)

Gastrulation of the human (inner cell mass, bilaminar disk, epiblast, hypoblast, primitive streak, node, formation of a trilaminar disk, development of the placenta).

Learning Outcomes and Assessment Criteria

Pass	Merit	Distinction
LO1 Describe the structural and functional features of eukaryotic cells		
P1 Describe the structural features of plant and animal cells and their associated organelles **P2** Explain the function of cell organelles and membranes	**M1** Discuss how the organelles of the endomembrane system work together to manufacture, modify and release proteins from the cell	**D1** Analyse the similarities and differences between pinocytosis, phagocytosis receptor mediated endocytosis and exocytosis
LO2 Describe the organisation of DNA and RNA in eukaryotic cells		**LO2 and LO3** **D2** Analyse the processes that ensure the DNA contained in the nucleus of the cells of an embryo diversifies from the DNA contained in the nuclei of the somatic cells of its parents
P3 Describe the structure of DNA and RNA **P4** Explain how DNA and RNA are stored within the cell	**M2** Illustrate how the information stored in DNA is used as a template to synthesise mRNA	
LO3 Explain the events of the cell cycle, mitosis and meiosis		
P5 Explain the events of the cell cycle and how it is controlled **P6** Describe the processes of mitosis and meiosis	**M3** Compare and contrast the processes of mitosis and meiosis	

Pass	Merit	Distinction
LO4 Explain how cleavage and gastrulation result in germ layer formation		**D3** Evaluate the significance of the gastrulation process in tissue formation
P7 Explain how the amount of yolk in the embryo determines the pattern of cleavage **P8** Describe the gastrulation process of the sea star, amphibian, chick and human	**M4** Illustrate the similarities in gastrulation between a chick and a human	

Recommended Resources

Textbooks

ALBERTS, B., HOPKIN, K., JOHNSON, A.D., MORGAN, D., RAFF, M., ROBERTS, K., WALTER, P. (2018) *Essential Cell Biology.* 5th ed. New York: W.W. Norton and Co.

ALBERTS, B., JOHNSON, A.D., LEWIS, J., MORGAN, D., RAFF, M., ROBERTS, K., WALTER, P. (2015) *Molecular Biology of the Cell.* 6th ed. New York: Garland Science (Taylor & Francis Group).

KHANNA, D.R. (2004) *Textbook of Embryology.* Delhi: Discovery Publishing House.

PLOPPER, G. (2014) *Principles of Cell Biology.* 2nd ed. Burlington, MA: Jones and Bartlett Learning.

SOLOMON, E., MARTIN, C., MARTIN, D., BERG, L. (2018) *Biology.* 11th ed. Boston, MA: Cengage Learning Inc.

Web

biology.kenyon.edu	Kenyon College Gastrulation (General reference)
biology-pages.info	Kimball's Biology Pages (General reference)
embryology.med.unsw.edu.au	UNSW Sydney Dr Mark Hill – Cleavage and Gastrulation (General reference)
hhmi.org	Howard Hughes Medical Institute (General reference)
khanacademy.org	Khan Academy Cell Organelles and Structure (Tutorials)
www2.le.ac.uk	University of Leicester Cell Cycle, Mitosis and Meiosis (General reference)

Links

This unit links to the following related units:

Unit 1: Fundamentals of Laboratory Techniques

Unit 6: Anatomy and Human Physiology

Unit 11: Physiological Adaptation of Plants to Environmental Changes

Unit 17: Fundamentals of Biochemistry

Unit 5: Fundamentals of Chemistry

Unit code	**F/617/5362**
Unit level	**4**
Credit value	**15**

Introduction

Chemistry is the study of the structure and composition of materials and how and why substances change to form new substances. An understanding of the fundamentals of chemistry is an essential component of biological units such as biochemistry, pharmacology, food science, environmental science and materials science.

The aim of this unit is to introduce some of the key concepts that underpin units such as those named above. It uses a theoretical and practical approach focusing on bonding, oxidation and reduction, and acid and base titrations, calculations of thermodynamic quantities and organic chemistry.

On completion of this unit, students will be able to apply their knowledge to bonding in biomolecules, quantitative calculations, energy changes in fuels and foodstuffs and synthesis of organic compounds.

Where possible, practical work should be encouraged and used to support theoretical aspects covered by the Essential Content.

Learning Outcomes

By the end of this unit, a student will be able to:

1. Explain the structure and properties of matter
2. Explain theoretical and practical aspects of titrations
3. Describe how thermodynamic quantities affect chemical reactions
4. Explore the reactions and synthesis of the homologous series of organic compounds.

Essential Content

LO1 **Explain the structure and properties of matter**

Atomic structure and electronic configuration:

Atomic number, mass number, the periodic table and electronic configuration.

Ionic, covalent and metallic bonding:

Formation and characteristics of ionic, polar, covalent, polar covalent and metallic compounds, chemical formulae, balancing equations.

Intermolecular forces:

Effects of Van der Waals forces, dipole-dipole forces and hydrogen bonding on boiling points.

Ionisation energies and reactivity:

Trends in electronegativity and ionisation energy in the periodic table and effects on reactivity.

Water:

Electronegativity of oxygen; polar covalent bonding; hydrogen bonding; Properties e.g. high boiling point, large range of temperature at which water is liquid, high surface tension, ability to dissolve many ionic compounds and organic polar molecules etc.

LO2 **Explain theoretical and practical aspects of titrations**

Quantitative calculations:

Mass, molar mass, moles, molarity and dilutions.

Acids and bases:

Bronsted-Lowry theory of acids and bases, conjugate acids and bases, weak acids and bases and equilibria, calculation of pH of acids and bases, indicators.

Oxidation numbers in redox reactions:

Apply oxidation numbers to chemical formulae, chemical equations and biological macromolecules.

Titrations:

Primary standards and preparation of titration solutions, acid-base and redox titrations.

LO3 **Describe how thermodynamic quantities affect chemical reactions**

Enthalpy:

Exothermic and endothermic reactions, bond making and breaking, reaction profile, standard enthalpy changes (ΔH^{θ}), enthalpy of combustion, bond energy, enthalpy of neutralisation, enthalpy of formation, other types of enthalpy, e.g. enthalpy of dissociation, hydration, solution, Hess's Law, thermodynamic tables.

Entropy and Gibbs energy:

Standard entropy changes (ΔS^{θ}), standard change in Gibbs energy (ΔG^{θ}), relationship between ΔH^{θ}, ΔS^{θ} and ΔG^{θ} ($\Delta G^{\theta} = \Delta H^{\theta} + T\Delta S^{\theta}$), spontaneous and non-spontaneous reactions, exorgonic and endergonic reactions, thermodynamic tables.

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 e.g. $NAD^{+}/NADH$; calculation of E^{θ}_{cell}; sign and magnitude of E^{θ}_{cell} as a predictor of feasibility of reactions.

Features of equilibrium:

Rate of forward reaction = rate of reverse reaction; sign of ΔH for forward and reverse reactions; dynamic nature of equilibrium; constant concentration of reactants and products at equilibrium; equilibrium constant, K; $\Delta G^{\theta} = -RT\ln K$; examples of equilibrium processes; drive to reach equilibrium e.g. osmosis; equilibrium condition $\Delta G = 0$; use of the size and sign of ΔH^{θ} and ΔS^{θ} to predict ΔH and ΔS hence estimate the temperature, at which it may be in equilibrium

LO4 **Explore the reactions and synthesis of the homologous series of organic compounds.**

Classes of organic compounds:

Alkanes, alkenes, alkynes, alcohols, benzene, halogenoalkanes, aldehydes, ketones, carboxylic acids, esters, amines, amides.

Representation of organic compounds:

Graphical formula; displayed and shortened structural formula; molecular formula; skeletal formula; functional groups.

Names of organic compounds:

International Union of Pure and Applied Chemistry (IUPAC) system

Main reactions of organic compounds:

alkanes e.g. combustion and free radical substitution;

alkenes, addition of e.g. Br_2, HBr, H_2, H_2O

alcohols e.g. oxidation of primary, secondary and tertiary alcohols, esterification;

halogenoalkanes e.g. substitution;

carboxylic acids e.g. reaction with base, esterification;

esters e.g. hydrolysis to alcohol and acid;

amines e.g. as bases

Biochemical molecules:

Fats

Amino acids

Proteins

Carbohydrates

Steroids

Isomerism

Structural isomers (chain, positional, functional group); geometric (cis/trans) isomers; optical isomers.

Learning Outcomes and Assessment Criteria

Pass	Merit	Distinction
LO1 Explain the structure and properties of matter		
P1 Describe the electronic configurations of the first thirty elements of the periodic table and trends in first ionisation energy, atomic radius, melting point and boiling point in the periodic table **P2** Explain how the bonding in simple compounds may be predicted and how that bonding determines physical properties of the compound	**M1** Explain why the intramolecular and intermolecular bonding in water makes it important in biological systems	**D1** Analyse the role that intermolecular and intramolecular bonding plays in biological macromolecules

Pass	Merit	Distinction
LO2 Explain theoretical and practical aspects of titrations		
P3 Describe the Bronsted Lowry theory of acids and bases and calculate the pH of strong and weak acids, alkalis and buffer solutions. **P4** Apply oxidation numbers to chemical formulae and equations to identify redox reactions **P5** Carry out and report on an acid base titration and a redox titration, including providing equations that explain the bases of the titrations	**M2** Calculate the masses and volumes of solutions needed to make up a range of solutions and dilutions.	**D2** Analyse the changes in pH that occur during an acid base titration.

Pass	Merit	Distinction
LO3 Describe how thermodynamic quantities affect chemical reactions		**LO3 and LO4**
P6 Calculate standard changes in enthalpy, entropy and Gibb's energy in order to predict the feasibility of reactions under standard conditions. **P7** Construct oxidation, reduction and redox equations and calculate E^{θ}_{cell} for couples of half cells in order to predict the feasibility of reactions **P8** Explain the features of typical equilibrium reactions	**M3** Justify a prediction of the feasibility of a range of reactions at different temperatures, taking relevant assumptions into consideration	**D3** Compare the thermodynamics of combustion reactions with esterification and ester hydrolysis reactions.
LO4 Explore the reactions and synthesis of the homologous series of organic compounds		
P9 Carry out an exercise in relating names of organic compounds, including isomers, to structural representations and vice versa **P10** Describe, typical reactions of a range of classes of organic compounds, using suitable examples	**M4** Analyse the optical properties and acid/base character of a range of amino acids	

Recommended Resources

Textbooks

BROWN, C., FORD, M. (2018) *Chemistry: Higher Level for the IB Diploma*. 2nd ed. Harlow: Pearson Education Ltd.

BROWN, T.E., LEMAY, H.E., BURSTEN, B.E., MURPHY, C., WOODWARD, P., STOLZFUS, M. (2017) *Chemistry: The Central Science*. 14th ed. Harlow: Pearson Education Ltd.

DEAN, J., HOLMES, D.A., JONES, A.M., JONES, A., WEYERS, J., REED, R. (2017) *Practical Skills in Chemistry*. 3rd ed. Harlow: Pearson Education Ltd.

HENRY, N. (2017) *AQA AS/A-Level Student Guide: Practical Chemistry*. Abingdon: Hodder Education.

TIMBERLAKE, K.C. (2017) *Chemistry: An Introduction to General, Organic, and Biological Chemistry*. 13th ed. New York: Pearson Education Ltd.

TRO, N.J. (2016) *Chemistry: A Molecular Approach*. 4th ed. Harlow: Pearson Education Ltd.

Web

chem.libretexts.org	LibreTexts Chemistry (General reference)
khanacademy.org	Khan Academy Chemistry (Tutorials)
rsc.org	Royal Society of Chemistry Experimentation Hub (General reference)

Links

This unit links to the following related units:

Unit 1: Fundamentals of Laboratory Techniques

Unit 10: Principles of Ecology and their Applications

Unit 13: Human Health and Nutrition

Unit 15: Introduction to Polymer Materials and Properties

Unit 29: Biochemistry of Macromolecules and Metabolic Pathways

Unit 35: Analytical Chemistry

Unit 6: Anatomy and Human Physiology

Unit code	**J/617/5363**
Unit level	**4**
Credit value	**15**

Introduction

The aim of this unit is to develop knowledge of the anatomy and biological systems of the human body and how they function. Analysis of the interrelationships between these systems and knowledge of the parameters of normal biological functioning are essential to any person involved in the field of biological sciences.

The unit looks at the structure and functioning of the biological systems of the human body, highlighting the role they play in the maintenance of human life. Students will study the systems with themes running through them: the muscular, nervous and skeletal systems and how they interact to create monitor and control movement; the lymphatic and cardiovascular systems and their involvement with the transportation of essential nutrients and waste; respiratory, digestive and urinary systems and evaluation of the efficacy of how these interact to provide raw materials for metabolism, absorb nutrients and rid the body of waste; male and female reproduction and management of reproduction.

On completion of the unit, the student will hold sufficient knowledge of human biological systems to understand the management of human health and normal biological function. They will be able to apply this knowledge to a range of scenarios within the field of biological science.

Learning Outcomes

By the end of this unit, a student will be able to:

1. Describe how the muscular and skeletal systems interact with one another to provide support and create movement
2. Explain the control systems of the human body
3. Describe the structure, function and interrelationship between the systems that obtain raw materials for metabolism, absorb and transport nutrients and rid the body of wastes
4. Explain the process and management of human reproduction.

Essential Content

LO1 **Describe how the muscular and skeletal systems interact with one another to provide support and create movement**

Movement:

Structure and function of skeletal, smooth and cardiac muscle

Process of muscle contraction; sliding filament theory

Role of skeletal muscles in creating movement

Structure and function of tendons and ligaments

Common injuries resulting from movement.

Support:

Structure and functions of the human skeletal system

Composition of bone tissue, bone metabolism

Types of bone, structure and functions

Bone growth

Types of joint: synarthrosis (fibrous), amphiarthrosis (cartilaginous), diarthrosis (synovial)

Anatomy of the joint

Range of movement of joints.

LO2 **Explain the control systems of the human body**

Nervous system:

Structure and functions of neurons and neuroglia: dendrites, axon, cell body, Schwann cells, astrocytes, microglia, oligodendrocytes, synapses, myelin sheath

Mechanism of nerve conduction, sodium-potassium pump

Neuronal control of muscle activity: skeletal, smooth and cardiac.

Endocrine System:

Structure of the endocrine system: glands, hormones

Types of hormones: hydrophilic, lipophilic

Mechanism of action of hormones: second messenger system (cAMP).

Homeostasis:

Components of a feedback mechanism

Negative and positive feedback systems.

LO3 **Describe the structure, function and interrelationship between the systems that obtain raw materials for metabolism, absorb and transport nutrients and rid the body of wastes**

Blood:

Composition and functions of blood

Blood cells: erythrocytes, leukocytes (neutrophils, eosinophils, basophils, lymphocytes, monocytes, macrophages)

Origin of blood cells

Role of platelets and blood clotting process

Impact of environment on blood composition; altitude.

Cardiovascular system:

Structure and function of the heart

Structure and function of blood vessels: arteries, veins, capillaries

Cardiac cycle

Circulation in the human body (pulmonary, systemic and coronary)

Physiology of circulation: thermoregulation, exercise, fight/flight response.

Respiratory system:

Structure and function of the human respiratory system

Ventilation and the process of gaseous exchange

Transport of respiratory gases

Respiratory diseases and disorders.

Digestive system:

Structure and function of the human digestive system

Accessory organs and structures: liver, pancreas, teeth

Process of digestion at each stage: mechanical and chemical

Neural and hormonal control of digestion

Diseases and disorders of the digestive tract.

Urinary system:

Structure and function of the kidney

Urine production

Osmoregulation and regulation, of pH and sodium.

LO4 **Explain the process and management of human reproduction**

Reproductive system:

Structure and function of the human male and female reproductive systems

Spermatogenesis, oogenesis.

Stages of reproduction:

Sexual maturity, fertilisation, implantation, embryonic development, parturition

Hormonal control of reproduction.

Management of reproduction:

Chemical

Physical

Artificial Insemination

Surrogacy

Cloning.

Learning Outcomes and Assessment Criteria

Pass	Merit	Distinction
LO1 Describe how the muscular and skeletal systems interact with one another to provide support and create movement		**D1** Analyse the interrelationship between the muscular and skeletal systems in providing support and creating movement in the human body
P1 Review the structure of bone and muscle tissues **P2** Identify how the muscular and skeletal tissues work together to create support and movement	**M1** Compare the differences in types of muscle and bone, with regards to their specific functions	
LO2 Explain the control systems of the human body		**D2** Compare and contrast, using specific examples, the roles of the endocrine and nervous systems in the maintenance of homeostasis within the human body
P3 Review the nerve cell structures and functions found in the nervous system **P4** Outline the structure and function of the endocrine system	**M2** Explore the processes of nerve conduction, and the mechanism of action of hormones	

Pass	Merit	Distinction
LO3 Describe the structure, function and interrelationship between the systems that obtain raw materials for metabolism, absorb and transport nutrients and rid the body of wastes		
P5 Describe the structures and functions of the systems used to assimilate and transport nutrients within the human body **P6** Describe the structures and functions of the systems used to remove waste from the human body	**M3** Explore the interrelationship between the various systems used to assimilate and transport nutrients and remove waste from the human body	**D3** Evaluate the efficiency of these systems working together to support and maintain good health in the human body
LO4 Explain the process and management of human reproduction		
P7 Describe the structures and functions of the male and female human reproductive systems **P8** Outline the stages of reproduction in humans and the methods by which these can be managed	**M4** Explore the hormonal regulation of the human reproductive processes	**D4** Evaluate the various methods of managing reproduction in the human body

Recommended Resources

Textbooks

TORTORA, G.J., DERRICKSON, B. (2017) *Principles of Anatomy and Physiology*. 15th ed. Hoboken, NJ: John Wiley & Sons, Inc.

WAUGH, A., GRANT, A. (2018) *Ross and Wilson Anatomy and Physiology in Health and Illness*. 13th ed. Edinburgh: Elsevier.

Web

khanacademy.org	Khan Academy Human anatomy and physiology Short lessons with animations (Tutorials)
leeds.ac.uk	University of Leeds Anatomy and physiology (General Information)
opentextbc.ca	BCcampus Open Education Reproductive systems (General information)
varta.org.au	The Victorian Assisted Reproductive Treatment Authority Assisted Reproductive Technology (General information)

Links

This unit links to the following related units:

Unit 4: Cell Biology

Unit 13: Human Health and Nutrition

Unit 31: Immunology

Unit 44: Advanced Health and Nutrition

Unit 7: Inorganic Chemistry

Unit code	**L/617/5364**
Unit level	**4**
Credit value	**15**

Introduction

Inorganic chemistry is the study of the chemical behaviour of all the non-carbon elements, and their compounds, found in the periodic table. To study inorganic chemistry students need to understand the fundamental properties of atoms, how atoms combine to form inorganic compounds, and the behaviour of these compounds.

The aim of this unit is to provide students with an overview of the key theoretical concepts that will enable them to understand inorganic chemistry. In addition, students will carry out a range of practical activities that will enable them to synthesise, characterise and analyse inorganic compounds.

The unit provides a comprehensive coverage of basic inorganic chemistry, and lays a firm foundation for studying chemistry at higher levels. It applies the principles of inorganic chemistry to aspects of structure and bonding, and the chemistry of selected elements and compounds. These, together with a survey of important industrial applications, form a firm foundation for employees working in the chemistry field, or for learners hoping to gain such employment or progress to higher levels of study.

Learning Outcomes

By the end of this unit, a student will be able to:

1 Describe the structure of atoms

2 Explain the structure of matter

3 Examine the periodic table and the chemical reactivity of the elements and compounds

4 Undertake synthetic and characterisation procedures with inorganic compounds.

Essential Content

LO1 Describe the structure of atoms

The electronic structure of atoms:

Electronic configurations (spdf) of elements 1 to 36 (Aufbau); shapes and orientation of s, p and d orbitals; atomic orbitals in terms of principal quantum number, orbital angular momentum quantum number and magnetic quantum number; Pauli exclusion principle in terms of electron quantum numbers; Hund's rule.

The periodic table and electronic structure:

Structure of periodic table in terms of s block, p block, d block and f block; ionisation energies and trends across periods 2 and 3; ionisation energies and trends down groups; electron affinity (definition and examples).

Atomic radii:

Covalent, metallic, ionic and Van der Waals radii; trends in radii across periods and down groups.

The spectrum of atomic hydrogen:

Characteristics of electromagnetic radiation; wavelength; amplitude; frequency; simple calculations using $c = \nu\lambda$ and Planck's equation; Bohr model; spectral series (Lyman, Balmer, Paschen); the Rydberg equation (including associated calculations), emission spectrum (Pashen Series, etc), absorption spectrum

LO2 Explain the structure of matter

Ionic bonding:

Explain the formation of ionic compounds using Lewis (dot and cross) diagrams and Born-Haber cycles; properties of ionic compounds; polarisation and covalency (Fajan's rules); role of electronegativity difference in determining ionic/covalent bonding.

Metallic bonding:

Metallic bonding, using the electron sea model; electrical conductivity; thermal conductivity.

Covalent bonding:

Bond length; bond order; bond enthalpy; bond polarity; polar molecules; dative covalent (coordinate) bonding.

Intermolecular forces of attraction:

Causes, occurrence and relative strengths; dispersion forces; dipole-dipole; hydrogen bonding.

Localised bond models of covalent bonding:

Lewis concepts (shared electron pairs); valence bond (resonance); hybridisation; valence shell electron pair repulsion (VSEPR) theory; VSEPR and shapes of molecules.

Types of structure:

Formation, structure and typical properties of ionic and metal crystal structures; simple molecular and giant covalent (macromolecular); explanation of properties in terms of bonding and intermolecular forces.

LO3 **Examine the periodic table and the chemical reactivity of the elements and compounds**

The third period of the Periodic Table:

Physical and chemical properties of the elements, oxides, hydrides and chlorides; interpretation of trends in terms of electronic structure and bonding.

Chemistry of the s block:

Physical and chemical properties of the elements in groups 1 and 2, oxides, chlorides, carbonates, nitrates, sulfates.

Chemistry of the p block:

Groups 13–16 to cover first two elements only in terms of physical and chemical properties of elements and their compounds with hydrogen, oxygen and chlorine (where appropriate); group 17 (halogens, fluorine to iodine) to include group trends (melting/boiling points, bond energy, oxidation states); anomalous nature of fluorine; formation of halides; reactions with sulfur and phosphorous; hydrogen halides; Lewis acids and bases, to include an explanation in the trends in the Lewis acidity of boron halides.

The chemistry of hydrogen:

The hydrogen (H^+) and hydroxonium ions (H_3O^+); the hydride ion (H^-).

The chemistry of the inert gases (group 18):

Trends within the group; inability of helium and neon to form compounds; synthesis and properties of xenon fluorides, xenon oxides; dangers of radon gas.

Chemistry of the d block, transition metals (Sc−Zn):

Trends in the physical properties of 3d metals; distinction between the terms transition metal and d block metal as given by IUPAC definitions; the electronic arrangement of the first row d block metals Sc−Zn, including the deviation of Cr and Cu; order of filling (4s before 3d) and order of loss on cation formation (4s lost before 3d); typical properties of transition metal compound to include formation of coloured ions; variable oxidation state; complex formation; anomalous behaviour of scandium and zinc.

Ligands; denticity, to include examples of monodentate, bidentate, tridentate and ethylene diamine tetra-acetic acid (EDTA) as a hexadentate ligand; formation of complexes; coordination numbers and coordination geometry limited to examples of tetrahedral, square planar, octahedral

Coordination chemistry:

Crystal field model: shapes and orientations of d orbitals; crystal field splitting effects in octahedral and tetrahedral complexes; crystal field splitting parameter; spectrochemical series.

LO4 **Undertake synthetic and characterisation procedures with inorganic compounds**

Minimising risks:

Hazards associated with chemicals, e.g. flammable, toxic, harmful; other hazards, e.g. high temperatures, use of glass equipment; risk minimisation, e.g. use of alternative substances, reduction of quantities, selection of method of heating, selection of location, use of fume cupboard, wearing gloves, lab coat, safety glasses, methods for handling hot objects.

Preparative techniques:

Common procedures, e.g. vacuum filtration, recrystallisation, simple distillation, fractional distillation, vacuum distillation, rotary evaporation, solvent extraction, drying.

Substances and experiments:

Experiments to investigate the chemical and physical properties of a series of compounds, such as the acid-base properties of oxides or the reactions of chlorides with water; comparing the properties of a group of elements; synthesis of complexes of copper or nickel; synthesis of tin (IV) iodide; gravimetric determination of nickel, using dimethylglyoxime; preparation of potassium trioxalatoferrate (III); assigning the position of ligands in the spectrochemical series by analysing the uv-vis spectra of complexes.

Tests to determine purity:

Melting points; boiling points, e.g. Siwoloboff's method and simple distillation; spectroscopic techniques, e.g. infrared spectroscopy, ultraviolet/visible spectroscopy; chromatographic techniques, e.g. thin layer chromatography.

Yields:

Theoretical and percentage yields.

Report:

Formal laboratory report; other methods of reporting, e.g. completion of a pro forma, preparation of a slide presentation, making a poster, writing an article.

Learning Outcomes and Assessment Criteria

Pass	Merit	Distinction
LO1 Describe the structure of atoms		
P1 State the spdf electron configuration for ten given atoms and ions and correlate the electronic configuration with the atom's position in the periodic table **P2** Explain qualitatively the trends in ionisation energy, atomic size and electron affinity across period and down a group **P3** Explain the atomic spectrum of hydrogen in terms of the Bohr Atom	**M1** Justify the quantum numbers associated with the occupied shells and subshells present in given atoms **M2** Use appropriate equations to calculate the wavelengths of lines in the atomic spectrum of hydrogen	**LO1, LO2 and LO3** **D1** Critically analyse the predictive value that may be gained from knowing an atom's electronic configuration, quantum number, ionisation energy, electron affinity and atomic radius
LO2 Explain the structure of matter		
P4 Explain the bonding of ionic, covalent and metallic substances **P5** Explain the bonding of covalent substances, using localised bonding models and assess the factors that contribute to the magnitude of intermolecular forces of attraction **P6** Explain the physical properties of covalent, ionic and metallic substances	**M3** Analyse the correlation between chemical bonding, structure and physical properties in a range of inorganic compounds	

Pass	Merit	Distinction
LO3 Examine the periodic table and the chemical reactivity of the elements and compounds		
P7 Describe the chemistry and physical properties of the period 3 elements, oxides, chlorides and hydrides **P8** Explore the chemistry of hydrogen and selected elements from the s block, p block, d block and group 18	**M4** Explain the trends in the chemistry of the period 3 elements, oxides, chlorides and hydrides **M5** Analyse the structure and bonding of a typical coordination complex	
LO4 Undertake synthetic and characterisation procedures with inorganic compounds.		
P9 Undertake and report on five practical activities **P10** Demonstrate an awareness of the health and safety implications associated with the preparation of inorganic compounds	**M6** Illustrate the underlying theory for the chosen practical activities	**D2** Evaluate the results of the chosen practical activities

Recommended Resources

Textbooks

BURROWS, A., HOLMAN, J., PARSONS, A., PILLING, G., PRICE, G. (2017) *Chemistry³: Introducing Inorganic, Organic and Physical Chemistry*, 3rd ed. Oxford: Oxford University Press.

FACER, G. (2015) *George Facer's Edexcel A Level Chemistry Student Book 1*. London: Hodder Education.

FACER, G. (2015) *George Facer's Edexcel A Level Chemistry Student Book 2*. London: Hodder Education.

Web

chemguide.co.uk	ChemGuide (General reference)
chemrevise.org	ChemRevise A Level Chemistry revision notes (General reference)
chemtube3d.com	ChemTube3D (General reference)

Links

This unit links to the following related units:

Unit 8: Organic Chemistry

Unit 9: Physical Chemistry

Unit 36: Aromatic and Carbonyl Compounds

Unit 37: Solid State and Transition Metal Chemistry

Unit 38: Spectroscopy, Surface Chemistry and Equilibria

Unit 8: Organic Chemistry

Unit code	**R/617/5365**
Unit level	**4**
Credit value	**15**

Introduction

Organic chemistry is the study of carbon containing compounds. Organic compounds are ubiquitous in our daily lives; they can be found in our household products, our medicines, our fuels, as well as throughout nature. Organic chemists synthesise new compounds with tailored properties that aim to improve our living standards.

The aim of this unit is to introduce you to organic chemistry. You will learn how organic compounds are chemically bonded, and how the presence of particular sets of atoms and bonds control the reactivity of those compounds. You will also learn how organic chemists explain organic reactions by looking closely at organic reaction mechanisms. In addition, you carry out practical organic chemistry where you synthesise, purify and characterise organic compounds.

Learning Outcomes

By the end of this unit, a student will be able to:

1 Describe the structure and bonding in organic compounds

2 Explain organic reaction mechanisms

3 Explain the reactions of organic compounds in terms of bond structure and reaction mechanisms

4 Undertake synthetic and characterisation procedures with organic compounds.

Essential Content

LO1 **Describe the structure and bonding in organic compounds**

The structure of organic molecules:

Representations of organic molecules; display/structural formula; condensed formula; skeletal/line formula; stereochemical 'flying wedge' formula; bond angles; bond lengths; shapes.

Bonding in organic molecules:

sp^3, sp^2, sp hybridisation; **π** and **σ** bonds.

Classification and naming of organic molecules:

Alkanes; alkenes; alcohols; aldehydes; ketones; carboxylic acids; esters; acid halides; amines; amides, cyanides (nitriles); ethers; haloalkanes; cyclic alkanes/alkenes; substituted arenes limited to haloarenes and phenol.

Isomerism in organic molecules:

Structural isomerism; chain, positional, functional group; stereoisomerism; geometric, including *E* and *Z* and cis/trans notation; optical isomerism, including effect on plane polarised light.

Physical properties of organic molecules:

Boiling/melting points in relation to intermolecular forces; dispersion, dipole-dipole, hydrogen bonding; effect of branching on boiling/melting points; solubility and insolubility in water.

LO2 **Explain organic reaction mechanisms**

Categorise reagents:

Recognise and categorise reagents with justification (electrophiles, nucleophiles, radicals, acids, bases).

Types of reactions:

Recognise and categorise reactions with justification (addition, substitution, elimination, rearrangement, condensation).

Reaction profile diagrams:

Energy profiles; reaction coordinate; transition state; reaction intermediate; activation energy; catalysis.

Mechanisms:

Use of curly arrows, one and two-electron movements; homolysis; heterolysis; free radical chlorination of methane; nucleophilic substitution (S_N1 and S_N2) reactions of haloalkanes; elimination reactions (E1 and E2) of haloalkanes; nucleophilic addition reactions of aldehydes and ketones; electrophilic addition reactions of alkenes, including application of Markovnikov's rule.

LO3 **Explain the reactions of organic compounds in terms of bond structure and reaction mechanisms**

Alkanes:

Halogenation; combustion; free radical substitution reactions; uses as fuels and sources of industrial materials.

Alkenes:

Electrophilic addition of hydrogen halides; Markovnikov addition; explanation of Markovnikov in terms of carbocation stability; rearrangements of carbocations; addition of halogens, including in the presence of water; addition of water in the presence of acids; reaction with potassium manganate (VII); reduction with hydrogen; polymerisation.

Haloalkanes:

Nucleophilic substitution reactions with OH^-, CN^-, NH_3, RO^-, S_N1 and S_N2; stereochemical consequences; elimination reactions; E1 and E2 reactions; elimination vs substitution; Grignard reagent formation; Grignard reactions with aldehydes, ketones; use of haloalkanes to synthesise other functional group compounds.

Alcohols and phenols:

Acidity; reaction with sodium; reaction with hydrogen halides and phosphorus halides; oxidation; dehydration; halogenation of phenols; use of alcohols to synthesise other functional group compounds.

Carbonyl compounds:

Aldehydes and ketones; oxidation and reduction; nucleophilic addition reactions, water, ammonia, hydrogen cyanide; haloform reaction; condensation with ammonia derivatives including the importance of 2,4 dinitrophenylhydrazine (DNP); reaction with Grignard reagents; use of aldehydes and ketones to synthesise other functional group compounds; carboxylic acids; acid-base reactions; esterification; acid halides; acid anhydrides; use of carboxylic acids to synthesise other functional group compounds.

Amines and amides:

Acid-base reactions of amines; amide formation; use of amines and amides to synthesise other functional group compounds.

LO4 **Undertake synthetic and characterisation procedures with organic compounds**

Minimising risks:

Hazards associated with chemicals, e.g. flammable, toxic, harmful; other hazards, e.g. high temperatures, use of glass equipment; risk minimisation, e.g. use of alternative substances, reduction of quantities, selection of method of heating, selection of location, use of fume cupboard, wearing gloves, lab coat, safety glasses, methods for handling hot objects.

Preparative techniques:

Common procedures, e.g. vacuum filtration, recrystallisation, simple distillation, fractional distillation, vacuum distillation, steam distillation, rotary evaporation, solvent extraction, drying.

Substances:

Solid organic compounds, e.g. DNP and semicarbazone derivatives, aspirin, paracetamol, antifebrin; a liquid organic compound, e.g. ethyl ethanoate, cyclohexene, heptene.

Tests to determine purity:

Melting points; boiling points, e.g. Siwoloboff's method and simple distillation; spectroscopic techniques, e.g. infrared spectroscopy, ultraviolet-visible spectroscopy; mass spectroscopy; high resolution nuclear magnetic resonance; chromatographic techniques, e.g. thin layer chromatography

Yields:

Theoretical and percentage yields

Report:

Formal laboratory report; other methods of reporting, e.g. completion of a pro forma, preparation of a slide presentation, making a poster, writing an article.

Learning Outcomes and Assessment Criteria

Pass	Merit	Distinction
LO1 Describe the structure and bonding in organic compounds		**D1** Analyse the links between bonding, structure, isomerism and physical properties for a range of organic compounds
P1 Illustrate the structure of organic molecules using four ways of structural representation, including isomers (structural, geometric and optical) **P2** Explain the chemical bonding present in organic molecules **P3** Apply IUPAC rules to classify and name organic compounds containing five types of functional groups **P4** Explain the physical properties of organic molecules	**M1** Assess how physical properties are affected by chain length and functional group	

Pass	Merit	Distinction
LO2 Explain organic reaction mechanisms		
P5 Describe organic reactions in terms of the type of reagents and the type of reaction involved **P6** Interpret organic reactions using mechanisms that include curly arrows **P7** Illustrate the use of reaction profile diagrams in relation to organic reactions	**M2** Compare and contrast nucleophilic substitution and elimination reactions of haloalkanes	**D2** Differentiate between the reaction profile diagrams in relation to reactions of haloalkanes

Pass	Merit	Distinction
LO3 Explain the reactions of organic compounds in terms of bond structure and reaction mechanisms		**D3** Design organic reaction schemes to synthesise five types of functional group compounds
P8 Explain the chemistry of the alkanes and alkenes, alcohols and phenols, haloalkanes, and carbonyl compounds, amines and amides	**M3** Compare and contrast the characteristic reactions of the alkanes and alkenes, alcohols and phenols, haloalkanes, and carbonyl compounds, amines and amides	
LO4 Undertake synthetic and characterisation procedures with organic compounds.		**D4** Evaluate the results of the chosen practical activities with reference to underlying theories
P9 Demonstrate an awareness of the health and safety implications associated with the preparation of organic compounds while undertaking at least four practical activities **P10** Report on at least four practical activities on synthetic and characterisation procedures with organic compounds	**M4** Discuss the underlying theory for the chosen practical activities	

Recommended Resources

Textbooks

BURROWS, A., HOLMAN, J., PARSONS, A., PILLING, G., PRICE, G. (2017) *Chemistry³: Introducing Inorganic, Organic and Physical Chemistry*. 3rd ed, Oxford: Oxford University Press.

FACER, G. (2015) *George Facer's Edexcel A Level Chemistry Student Book 1*. London: Hodder Education.

FACER, G. (2015) *George Facer's Edexcel A Level Chemistry Student Book 2*. London: Hodder Education.

HORNBY, M., PEACH, J. (1993) *Foundations of Organic Chemistry (Oxford Chemistry Primers)*. Oxford: Oxford University Press.

Web

chemguide.co.uk	ChemGuide (General reference)
chemrevise.org	ChemRevise A Level Chemistry revision notes (General reference)
chemtube3d.com	ChemTube3D (General reference)

Links

This unit links to the following related units:

Unit 7: Inorganic Chemistry

Unit 9: Physical Chemistry

Unit 36: Aromatic and Carbonyl Compounds

Unit 37: Solid State and Transition Metal Chemistry

Unit 38: Spectroscopy, Surface Chemistry and Equilibria

Unit 9: Physical Chemistry

Unit code	**Y/617/5366**
Unit level	**4**
Credit value	**15**

Introduction

Physical chemistry is the study of how matter behaves at the atomic and molecular scale. Physical chemistry, therefore, underpins the study of both organic and inorganic chemistry and, in a broader sense, underpins the study of biological systems. This unit introduces thermodynamics, chemical kinetics and electrochemistry.

Thermodynamics is one of the cornerstones of physical chemistry leading to powerful insights that allow chemical reactions to be explained. Chemical kinetics allows explanation of how fast or slow chemical reactions occur. Electrochemistry involves the study of a major class of chemical reaction, those reactions where electrons are transferred between substances.

The aim of this unit is to introduce the fundamentals of physical chemistry. Thermodynamics is used to predict whether chemical reactions can take place. Chemical kinetics is used to show how concentration changes can affect the rate of a chemical reaction. Finally, redox reactions are studied introducing the physical chemistry associated with electrochemistry. There is also the opportunity to undertake several practical investigations relating to the theoretical topics studied.

Learning Outcomes

By the end of this unit, a student will be able to:

1 Apply the first, second and third laws of thermodynamics to predict the feasibility of reactions

2 Apply rate equations to determine the order of a reaction

3 Apply the principles of oxidation and reduction to electrochemical systems

4 Undertake experimental investigations relating to physical chemistry.

Essential Content

LO1 **Apply the first, second and third laws of thermodynamics to predict the feasibility of reactions**

Laws of thermodynamics:

First, second and third laws.

Standard enthalpy changes:

Definitions of standard enthalpy changes; Explanation of the magnitude and sign of standard enthalpy changes in terms of the physical and chemical processes involved; Enthalpy changes to be considered: Enthalpy of combustion; enthalpy of formation; enthalpy of neutralisation; enthalpy of solution; enthalpy of hydration; lattice enthalpy; enthalpy of dissociation; mean bond enthalpy; ionisation enthalpy; electron affinity; enthalpy of fusion; enthalpy of vaporisation; enthalpy of sublimation.

Calculation of entropy changes:

Changes of state and heating and cooling of a single substance (including use of molar heat capacity at constant pressure and enthalpies of vaporisation and fusion).

Calculation of ΔH^{θ}, ΔS^{θ}:

From tables of standard enthalpy and entropy changes; calculation of ΔH_f^{θ} from mean bond enthalpies; calculation of enthalpy changes involving standard enthalpy of combustion.

Enthalpy changes at different temperatures:

Use of the Kirchoff equation.

Feasibility:

Gibbs energy; condition of a negative change in Gibbs energy for a feasible reaction; significance of the signs of ΔH and ΔS

$\Delta G^{\theta} = \Delta H^{\theta} - T\Delta S^{\theta}$; assumptions made; relationship to equilibrium constants.

LO2 **Apply rate equations to determine the order of a reaction**

Methods for following rate of reaction:

Methods, e.g. spectrophotometry, conductivity, optical rotation, refractive index, dilatometry, measurement of gas pressure, titrimetry of aliquots, problems of fast reactions.

Integrated rate equations:

Zero, first and second order reactions (integration of rate expressions is desirable but not mandatory); units of rate constant; half-life expressions; percentage reaction.

Relationship between rate constant and temperature:

Arrhenius equation – relationship between rate constant and activation energy: $k = Ae^{-Ea/RT}$; explanation of terms in the equation; plot of ln(k) versus 1/T gives a graph of slope $–E_a/RT$; $\ln (k_2/k_1) = -E_a(1/T_2 – 1/T_1)$ or $\ln k_2 - \ln k_1 = -E_a(1/T_2 – 1/T_1)$; use of equation to determine k, A, E_a or T.

Methods for finding reaction order:

Minimum of two, e.g. plotting graphs of functions of concentration versus time in accordance with the integrated rate expressions, use of the general half-life expression for an nth order reaction, use of gradients of two tangents (d[A]/dt) to the reactant concentration versus time plot at concentrations, $[A]_1$ and $[A]_2$, using the method of initial rates for systems involving more than one reactant.

Basis:

Theoretical explanations; relevant equations; assumptions.

Determining reaction order from data:

Methods based on experimental data.

LO3 **Apply the principles of oxidation and reduction to electrochemical systems**

Standard cell voltage, E^{θ}_{cell}:

Oxidation and reduction equations for half-cells; overall cell reaction (redox equation); experimental set-up; redox reactions involving metal/metal ion and platinum/redox couple; use of tables of standard reduction potential to calculate theoretical values of E^{θ}_{cell}; positive standard cell potential, E^{θ}_{cell} for a feasible cell reaction; pictorial representation of apparatus showing electron flow; IUPAC standard cell notation; reference electrodes. e.g. standard hydrogen, calomel, silver/silver chloride; liquid junction; salt-bridges; experimental determination of cell voltage for simple cells involving metal/metal ion couple or platinum-redox couple half cells; possible reasons for differences between measured and calculated values (e.g. use of concentration rather than activity, liquid junction potential, differences in temperature; $\Delta G = -nFE$ and $\Delta G^{\theta} = -nFE^{\theta}$).

Nernst equation:

Relationship between activity and concentration; $E_{cell} = E^{\theta}_{cell} – (RT/nF)\ln Q$ where Q is the product of product activities divided by the product of reactant activities (raised to the powers of the stoichiometric numbers, where applicable) for the cell reaction; write a Nernst equation formula for a range of cells; calculate a value for E_{cell} given the half-cells involved, temperature and the activity of relevant ions.

Electrolysis:

Molten salts; aqueous solutions of ions, the role of water; overvoltage; oxidation and reduction equations; products at anode and cathode.

Use of Faraday's law:

One Faraday equivalent to one mole of electrons flowing in an electrolysis cell; one Faraday = 96485 C mol^{-1}; current = charge/time; calculation of mass of metal plated on cathode, given current and time; volume of gas collected at one bar pressure and a temperature of 298 K in a given electrolysis cell.

Commercial applications:

electrolytic processes e.g. chlor-alkali industry (Downs cell, diaphragm cell, membrane cell), Hall-Heroult process, electrorefining, electroplating

LO4 Undertake experimental investigations relating to physical chemistry.

Health and Safety:

Perform practical activities in line with instructions and health and safety regulations.

Thermodynamics and electrochemistry:

Experimental investigations in enthalpy, entropy, and Gibbs energy; any reaction for which two of these changes may be used to determine the third, e.g. for metal/metal salt displacement where ΔH may be found from temperature measurements and ΔG from the appropriate electrochemical cell; investigations relating to factors that influence cell potential such as concentration and temperature.

Experimentally determining reaction order from data:

Investigations involving monitoring changes in reactant concentration and the effect on reaction rate; measurements such as absorbance, pH, gas volume or pressure.

Learning Outcomes and Assessment Criteria

Pass	Merit	Distinction
LO1 Apply the first, second and third laws of thermodynamics to predict the feasibility of reactions		
P1 Show how the magnitude and sign of a range of standard enthalpy changes relate to the physical and chemical processes involved **P2** Show how feasibility of chemical reactions may be predicted from the standard changes in Gibb's energy based on calculations of the standard changes in enthalpy and entropy from tabulated entropies and enthalpy changes for formation. **P3** Calculate entropy changes involving heating/cooling a substance and use the Kirchoff equation to calculate an enthalpy change at a temperature other than 298K.	**M1** Analyse the feasibility of reactions in terms of the relative contributions of the associated entropy and enthalpy changes, taking account of temperature	**D1** Evaluate how the first, second and third laws of thermodynamics are used in predicting the feasibility of reactions

Pass	Merit	Distinction
LO2 Apply rate equations to determine the order of a reaction		**D2** Critically evaluate the impact that temperature has on the reaction rate taking into consideration the rate constant (k), catalysts and reaction order
P4 Describe experimental methods of following the rate of a reaction **P5** Undertake a range of calculations, using integrated rate equations and the Arrhenius equation **P6** Explain the bases for and operation of two methods for the determination of reaction order in relation to experimental or synthesised sets of concentration/time data	**M2** Evaluate the accuracy and ease of use of a minimum of two different methods for finding reaction order	

Pass	Merit	Distinction
LO3 Apply the principles of oxidation and reduction to electrochemical systems		**D3** Discuss the applications of the Nernst Equation
P7 Construct the Nernst equations for a range of simple electrochemical cells and calculate the cell voltages under standard conditions and where the activities of the ions are different from unity. **P8** Apply Faraday's laws to electrolysis cells **P9** Investigate an industrial application of electrolysis	**M3** Analyse the electrochemical processes involved in an industrial application of electrolysis	
LO4 Undertake experimental investigations relating to physical chemistry.		**D4** Evaluate the results of the chosen practical activities with reference to the underlying theory
P10 Safely carry out and report on an experiment to determine the entropy change associated with a displacement reaction **P11** Safely carry out and report on an investigation to determine the order of a reaction	**M4** Explain the underlying theory for the chosen practical activities	

Recommended Resources

Textbooks

ATKINS, P., DE PAULA, J. (2016) *Elements of Physical Chemistry*. Oxford: Oxford University Press.

BURROWS, A., HOLMAN, J., PARSONS, A., PILLING, G., PRICE, G. (2017) *Chemistry^3: Introducing Inorganic, Organic and Physical Chemistry*. 3rd ed. Oxford: Oxford University Press.

FACER, G. (2015) *George Facer's Edexcel A Level Chemistry Student Book 1*. London: Hodder Education.

FACER, G. (2015) *George Facer's Edexcel A Level Chemistry Student Book 2*. London: Hodder Education.

Web

chemguide.co.uk	ChemGuide (General reference)
chemrevise.org	ChemRevise A Level Chemistry revision notes (General reference)
khanacademy.org	Khan Academy (General reference)

Links

This unit links to the following related units:

Unit 7: Inorganic Chemistry

Unit 8: Organic Chemistry

Unit 36: Aromatic and Carbonyl Compounds

Unit 37: Solid State and Transition Metal Chemistry

Unit 38: Spectroscopy, Surface Chemistry and Equilibria

Unit 10: Principles of Ecology and their Applications

Unit code	**D/617/5367**
Unit level	**4**
Credit value	**15**

Introduction

The principles of ecology are the building blocks that form and shape our natural world. Ecology is the science behind the complex interactions between organisms and their environment. The outcomes of these interactions alter and affect the delicate balance of life.

Organisms survive as populations and communities of individuals whose success or failure is governed by the environment in which they reside. These natural processes can be broken down into the physical and the biotic components that interact together to form an ecosystem or biome. Their stability is fragile, and change can have severe consequences to the species and organisms that call that ecosystem home. Anthropogenic disturbance and environmental pressures have a negative effect on the natural world, while there is increasing recognition that nature and green spaces are beneficial to health and well-being. Global biodiversity loss due to declines in abundance and distribution of species and habitats are increasing concerns.

This unit will outline the factors that influence life on earth and explain the theory behind these interactions. The students will apply this theory to assess the composition and functionality of real-world ecosystems, interpreting disturbance and evaluating strategies aimed at reversing decline. Students will be able to identify the causes of degradation and exploitation, while exploring how recognition of the value of natural resources could be used as a tool to help drive the success of restoration methods and conservation techniques.

Learning Outcomes

By the end of this unit, a student will be able to:

1 Explain how ecology is the study of interactions between organisms and their environment

2 Identify a variety of biomes and interpret their differences

3 Explain the factors that disturb the ecological balance in a given ecosystem

4 Explore ways to restore the balance in a degraded ecosystem.

Essential Content

LO1 **Explain how ecology is the study of interactions between organisms and their environment**

Organisms:

Evolution

Natural selection

Biological Fitness

Taxonomy

Flora and fauna.

The physical components to the environment:

Environmental variation, i.e. climate

Water properties, water availability, plants and water, and animals and water

Responses to temperature, temperature and species distribution

Soil acidity

Geomorphology: physical, chemical and biological processes

Nutrients: sources and cycles; soil formation, properties and classification; and plants

Global biogeochemical cycles, i.e. carbon, water, nitrogen.

The biotic components to the environment:

Competition: the nature of competition; intraspecific competition, predation and parasitism

Trophic levels and relationships (species interactions)

Population ecology: populations, population structure, population growth, mortality, natality, density, population dynamics (fluctuations and cycles)

Community ecology: the community, structure and stability, community patterns, community response to disturbance.

LO2 **Identify a variety of biomes and interpret their differences**

Surviving with stress and thriving without stress:

Adaptation to environmental variation

The ecological niche

Habitat

Speciation

Succession

Colonisation

Introduced species.

Examples of terrestrial and marine biomes across earth:

Terrestrial Biomes: temperate deciduous forest, coniferous forest, woodland, tundra, grassland, desert, tropical savanna and tropical forest

Marine Biomes: oceanic and coral reef.

Isolated ecosystems and communities:

Extreme competition

Specialisation

Biogeography

Island communities.

LO3 **Explain the factors that disturb the ecological balance in a given ecosystem**

Anthropogenic disturbance:

Pollution

Global warming

Habitat encroachment

Exploitation of resources (nutrients, water and energy use)

Intensive land management

Unsustainable extraction

Species removal through poaching.

Changes to the physical environment:

Climate change

Erosion

Eutrophication.

LO4 **Explore ways to restore the balance in a degraded ecosystem**

Conservation:

Reducing disturbance

Protection, i.e. environmental policy and wildlife legislation

Mitigation

Reintroductions.

Restoration:

Restoring natural processes.

Appreciation and recognition:

Natural capital

Paying for ecosystem services

Corporate social responsibility.

Learning Outcomes and Assessment Criteria

Pass	Merit	Distinction
LO1 Explain how ecology is the study of interactions between organisms and their environment		**D1** Provide an evaluation of the physical and biotic factors which enable the existence and function of a given ecosystem
P1 Define an organism and its role within an ecosystem **P2** Explain the physical components of the environment and explore the effect they have upon an ecosystem **P3** Explain the biotic components of the environment and explore the effect they have upon an ecosystem	**M1** Analyse how the interactions between the physical and biotic components of an ecosystem determine the success of an organism or species	
LO2 Identify a variety of biomes and interpret their differences		**D2** Compare two specific biomes and analyse their differences
P4 Identify a species that is an intrinsic part of a biome and describe its role **P5** Outline the environmental components which enable the existence of any given functioning biome **P6** Identify and describe the environmental components of a biome in either an extreme environment or an isolated location	**M2** Differentiate the environmental components which define two separate biomes	

Pass	Merit	Distinction
LO3 Explain the factors that disturb the ecological balance in a given ecosystem		**D3** Evaluate the future cost of continuing to exploit natural resources
P7 Explain the negative anthropogenic impact on any given ecosystem **P8** Explain the effect of changes to the physical environment on an ecosystem	**M3** Analyse the exploitation of natural resources	
LO4 Explore ways to restore the balance in a degraded ecosystem.		**D4** Explore, making justified recommendations, how the appreciation of natural assets could help drive conservation and restoration work of the future
P9 Explain conservation measures currently in practice to reduce loss and degradation of the natural environment **P10** Explain restoration techniques currently in practice to restore degraded habitats **P11** Outline the theory of natural capital and ecosystem services	**M4** Analyse the importance of restoring natural processes in selecting viable methods to minimise degradation	

Recommended Resources

Textbooks

ALLABY, M. (2010) *A Dictionary of Ecology*. 4th ed. Oxford: Oxford University Press.

BEGON, M., HOWARTH, R., TOWNSEND, C.R. (2014) *Essentials of Ecology*. 4th ed. Oxford: John Wiley & Sons Ltd.

BEGON, M., TOWNSEND, C.R., HARPER, J.L. (2006) *Ecology from Individuals to Ecosystems*. 4th ed. Oxford: Blackwell Publishing.

MACKENZIE, A., BALL, A.S., VIRDEE, S.R. (2001) *BIOS Instant Notes in Ecology*, 2nd ed. Abingdon: Taylor & Francis Group.

Web

britishecologicalsociety.org	British Ecological Society Learning and Resources (Research)
cell.com	Trends in Ecology and Evolution Journal (Articles)
cieem.net	Chartered Institute for Ecology and Environmental Management Training & Events, Publications (Training, Articles)
gov.uk	Natural England Wildlife and Habitat Conservation (Research)
iucn.org	International Union for the Conservation of Nature Resources (General reference)
jncc.defra.gov.uk	Joint Nature Conservation Committee UK Habitats, UK Species Research, Legislation & Policy, Protection (Discussion Forum)
magic.defra.gov.uk	MAGIC Map DEFRA Get Started (Datasets, Development tool)

Links

This unit links to the following related units:

Unit 2: Scientific Data Handling Approaches and Techniques

Unit 5: Fundamentals of Chemistry

Unit 11: Physiological Adaptation of Plants to Environmental Changes

Unit 12: Managing Environmental Resources

Unit 28: Applied Sciences Research Project

Unit 42: Materials Life Cycle and the Circular Economy

Unit 11: Physiological Adaptation of Plants to Environmental Changes

Unit code	**H/617/5368**
Unit level	**4**
Credit value	**15**

Introduction

Plants have evolved over hundreds of millions of years through evolution. By adapting to different environments, they are able to colonise much of the planet, including oceans, deserts and tundra. For several millennia, this adaptation has been assisted by human intervention, through breeding and the selection of superior strains of crop plants.

This unit provides students with the ability to relate the adaptation of plants to different and often changing environments, both natural and adapted by humans in protected cropping and urban agriculture. It investigates vital plant processes, such as the uptake of water into the plant by the process of osmosis, and the manufacture of glucose in leaves and stems by the process of photosynthesis. The morphological modification of roots, leaves and stems, such as tendrils, spines, stolons, rhizomes and corms, will also be explored.

Furthermore, the physiological development of crop plants from their wild ancestors and their physiological adaptations to dry (xerophytic), salt water (halophytic) and aquatic (hydrophytic) environments will be discussed. The potential of soilless growing systems (hydroponics) in optimising cropping in protected environments and the suitability of different media in supporting strong and healthy root growth will be explored. Finally, the use of technological advancements to increase yields and make crop production more economical, and the use of new energy efficient lighting systems, to reduce the cost of providing photosynthetically active radiation in the absence of natural light, will be explained.

On successful completion of this unit, students will be able to explain how plants adapt to different environmental regimes and how knowledge of these adaptations is used to breed and cultivate plants in both field and protected cropping environments.

Learning Outcomes

By the end of this unit, a student will be able to:

1 Explain the relationship between plant anatomy and physiological processes

2 Explain the purpose of plant adaptations to different environments with reference to named examples

3 Investigate the application of environmental adaptations that are used in crop production to optimise plant growth and cropping

4 Explore the development of the physiology of crop plants from their wild ancestors to the present.

Essential Content

LO1 **Explain the relationship between plant anatomy and physiological processes**

Root structure and function:

Water and nutrient uptake

Anchorage

Root tissues and cell types

Cultural activities that optimise or inhibit root functions in soil or growth media

Stem structure:

Cell types and cellular arrangements

The function of the different cell types in relation to the prime functions of water and mineral transportation and support

Cultural practices that affect stem growth

Leaf structure:

Cellular arrangements and leaf tissues, and how these facilitate photosynthesis

LO2 **Explain the purpose of plant adaptations to different environments with reference to named examples**

Xerophytic and halophytic:

Root, stem and leaf adaptations

Modified pathways for carbon dioxide uptake and photosynthesis

Hydrophytic, e.g. modified stem, root and leaf structure

Modified carbon dioxide uptake and oxygen movement

LO3 **Investigate the application of environmental adaptations that are used in crop production to optimise plant growth and cropping**

Supplementary lighting:

Wavelength selection, intensity, duration.

Photoperiod:

Effect on flowering and morphology, duration.

Carbon dioxide enrichment:

Concentration and cost effectiveness of use.

Optimising photosynthesis

Hydroponics:

Different substrates, e.g.: sustainability and durability, nutrient application

LO4 **Explore the development of the physiology of crop plants from their wild ancestors to the present.**

Suitable species:

Beta vulgaris and Brassica oleracea, or other cultivated species that have been developed substantially from wild ancestors

Response to:

Temperature, day length, rainfall and irrigation, extreme weather, different levels of salinity, soil nutrition.

Adaptation to mechanised harvesting:

Crop uniformity, increased yield.

Learning Outcomes and Assessment Criteria

Pass	Merit	Distinction
LO1 Explain the relationship between plant anatomy and physiological processes		
P1 Explain how typical plant structure facilitates key physiological processes, using annotated diagrams **P2** Describe the key differences between monocotyledons and dicotyledons in terms of structure, relating these differences to key physiological processes	**M1** Analyse how the physiology of plants varies according to their role within a defined plant community	**D1** Evaluate how knowledge of plant physiology and environmental responses has developed cultural technology in either horticulture or agriculture
LO2 Explain the purpose of plant adaptations to different environments with reference to named examples		
P3 Describe how plants are able to adapt to xerophytic and halophytic environments **P4** Describe how plants are able to adapt to hydrophytic environments	**M2** Investigate the culture of a hydrophytic, xerophytic or halophytic crop plant	**D2** Evaluate how knowledge of plant adaptation to different environments can be used to build resilience for crops growing in marginal land or affected by environmental change

Pass	Merit	Distinction
LO3 Investigate the application of environmental adaptations that are used in crop production to optimise plant growth and cropping		
P5 Explore the use of supplementary lighting and day length lighting with reference to a specific crop plant **P6** Explain different substrate materials for use in hydroponics in terms of performance and sustainability	**M3** Investigate the economic benefits of supplementary lighting and carbon dioxide enrichment, comparing the advantages and disadvantages of different systems	**D3** Evaluate environmental adaptations in commercial urban crop production that utilises intensive cultivation techniques in an indoor or underground environment
LO4 Explore the development of the physiology of crop plants from their wild ancestors to the present.		
P7 Describe the development of three distinct cropping plants from a wild ancestor **P8** Explain how cropping plants are modified by reference to three specific examples	**M4** Evaluate the development of at least three crop plants from a single wild ancestor	**D4** Investigate a current research project that aims to develop resilience, or other attributes in a crop in response to environmental change

Recommended Resources

Textbooks

BECK, C. (2010) *An Introduction to Plant Structure and Development*. 2nd ed. Cambridge: Cambridge University Press.

BELL, D. (2008) *Plant Form: An Illustrated Guide to Flowering Plant Morphology*. Portland, OR: Timber Press Inc.

SOLTANI, A. (2012) *Modelling Physiology of Crop Development, Growth and Yield.* Wallingford: CABI publishing.

TAIZ, L., ZEIGER, E., MOLLER, I.M., MURPHY, A. (2018) *Plant Physiology and Development*. 6th ed. Sunderland, MA: Sinauer Associates (Oxford University Press).

Web

bsbi.org	Botanical Society of Great Britain and Ireland Homepage (General reference)
journals.elsevier.com	Elsevier Plant Physiology and Biochemistry (Journal)
kew.org	Kew Gardens Science (General reference)
plantphysiol.org	Plant Physiology Homepage (General reference)
sciencedirect.com	Science Direct Journal of Plant Physiology (Journal)

Links

This unit links to the following related units:

Unit 2: Scientific Data Handling Approaches and Techniques

Unit 5: Fundamentals of Chemistry

Unit 10: Principles of Ecology and their Applications

Unit 12: Managing Environmental Resources

Unit 28: Applied Sciences Research Project

Unit 42: Materials Life Cycle and the Circular Economy

Unit 12: Managing Environmental Resources

Unit code	**K/617/5369**
Unit level	**4**
Credit value	**15**

Introduction

Environmental sustainability is a key component in the goal towards managing environmental resources. Environmental sustainability relates to the need for maintaining and, where possible, improving the bio-systems of the Earth. These are the systems sustaining all life, i.e. the natural ecosystem. The way in which mankind interacts with this system is of primary importance in maintaining this natural ecosystem.

A core concept relates to the fact that resources harvested from the earth are finite. These resources may be reused or recycled, particularly when they have been mined from the earth in the first instance. Renewable resources, such as crops, are not finite as they can be renewed but equally, they cannot be consumed at a greater rate than they can be produced. All resources need appropriate and sympathetic management.

Environmental ecosystems also require consideration as a delicate network exists that connects and interacts with elements in the environment. Ecosystems, therefore, can be said to need biodiversity to function.

This unit will look at the management of environmental resources in terms of raw materials, energy, water resources, climate, biodiversity, pollutants and waste. It will also look at the overarching legislation and regulations currently in place and those proposed for future adoption. The effects such management has on an organisation will also be ascertained.

On successful completion of this unit, the student will be cognisant of the potential impact consumerism, public attitudes and the importance of environmental matters has on suppliers/producers. They will have an awareness of considerations needed when addressing the environmental credentials of products within their industry. This awareness will aid in the aim to adopt a more sustainable approach to the consumption and use of resources and appropriate management of waste.

Learning Outcomes

By the end of this unit, a student will be able to:

1 Explain the environmental issues connected with the biosphere

2 Identify the pressures on the environment from utilising finite resources

3 Identify the pressures on the environment from utilising renewable resources

4 Explore the challenges for manufacturers and businesses aiming to improve their environmental management credentials.

Essential Content

LO1 **Explain the environmental issues connected with the biosphere**

Concepts concerning the biosphere:

Defining the biosphere

Bioregions and biosphere reserves

Produce from the biosphere, including: timber; drugs and medicines (rainforest plant contribution)

Importance of biodiversity, including potential imbalance effects

Acoustic ecology

Anthropocene era

Cultural values

Carbon footprint.

Services provided by the biosphere:

Provision of nutrients

Clean air and absorption of CO_2

Control of the hydrological cycle.

Greenhouse gases causes and effects:

Human endeavours, including: industry; deforestation; population increases; acidification of the oceans

Agriculture, including: overfishing; overharvesting; livestock.

Potential impact and the causes of climate change:

Effects on nature, including: wildlife; sea levels; weather; natural flood controls; biodiversity; fire risks

Subsequent effects on: crops; food-chain; vulnerable populations; habitat adaptation.

LO2 **Identify the pressures on the environment from utilising finite resources**

Material resources and extraction:

Metal ore extraction, such as: aluminium (bauxite); copper; iron; lead; nickel; tin; precious metals

Mined materials, such as: salt; clays; potash; feldspar; quartz; lithium; bauxite (aluminium)

Fossil fuels, such as: coal; oil; gas; peat.

Processing:

Use of water in processing

Use of energy in processing

Use of heavy metals/toxins/chemicals during processing.

Environmental impact from extraction and processing:

Water pollution

Ocean acidification

Increased sediment in water courses

Metal contamination (heavy metals)

Soil contamination

Sinkholes

Green-house gas emissions

Air pollution

Loss of biodiversity

Noise pollution.

LO3 **Identify the pressures on the environment from utilising renewable resources**

Crops utilised as raw material for industry:

Timber and related for products, such as: paper; rubber; wood; palm oil

Textile crops, such as: cotton; flax; coir; hemp

Biomaterials for plastics

Biomass for fuel

Food industry crops, such as: cereals; vegetables; fruits; nuts; oils (e.g. olive, sunflower, rapeseed, vegetable, coconut)

Animal husbandry:

Rearing of animals and their impact on the environment including; depletion of pasture lands; methane production.

Processing:

Use of water in processing

Use of energy in processing

Use of chemicals and other pollutants during processing.

Environmental impact from cultivation and processing:

Water pollution; consider, e.g. the textile and paper industry

Water supply issues for local population

Increased sediment in water courses

Metal and chemical contamination

Soil contamination; consider, e.g. over farming; stripping of nutrients; salinisation of the soil; soil degradation

Desertification

Deforestation

Green-house gas emissions

Air pollution; consider processing plants

Loss of biodiversity particularly through stripping land for intensive farming of a single crop; consider e.g. palm oil production

Non-indigenous planting.

Renewable Energy:

Sources of energy, including: hydroelectric; tidal; geothermal; ocean energy; biomass; bio-methane; solar; wind; wood and/or waste incineration; nuclear (note: the energy can be considered renewable technically but generally the overall production can be said to be non-renewable)

Issues relating to renewable energy, such as: land usage; Emissions; Sustainability; consistency in supply; development of fuel cells; development of increased battery power.

LO4 **Explore the challenges for manufacturers and businesses aiming to improve their environmental management credentials.**

Environmental impact, including that of carbon footprint:

Production and manufacture, considering industries such as, but not limited to: textile; food; packaging; automotive; electrical and electronic; construction

Delivery of goods and services, including: transportation; logistical approach considering locality

Seasonality.

Approaches to consider from a manufacturers/business perspective:

Identifying the environmental impacts

Design approach, including: adoption of the concept of 'building to last'; recycling/disassembly potential; avoiding planned obsolescence

Minimising waste

Energy efficiency in production

Use of bio-refineries

Influence of costs/finances on the outcomes

Concepts of adopting a 'worldwide view'

Impact on business models

Resource efficiency

Biomimicry

The role of technology.

Waste and end of life issues and initiatives:

End-of-life usage and disposal

Retrieval of component parts

'Reuse, remanufacture, repair, recycle' model

Energy recovery

Directives targeted at particular goods such as electrical (WEEE directive)

The Waste and Resources Action Programme (WRAP)

Resources and waste strategy (UK).

Global environmental protocols and agreements:

International agreements, including the: Kyoto Protocol; Paris Accord; Greenhouse Gas Protocol

The politics and economics of sustainability

International frameworks, such as: United Nations strategies; European Union Emissions Trading Scheme; Sustainability forum such as COP21

Global conventions covering issues, such as: marine life; atmosphere; noise pollution; freshwater

International specification − ISO14001.

Learning Outcomes and Assessment Criteria

Pass	Merit	Distinction
LO1 Explain the environmental issues connected with the biosphere		**D1** Investigate the issues surrounding climate change and the potential to limit its impact
P1 Explain the concept of an Anthropocene era and suggest whether this is a valid descriptor of the present era **P2** Describe the importance of ocean health in maintaining and regulating the biosphere	**M1** Assess the outcomes arising when an imbalance in the hydrological cycle occurs	

Pass	Merit	Distinction
LO2 Identify the pressures on the environment from utilising finite resources		**LO2 and LO3** **D2** Investigate the impact on the environment on harvesting a given selection of finite and renewable resources and suggest ways by which their consumption might be managed
P3 Identify the extraction methods and subsequent uses for two metal ores, two mined materials and two fossil fuels **P4** Compare the water usage when processing a selection of at least three different types of finite resources and note the typical location of the processing plants of these materials	**M2** Assess the use of shale gas as an energy source, including its advantages and disadvantages and the legislation and regulations surrounding its extraction	
LO3 Identify the pressures on the environment from utilising renewable resources		
P5 Identify the use and disposal of chemicals in the processing of at least three different types of goods derived from renewable resources **P6** Describe the issues associated with battery and fuel cell development	**M3** Assess the impact on the land in the production of renewable resources	

Pass	Merit	Distinction
LO4 Explore the challenges for manufacturers and businesses aiming to improve their environmental management credentials		**D3** Justify the steps that must be taken by a manufacturer or business in a given sector to improve its environmental management credentials
P7 Assess the importance of waste management in managing environmental resources **P8** Describe the importance to a business of adopting a standard such as ISO14001	**M4** Evaluate the impact global environmental protocols and agreements have had on environmental sustainability	

Recommended Resources

Textbooks

BERNERS-LEE, M. (2010) *How Bad Are Bananas?* London: Profile Books Ltd.

BOYLE, G., Open University. (2017) *Renewable Energy*. 4th ed. Oxford: Oxford University Press.

EVERETT, B., BOYLE, G., PEAKE, S. (2011) *Energy Systems and Sustainability: Power for a Sustainable Future.* 2nd ed. Oxford: Oxford University Press.

FENNER, A., AINGER, C. (2013) *Sustainable Infrastructures: Principles into Practice*. London: ICE Publishing.

HELM, D. (2015) *The Carbon Crunch: Revised and Updated*. 2nd ed. New Haven, CT: Yale University Press.

Web

biospherejournal.org	UNESCO Biosphere Journal UNESCO Biosphere Reserve Management Evaluation: where do we stand and what's next? (Article)
consultancy.uk	Consultancy UK Circular economy in materials needed for sustainable growth (Article)
cop21paris.org	COP21 (General reference)
fairplanet.org	Fair Planet Cradle to cradle – a concept for an ideal circular economy (Article)
ghgprotocol.org	Greenhouse Gas Protocol (General reference)
gov.uk	UK Government Resources and Waste Strategy (Report)

lrqa.co.uk	Lloyd's Register ISO 14001: Environmental Management System Standards (General reference)
nationalgeographic.org	National Geographic Biosphere (General reference)
populationinstitute.org	The Population Institute Demographic Vulnerability Report (Report)
stockholmresilience.org	Stockholm Resilience Centre News about Biosphere (Research)
un.org	United Nations Integrating Population Issues into Sustainable Development (Report)
wrap.org.uk	The Waste and Resources Action Programme (Report)
wri.org	World Resources Institute Managing environmental impact (General reference)

Links

This unit links to the following related unit:

Unit 20: Introduction to Material Properties and Applications

Unit 13: Human Health and Nutrition

Unit code	**D/617/5370**
Unit level	**4**
Credit value	**15**

Introduction

The food we consume directly influences the functions of our body. Our bodies need adequate nutrition, otherwise they begin to function abnormally. We can optimise our physical and psychological wellbeing by consuming a healthy balanced diet.

This unit aims to equip the student with the knowledge, skills and competencies to understand the nutritional composition of food and the effects of nutritional choices on the health of a person. Students will gain knowledge of the importance of eating a balanced diet and the dangers associated with the consumption of a poor diet. They will focus on diet prescription for specific populations and gain an understanding of labelling systems, and the pitfalls that can be associated with them.

Students will research current therapeutic diets for specific groups with intolerances and diseases, while also investigating fad diets. Students will learn about the components of the digestive system and how it functions, and will become familiar with the academic language associated with nutrition. Within this unit students will engage in self-directed learning.

Learning Outcomes

By the end of this unit, a student will be able to:

1. Identify the main components of nutrition for optimal health and physical condition
2. Explain the main components of the digestive system and the factors that affect optimal function
3. Investigate the connection between food consumption and disease
4. Explore a range of specific diets, with particular focus on their dietary principles.

Essential Content

LO1 **Identify the main components of nutrition for optimal health and physical condition**

Definition, structure, function and sources of micro and macro nutrients:

Protein, lipids, carbohydrates, vitamins and minerals

Food pyramid and food groups

Cholesterol

Deficiencies of micro and macro nutrients

Effects of dehydration

The importance of soluble and insoluble fibre in the diet

Superfoods.

The nutritional needs of specific populations in society:

Athletes, children, young people, adults, the elderly, and pregnant mothers

Nutritional supplements

Potential benefits from nutritional supplements.

Food labels:

Labelling systems, e.g. the traffic light system

Nutritional information, e.g. ingredients and additives

Marketing tools, brand imaging, the effectiveness of food labels

Review the European Union (EU) labelling laws.

LO2 **Explain the main components of the digestive system and the factors that affect optimal function**

Physiology of the digestive system and ancillary organs:

Functions of the digestive system, e.g. mechanical and chemical digestion

Functions of the liver, pancreas, gall bladder and the kidneys

Five phases involved in the digestive process

Different processes involved in digestion and where they occur – ingestion of food, breakdown, digestion, absorption, and egestion.

Microbiome and microbiota:

Microbiome, in terms of its function and the microbiota that inhabit it

Role of microbes in sustaining a healthy gut; leaky gut

Microbiome and the pathophysiology of the body

Healthy diet in maintaining a healthy gut, consumption of prebiotics and probiotics.

LO3 **Investigate the connection between food consumption and disease**

Disordered physiological processes:

Energy balance, input versus output, calculation, Harris Benedict equation

Poor dietary habits, e.g. atherosclerosis, hypodyslipidaemia, hypertension, joint problems, obesity, type 2 diabetes, coronary heart disease, inflammatory disorders, depression, anxiety and food intolerance.

Factors leading to these conditions:

Dietary gaps that lead to deficiencies

Dietary improvements to improve health.

Nutritional tests, medical tests:

Heart angiogram, food tolerance tests, foetal test, urine test, small intestine biopsy for microbes, cholesterol test, vitamin D deficiency test, and others.

LO4 **Explore a range of specific diets, with particular focus on their dietary principles**

Prescriptive diets:

Diets for optimal physical condition, athletic diet for strength and endurance, coeliac diet, lactose intolerant diet, vegan diet, diabetic diet, vegetarian.

Dysfunctional diets:

High fat diet, processed food diet, high sugar diet, high alcohol diet.

Fad diets:

Atkins diet, celebrity diet, slim diet plan, 5:2 diet, probiotic diet, apple cider vinegar diet, Mediterranean diet, the keto diet, fodmap diet.

Learning Outcomes and Assessment Criteria

Pass	Merit	Distinction
LO1 Identify the main components of nutrition for optimal health and physical condition		**D1** Analyse different food labels, discuss their nutritional benefits and shortcomings, paying particular attention to any additives that may be in the ingredients
P1 Outline the structure, function and sources of micro and macro nutrients **P2** Explain the impact of micro and macro nutrients on optimal health and physical condition from deficiencies **P3** Describe the specific nutritional requirements of specific populations	**M1** Justify why labels are important for the consumer **M2** Explore food labelling laws in regards to additives, nutritional information and ingredients lists	
LO2 Explain the main components of the digestive system and the factors that affect optimal function		**D2** Analyse how the microbiome can affect the pathophysiology of the body
P4 Explain the physiology of the digestive system and ancillary organs **P5** Explain the importance of a healthy diet in maintaining a healthy gut	**M3** Explore the functional properties of the microbiome	

Pass	Merit	Distinction
LO3 Investigate the connection between food consumption and disease		**D3** Explore nutritional recommendations that could be implemented to reverse or improve these conditions
P6 Explore specific disordered physiological processes that can occur due to poor dietary habits and the factors leading to these conditions	**M4** Review the range of nutritional tests that are available to people suffering from nutrition related conditions	
LO4 Explore a range of specific diets, with particular focus on their dietary principles		**D4** Evaluate the validity of these diets based on scientific research and medical statistics
P7 Differentiate between fad diets, prescriptive diets and dysfunctional diets	**M5** Compare and contrast one of each diet category: fad diet, prescriptive diet, and dysfunctional diet	

Recommended Resources

Textbooks

BEEN, A. (2017) *The Complete Guide To Sports Nutrition*. 8th ed. London: Bloomsbury Sport.

HOLFORD, P. (2004) *The Optimum Nutrition Bible*. London: Piatkus.

HOLFORD, P. (2010) *Optimum Nutrition For The Mind (e-book)*. London: Piatkus.

MAYER, E. (2016) *The Mind Gut Connection.* New York: Harper Wave.

PERLMUTTER, D. (2015) *Brain Maker*. London: Yellow Kite.

Web

food.gov.uk	Food Standards Agency
	Allergies/intolerances (Research)
	Regulation/legislation (General reference)
	Food alerts (Discussion forum)
nutrition.org.uk	British Nutrition Foundation
	(General reference)

Links

This unit links to the following related units:

Unit 6: Anatomy and Human Physiology

Unit 14: Food Technology

Unit 43: Investigating the Properties of Food Molecules

Unit 44: Advanced Health and Nutrition

Unit 45: Nutritional Diseases and Disorders

Unit 14: Food Technology

Unit code	**H/617/5371**
Unit level	**4**
Credit value	**15**

Introduction

The aim of this unit is to develop a working knowledge of the processes and methods used in the development of new food products. Food technology is an important industry as we seek new and novel ways of feeding a growing global population with increasingly limited resources.

Students will study the human and design factors affecting how new dietary options are created, and the processes involved in developing these new food products. There will be emphasis on hygiene and legislation throughout, to ensure a working knowledge of the importance of food safety. Methods of food preservation through packaging and other means will be part of the developmental process.

The student will be directed to produce a final product, using the processes and methods taught, and to complete an evaluation of their product in terms of not just the food value, but also the economic viability.

On completion of this unit, the student will possess a working knowledge of Food Technology, which can allow them to move directly into employment in this area, or to progress into honours degree programmes.

Learning Outcomes

By the end of this unit, a student will be able to:

1 Describe the human factors that affect the development of new food products

2 Investigate the factors affecting the design of new food products

3 Investigate the process of developing new food products

4 Apply manufacturing processes to develop a food product.

Essential Content

LO1 **Describe the human factors that affect the development of new food products**

Dietary needs:

Age

Physiological condition

Ethnic and religious taboos

Food allergies

Lifestyle choices − vegetarian/vegan.

Health:

Nutritional diseases and disorders: obesity, diabetes, heart disease, dental caries, hypertension and sodium.

Social factors:

Family circumstances: composition of family, lifestyle, work/leisure balance, culture, economic status.

Dietary planning:

Composition of diet plans

Sources of nutrients

A balanced diet and application of current healthy eating recommendations.

LO2 **Investigate the factors affecting the design of new food products**

Opportunities for product development:

Legislation

Changes in world food resources

World food transport logistics.

Food Safety and Hygiene:

Factors affecting the growth of microorganisms

Contamination of food: physical, chemical, biological.

Legislation:

Current food safety legislation

Current food hygiene legislation

Food labelling legislation.

LO3 **Investigate the process of developing new food products**

Analysis of existing products:

Lifecycle: evolution, introduction, growth, maturity and decline.

Design for manufacture:

Concept development

Screening, commercial liability

ICT − CAD/CAM

Marketing and communication, launch of product.

Health and social implications:

Quality control systems

HACCP

Environmental sustainability of product, packaging and ingredients

Seasonality of ingredients

Carbon footprint

Choice of materials for packaging

Social, moral and economic implications.

LO4 **Apply manufacturing processes to develop a food product**

Processing methods:

Heat transfer methods

Methods of food preparation: bakery, meat and fish, dairy, vegetables and fruit, novel food ingredients.

Use of tools and equipment:

Range of preparatory equipment

Hygiene, safe food handling, refrigeration

Range of cooking equipment.

Preservation of food:

Preservatives

Reduction of oxygen

Packaging in vacuum

Increased or decreased temperature

Irradiation

pH.

Evaluation of product:

Sensory evaluation

Aesthetic appeal

Suitability for the intended market: nutritional value, value for money.

Learning Outcomes and Assessment Criteria

Pass	Merit	Distinction
LO1 Describe the human factors that affect the development of new food products		**LO1 and LO2** **D1** Evaluate the importance of human and design factors in the development of new food products
P1 Describe how age, health and social factors affect the development of new food products **P2** Describe the process of planning diets	**M1** Create and assess the suitability of a dietary plan for a given subject	
LO2 Investigate the factors affecting the design of new food products		
P3 Identify what opportunities affect food development **P4** Investigate the role of food safety, hygiene and legislation in product development	**M2** Analyse the effectiveness of current food safety and hygiene legislation in the production of new food products	

Pass	Merit	Distinction
LO3 Investigate the process of developing new food products		**LO3 and LO4** **D2** Evaluate, using appropriate methods, the design and production of the food item created
P5 Explain the process of developing new food products **P6** Describe the health and social implications of new food product development	**M3** Create in detail, a design for a food product	
LO4 Apply manufacturing processes to develop a food product.		
P7 Explain the importance of correct equipment and processing methods **P8** Explain the reasons for, and methods of food preservation **P9** Create, using appropriate equipment and processing methods, a food product for a given subject	**M4** Justify the equipment and processing methods used to create the food product	

Recommended Resources

Textbooks

CAMPBELL-PLATT, G. (Ed). (2017) *Food Science and Technology.* 2nd ed. Hoboken, NJ: Wiley-Blackwell.

GEISSLER, C., POWERS, H. (2017) *Human Nutrition and Dietetics.* 13th ed. Oxford: Oxford University Press.

PROUDLOVE, R.K. (2009) *The Science and Technology of Foods*. 5th ed. Wallingford: Forbes Publications Ltd.

Web

chilledfood.org	Chilled Food Association (General reference)
ec.europa.eu	European Commission Food, Farming, Fisheries – Food Safety in the EU (General reference)
fdf.org.uk	Food and Drink Federation (General reference)
foodmanufacture.co.uk	Food Manufacture Magazine (General reference)
thegrocer.co.uk	The Grocer Magazine (General reference)
hfma.co.uk	The Health Foods Manufacturer's Association (General reference)
hse.gov.uk	Health and Safety Executive Food and Drink Manufacture Policies and Inspectorate (General reference)

Links

This unit links to the following related units:

Unit 13: Human Health and Nutrition

Unit 43: Investigating the Properties of Food Molecules

Unit 44: Advanced Health and Nutrition

Unit 45: Nutritional Diseases and Disorders

Unit 15: Introduction to Polymer Materials and Properties

Unit code	**K/617/5372**
Unit level	**4**
Credit value	**15**

Introduction

The development of materials throughout the ages has enabled all manner of technological leaps in human progress. One only has to think of the great ages of mankind as defined by the material essential to their time; stone age; bronze age; iron age. It can be argued that we are currently living through the polymer age with all the advantages, and sometimes controversy, that entails.

Polymers, such as plastics and rubbers, are so widely used that they can be found in nearly every industry and in many aspects of our lives. The reasons why they are so integrated into modern living are manifold and diverse. Not least among these is the sheer range of materials available to the manufacturer.

Plastic materials are continually being developed and their range extended by co-polymerisation, blending and modification. These materials are on the whole synthetic in nature but increasingly natural or biodegradable polymers are becoming mainstream. Rubbers too can take many forms, also starting as natural materials, but now with many synthetic varieties.

This unit will introduce these materials in their varying forms, relate structure to properties and show how they can be modified and adapted. It will also introduce the concept of data sheets and show how these can be interpreted.

On successful completion of this unit, the student will be able to classify forms of polymer materials and be able to identify a range of materials within each classification in terms of their characteristics and properties. They will also have a grounding on the various methods utilised to modify these materials in order to manipulate specific properties.

Learning Outcomes

By the end of this unit, a student will be able to:

1 Identify the advantages and limitations of utilising a polymer material over other suitable materials for the same product

2 Define polymers in terms of their classifications and sub-groups, and in relation to their structure

3 Identify the properties that characterise the behaviour of a polymer

4 Explain how a polymer can be modified through the use of additives, blending or co-polymerisation.

Essential Content

LO1 **Identify the advantages and limitations of utilising a polymer material over other suitable materials for the same product**

Considerations made when selecting a material for use, including but not limited to:

Density/weight, especially in areas of transportation; aerospace; consumer products

Colourability, in terms of natural colour of base polymer; ease of pigmentation; surface coating

Environmental behaviour; resistance to corrosion in a wet environment; environmental stress cracking (ESC); behaviour when exposed (ozonation, oxidation); reaction to humidity (swelling)

Insulating effects, in terms of thermal or electrical conductivity

Range of materials available; ability to compound or otherwise tailor properties

Availability and cost factors

Design flexibility; freedom of design; potential to produce complex shapes

Economy of processing; ease of processing; processing energy consumption; complexity of shape without the need for joining

End-of-life considerations; repurposing; recycling; disposal.

LO2 Define polymers in terms of their classifications and sub-groups, and in relation to their structure

Polymers:

Thermoplastic, including the sub groupings; amorphous; crystalline

Thermoset

Elastomers (including rubbers)

General classing of, commodity; engineering; speciality/high performance; in terms of usage; costing; general physical attributes

Molecular structure in relation to classifications and groupings including; tacticity; linearity; branching; cross-linking; length and distribution; spherulitic growth and number; lamellar structure

Molecular bonding forces and intermolecular forces

Effects of temperature in terms of molecular movement and transitions including; Tg; Tm; Tc

Variances in molecular attributions and transition temperatures in basic terms of strength; rigidity; opacity.

LO3 Identify the properties that characterise the behaviour of a polymer

Mechanical properties:

Tensile; flexure; compression; strength; stiffness; impact; hardness; toughness; fracture; wear.

Chemical properties:

To include polymer behaviour when in contact with a range of chemical elements.

Electrical properties:

Electrical conductivity; Resistivity.

Other relevant properties:

Thermal properties

Optical properties

Magnetic properties.

Property comparison and evaluation:

Interpretation of data from secondary sources such as manufacturer's data sheets or design specifications.

LO4 **Explain how a polymer can be modified through the use of additives, blending or co-polymerisation.**

Categorise the additive type in terms of:

Chemical compound seeking to impart properties such as: lubricants; process aids; blowing agents; plasticisers; antimicrobials; antioxidants; impact modifiers; light stabilisers; pigments; flame retardants

Particulate filler in the form of, for example: chalk; clay; talc; carbon black; wood flour; glass beads; nanotubes

Fibre reinforcement in the form of: glass: carbon; aramid; nylon; polyester.

Purpose of additive inclusion:

Control shrinkage; Control warpage; Extend the raw material (economic benefits); Stiffen product; Pigmentation; Reduce creep.

Other modifying considerations:

Rubber compounding

Blending; miscibility; entropy

Polymerisation techniques

Co-polymerisation; mechanisms and definitions of co-polymerisation.

Learning Outcomes and Assessment Criteria

Pass	Merit	Distinction
LO1 Identify the advantages and limitations of utilising a polymer material over other suitable materials for the same product		**LO1 and LO2**
P1 Identify a polymer-based product of choice and detail its general attributes **P2** Explain the reasons behind the choice of polymer material, while making comparisons to other material types such as metal, ceramic or natural	**M1** Assess the significance of considering limitations in the capabilities of a polymer material when deciding on its suitability to a particular application	**D1** Evaluate the characteristics that enable a particular polymer type and/or grouping to be selected, and show how structure influences this selection
LO2 Define polymers in terms of their classifications and sub-groups, and in relation to their structure		
P3 Explain the various classifications of a polymer, with an emphasis on their underpinning structure	**M2** Explain the fundamental expectations from each sub group in terms of, e.g. usage, cost, manufacturing ease, availability and handling	

<table>
<tr><th>Pass</th><th>Merit</th><th>Distinction</th></tr>
<tr><td colspan="2">LO2 Define polymers in terms of their classifications and sub-groups, and in relation to their structure</td><td rowspan="4">LO3 and LO4

D2 Analyse the effects on the properties of a particular polymer, both detrimental and beneficial, following the incorporation of a given additive. The answer ought to consider the properties before and after incorporation of an additive</td></tr>
<tr><td>P4 Identify the general difference in properties exhibited by the main polymer types of thermoplastics, thermosets and elastomers

P5 Compare the properties of a range of polymers and relate these to its microstructure</td><td>M3 Assess the importance of published data sheets, and their correct interpretation, in determining the properties of a material destined for a specific application</td></tr>
<tr><td colspan="2">LO4 Explain how a polymer can be modified through the use of additives, blending or co-polymerisation.</td></tr>
<tr><td>P7 Identify how properties may be tailored through the use of additives

P8 Explore areas of application where modification would be beneficial</td><td>M4 Assess whether additives can be used to enhance certain properties in a more effective manner than through blending or co-polymerisation</td></tr>
</table>

Recommended resources

Textbooks

DEVLIN, T.M. (2019) *Textbook of Biochemistry with Clinical Correlations.* 8th ed. Hoboken, NJ: John Wiley & Sons, Inc.

MATHEWS, C.K., VAN HOLDE, K.E., APPLING, D.R., ANTHONY-CAHILL, S.J. (2012) *Biochemistry.* 4th ed. New York: Pearson Education Ltd.

NELSON, D.L., COX, M.M. (2017) *Lehninger Principles of Biochemistry.* 7th ed. New York: W.H. Freeman.

SOLOMON, E., MARTIN, C., MARTIN, D., BERG, L. (2018) *Biology.* 11th ed. Boston, MA: Cengage Learning Inc.

STRYER, L., BERG, J.M., TYMOCZKO, J.L. (2002) *Biochemistry.* 5th ed. New York: W.H. Freeman.

VOET, J.G., PRATT, C.W., VOET, D. (2012) *Principles of Biochemistry.* 4th ed. Hoboken, NJ: John Wiley & Sons, Inc.

Web

biochemden.com	Biochemistry Den (General reference)
biochemweb.net	BioChemWeb.net (General reference)
biology-pages.info	Kimball’s Biology Pages Fundamentals of Biochemistry (General reference)
khanacademy.org	Khan Academy Amino acids, proteins and enzymes (General reference)
metacyc.org	MetaCyc Metabolic pathways and regulation (General reference)

Links

This unit links to the following related units:

Unit 1: Fundamentals of Laboratory Techniques

Unit 2: Scientific Data Handling Approaches and Techniques

Unit 4: Cell Biology

Unit 5: Fundamentals of Chemistry

Unit 6: Anatomy and Human Physiology

Unit 8: Organic Chemistry

Unit 13: Human Health and Nutrition

Unit 16: Polymer Manufacturing Techniques

Unit code	**M/617/5373**
Unit level	**4**
Credit value	**15**

Introduction

Polymers, that is to say plastics and rubbers, possess an ability to be shaped economically, even when complex shapes are required. This relative ease of production, where products can be manufactured in a single process, can mitigate the sometimes several-staged operation necessary in more conventional materials such as metals or ceramics.

There are additional economic and environmental advantages, particularly when one considers the temperature range within which polymers can be processed, generally far lower than their more traditional counterparts. Lower processing temperatures lead to less energy usage, and so lower emissions and associated carbon footprint. Moreover, there are a number of polymer processes available to the manufacturer, so offering a greater choice when seeking a best fit to requirements.

This unit sets out to describe, in general terms, the steps involved in transforming the raw material into the required shaped by considering a number of factors, both physical and economical. A more detailed approach will then be taken to describe the two main processes used in the polymer manufacturing industry before the other commonly utilised processes are then explored.

Following this unit, the student be informed of the range and scope of major processing techniques. They will also be informed of other issues surrounding processing, so giving them the tools to be aware of, and make decisions about, the processes best suited for an application. They will also be cognisant as to why a particular process is chosen for a product.

Learning Outcomes

By the end of this unit, students will be able to:

1 Identify the principles of processing that determine the choice of polymer for a particular product

2 Investigate extrusion and extrusion-related processes

3 Investigate the injection moulding process and injection-related moulding techniques

4 Identify other key polymer processing techniques available to the manufacturer.

Essential content

LO1 **Identify the principles of processing that determine the choice of polymer for a particular product**

Overview of material influences:

Thermoplastics: form of raw material (powder; granules; beads); heating/temperature requirements; shaping; cooling

Thermosets: Form of raw material; pre-polymer (linear or branched molecules); heating/temperature; shaping; additional heating; fixing shape (chemical reaction; 3D network; crosslinking/curing/permanent set)

Rubbers: recipe/formulation; sequential addition; mastication; heating/temperature; shaping; additional heating; fixing shape.

Factors influencing choice of process:

Consider for example: shape of the product; numbers required; consider capital costs for tooling, e.g. moulds or dies; physical form of the raw material.

Basic introductory overview of important processes:

Consider for example: injection moulding; extrusion; compression moulding; blow moulding; thermo (vacuum) forming.

Basic introduction of specific processes for liquid polymers:

Consider long and short fibre processes, for example; hand lay-up; spray-up; pultrusion; filament winding; resin transfer moulding; SMC/DMC Moulding; subsidiary processes.

Overview of other operations within the manufacturing process:

Material handling and storage

Materials feeding to the processing machine

Control of the machine

Product removal; robotics

Finishing operations, potentially including, removal of flash; printing; painting; foiling; machining; assembly

Assembly: welding; adhesion; snap-fit.

LO2 **Investigate the extrusion and extrusion-related processes**

Construction of the extruder and ancillary equipment:

Hopper (use of agitator or conveyor); barrel; motor and gearing; heaters (heating zones); archimedean screw; breaker plate; screen pack; die; control unit; haul off; in-line testing.

Function of the extruder:

Screw, including consideration of; feeding; conveying; fusion; homogenisation; and the behaviour of the polymer melt in terms of; flow; viscoelasticity

Purpose of: flights; land length; pitch/helix angle

Die shaping including die types and configurations and effect on the melt, e.g. die swell

Consideration of haul off system, including; function; speed; support; conveyance medium; automatic monitoring; testing; cooling (rate – effects on e.g. crystallinity, shrinkage, and medium e.g. water, air) and solidification

Post manufacture considerations: product cutting/reeling; coding; quality tests; packaging; storage; dispatch.

Overview of specialist applications of extrusion:

Co-extrusion, including: co-axial dies; tapered machines; compound machines; cascading extrusion; cable/wire coating.

Extrusion blow moulding:

Extrusion blown film line, including: Downstream components e.g. die, collapsing rolls; bubble inflation; freeze line

Extrusion blow moulding: including parison formation and mould.

LO3 **Investigate the injection moulding process and injection-related moulding techniques**

Elements to consider in the injection moulding process:

Part design; mould design; mould fabrication; selection of correct machine and process settings; post mould operations; assembly

Thermal considerations, including; understanding of heat exchange; temperature; thermal conductivity; mechanical considerations

Considerations for thermoset materials, include; moulding process; mould; flow; shrinkage; test for cure.

Injection Moulding process and equipment:

Process entails; plasticising; moulding

Equipment includes; hopper; cylinder/barrel; reciprocating screw; heating system; drive motor

Mould considerations, include; gating system; heating system; ejector system

Examples of other injection-based moulding:

Injection blow moulding: consider machine set-up; mould stages; preform production; injection-blowing-ejection cycle; typical products

Gas assist: consider elements including; advantages; typical materials utilised; typical products

Consider method of operation, including: internal and external gas injection; full shot; short shot; moving core

Resin transfer: consider materials used, typical products and methods of operation, including: process elements; catalyst; resin; pump; mixing head; mould; fibre pack

RAM injection: consider advantages and typical applications. elements of process including: injection chamber; RAM operation; torpedo.

LO4 **Identify other key polymer processing techniques available to the manufacturer.**

Vacuum forming also known as thermoforming:

Consider elements, including; form of material to be moulded; typical materials utilised; material selection limitations

Process steps, including; clamping; heating; forming; pressure; vacuum; removal; trimming; finishing

Mould considerations and impact on moulding outcome and number; male; female; mould material.

Compression moulding:

Configuration, including, for example; up-stroke; down-stroke; horizontal platens (fixed, moving); daylight (single, multiple).

Rotational moulding:

Consider issues including; raw material form; machine configuration for example; mould chambers; heaters; loading/unloading bay; drive motor.

3D printing:

Consider, for example; typical materials; techniques utilised; design; cycle time.

Fibre reinforced moulding:

Consider techniques for example; hand lay-up; spray-up; pultrusion; filament winding; SMC/DMC moulding

Consider: equipment; processes; raw materials.

Learning Outcomes and Assessment Criteria

Pass	Merit	Distinction
LO1 Identify the principles of processing that determine the choice of polymer for a particular product		
P1 Identify the considerations involved in selecting the best processing methods for a given range of polymers **P2** Show how product shape can greatly influence the choice of manufacturing process.	**M1** Illustrate how product size, and numbers required, can make one manufacturing technique more economical than another	**D1** Recommend the best suited production method for a given product, noting the steps taken on making this decision, and outline the journey made through the process from raw material to finished product
LO2 Investigate the extrusion and extrusion-related processes		**LO2 and LO3** **D2** Compare the main factors relating to the processing of blown products, that is, products that have been processed via a blown film line, extrusion blow moulded or injection blow moulded
P3 Describe the journey a given polymer takes when travelling through an extruder **P4** Identify the issues to be considered when selecting the correct die for a given application	**M2** Analyse the various screw and extruder configurations available and suggest where they may be applied in a manufacturing context	
LO3 Investigate the injection moulding process and injection-related moulding techniques		
P5 Identify the considerations made when injection moulding a given thermoset material **P6** Review a set number of the injection moulding processes available and suggest typical products for each	**M3** Assess the reasons an injection moulding process is selected for a given application, and show how the polymer material behaves when transported through the system	

Pass	Merit	Distinction
LO4 Identify other key polymer processing techniques available to the manufacturer		**D3** Differentiate between the various methods of manufacture for reinforced polymers and suggest a typical product resulting from each technique
P7 Identify the advantages and disadvantages of utilising the vacuum forming process over other moulding techniques **P8** Explain how the rotational moulding process operates from raw material to finished product	**M4** Describe the steps taken when producing a product through the compression moulding process and show how these steps may require adjustment depending on whether the raw material is a thermoset or rubber	

Recommended resources

Textbooks

BAIRD, D.G., COLLIAS, D.I. (2014) *Polymer Processing: Principles and Design*. 2nd ed. Hoboken, NJ: Wiley-Blackwell.

MORTON-JONES, D.H. (2013) *Polymer Processing*. New York: Chapman and Hall.
STRONG, A.B. (2005) *Plastics: Materials and Processing*. 3rd ed. Harlow: Pearson Education Ltd.

Web

bpf.co.uk	The British Plastics Federation (General reference)
hardiepolymers.com	Hardie Polymers Knowledge: Polymer Manufacturing Processes (General reference)

Links

This unit links to the following related units:

Unit 12: Managing Environmental Resources

Unit 15: Introduction to Polymer Materials and Properties

Unit 20: Introduction to Material Properties and Applications

Unit 42: Materials Life Cycle and the Circular Economy

Unit 17: Fundamentals of Biochemistry

Unit code	**T/617/5374**
Unit level	**4**
Credit value	**15**

Introduction

Biochemistry is the study of chemical substances and vital processes that occur in living organisms. It involves the study of the structure and function of cellular components, such as proteins, carbohydrates, lipids, nucleic acids, and other biomolecules, and of their functions and transformations during life processes. Its main objective is to understand how biomolecules relate to a particular process within a living cell. This unit serves as an introduction to the fundamentals of biochemistry with emphasis on the structure of biomolecules in the cell.

This unit will introduce students to the biochemical building block molecules amino acids, monosaccharides, nucleotides and fatty acids. The unit will also give the student an opportunity to develop an appreciation and understanding of how the structure of macromolecules are determined by the chemical structure and functional group chemistry of the building block molecules.

The unit will introduce students to the structure, catalytic function and properties of enzymes. The different classes of enzymes shall be explored. The unit will also introduce students to processes and biomolecules involved in cellular respiration. The students will be introduced to the role of enzymes and electron carriers in the respiration process.

Learning Outcomes

By the end of this unit, students will be able to:

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

2 Explain the structures of biological macromolecules

3 Explain the structure, catalytic function and characteristic of enzymes

4 Outline the stages involved in cellular respiration.

Essential content

LO1 **Describe the chemical principles that apply to the structures of biological building block molecules**

Functional group chemistry and properties of amino acids, monosaccharides, nucleotides and fatty acids:

Structure of an amino acid

Classes of amino acid side chains, including: polar, nonpolar, acidic and basic amino acid side chains

D and L classification of amino acids

Isoelectric points

Chemical structure of monosaccharides, to include aldoses and ketoses

Cyclic structure of aldoses and ketoses

Structure of the nucleotide, including: the phosphate group, ribose/deoxyribose and the nitrogenous base

The purines and pyrimidines

The difference between nucleotides and nucleosides

Fatty acid structure

Saturated and unsaturated fatty acids

Cis and trans fatty acids and melting points.

Tests to identify classes of amino acids, monosaccharides and fatty acids:

Perform a number of tests to identify amino acids: The ninhydrin reaction to identify proline, containing amides (NH_2) in their side chains, containing benzene rings, containing thiol groups

Benedict's test for reducing sugars

Test for non-reducing sugars to determine if fructose is present

Emulsion test for lipids.

LO2 **Explain the structures of biological macromolecules**

How the biological building block molecules are joined together to form macromolecules:

Condensation reactions

The formation of the peptide bond

The formation of the glycosidic linkage

The formation of the phosphodiester linkage

The ester linkage of fatty acids to glycerol

The formation of phospholipid bilayers and membrane bilayers from lipids and proteins

How hydrolases use water to cleave chemical bonds.

The major features of proteins, polysaccharides, nucleic acids and fats:

How secondary structures of proteins are determined by hydrogen bonding

The bonds and attractions that determine the tertiary structure of proteins

Quaternary structure of proteins

The difference between a globular and fibrous protein

Difference between α and β glycosidic linkages

The difference in structure between glycogen, starch and cellulose

The structure of DNA and RNA

The structure of neutral lipids.

LO3 Explain the structure, catalytic function and characteristic of enzymes

The structure, catalytic function and characteristic properties of enzymes:

How enzymes act as catalysts

Role of amino acid side chains in active sites

Induced fit model of enzyme substrate formation

Classes of enzymes based on the reactions they catalyse

How enzymes are organised into pathways

Feedback inhibition

How phosphorylation can inhibit the activity of an enzyme

Allosteric enzymes.

Determine experimentally the optimum pH and temperature of an enzyme:

Conduct experiments to determine the optimum pH and Temperature for an enzyme.

LO4 Outline the stages involved in cellular respiration

Glycolysis:

Energy investment phase

Energy yielding phase

Glucose, glyceraldehyde 3 phosphate, pyruvate.

Acetyl coenzyme A, the citric acid cycle and the electron transport chain.

The formation of acetyl coenzyme A

The citric acid cycle: oxaloacetate, acetyl coenzyme A, citric acid, α-ketoglutarate

The role of NADH and $FADH_2$

Transfer of Electrons from NADH and $FADH_2$ resulting in the formation of ATP.

Learning Outcomes and Assessment Criteria

<table>
<tr><th>Pass</th><th>Merit</th><th>Distinction</th></tr>
<tr><td colspan="2">LO1 Describe the chemical principles that apply to the structures of biological building block molecules</td><td rowspan="5">LO1 and LO2

D1 Analyse the importance of functional group chemistry and chemical attraction in determining the structure and properties of proteins, polysaccharides and membrane bilayers</td></tr>
<tr><td>P1 Describe the functional group chemistry and properties of amino acids, monosaccharides, nucleotides and fatty acids

P2 Carry out a series of tests to identify classes of amino acids, monosaccharides and fatty acids</td><td>M1 Explain the role of the glycosidic OH group in the formation of monosaccharide cyclic structures and disaccharide α and β glycosidic links</td></tr>
<tr><td colspan="2">LO2 Explain the structures of biological macromolecules</td></tr>
<tr><td>P3 Explain how biological building block molecules are joined together to form proteins, polysaccharides and phospholipid bilayers

P4 Describe the main structural features of proteins, polysaccharides, nucleic acids and fats</td><td>M2 Analyse how enzymes in the digestive system breakdown biological macromolecules to their biological building block molecules</td></tr>
</table>

<table>
<tr><th>Pass</th><th>Merit</th><th>Distinction</th></tr>
<tr><td colspan="2">LO3 Explain the structure, catalytic function and characteristics of enzymes</td><td rowspan="4">LO3 and LO4

D2 Analyse the enzymes involved in cellular respiration, the reactions that they catalyse and the optimum conditions for their use and identify the key stages where ATP is produced and required</td></tr>
<tr><td>P5 Explain the structure, catalytic function and characteristic properties of enzymes

P6 Determine experimentally the optimum pH and temperature of an enzyme</td><td>M3 Explain how enzymes combine their functions to form metabolic pathways and the methods they use to inhibit those pathways</td></tr>
<tr><td colspan="2">LO4 Outline the stages involved in cellular respiration</td></tr>
<tr><td>P7 Describe the process of glycolysis

P8 Explain the creation of acetyl coenzyme A, the events of the citric acid cycle and the events of the electron transport chain</td><td>M4 Describe where the net yield of ATP, which results for each molecule of glucose that enters glycolysis, is derived from in the cellular respiration process</td></tr>
</table>

Recommended resources

Textbooks

DEVLIN, T.M. (2019) *Textbook of Biochemistry with Clinical Correlations.* 8th ed. Hoboken, NJ: John Wiley & Sons, Inc.

MATHEWS, C.K., VAN HOLDE, K.E., APPLING, D.R., ANTHONY-CAHILL, S.J. (2012) *Biochemistry.* 4th ed. New York: Pearson Education Ltd.

NELSON, D.L., COX, M.M. (2017) *Lehninger Principles of Biochemistry.* 7th ed. New York: W.H. Freeman.

SOLOMON, E., MARTIN, C., MARTIN, D., BERG, L. (2018) *Biology.* 11th ed. Boston, MA: Cengage Learning Inc.

STRYER, L., BERG, J.M., TYMOCZKO, J.L. (2002) *Biochemistry.* 5th ed. New York: W.H. Freeman.

VOET, J.G., PRATT, C.W., VOET, D. (2012) *Principles of Biochemistry.* 4th ed. Hoboken, NJ: John Wiley & Sons, Inc.

Web

biochemden.com	Biochemistry Den (General reference)
biochemweb.net	BioChemWeb.net (General reference)
biology-pages.info	Kimball's Biology Pages Fundamentals of Biochemistry (General reference)
khanacademy.org	Khan Academy Amino acids, proteins and enzymes (General reference)
metacyc.org	MetaCyc Metabolic pathways and regulation (General reference)

Links

This unit links to the following related units:

Unit 1: Fundamentals of Laboratory Techniques

Unit 2: Scientific Data Handling Approaches and Techniques

Unit 4: Cell Biology

Unit 5: Fundamentals of Chemistry

Unit 6: Anatomy and Human Physiology

Unit 8: Organic Chemistry

Unit 13: Human Health and Nutrition

Unit 18: Microbiological Techniques

Unit code	A/617/5375
Unit level	**4**
Credit value	**15**

Introduction

Microbiology is the study of microscopic organisms that are too small to see with the naked eye and includes bacteria, fungi, protozoa and viruses. Microbiological techniques are methods used for the study of microbes and they include techniques in how to culture, stain, identify, engineer and manipulate microbes. Despite the negative effect microbes can have on human health they also play an important role in our lives.

This unit introduces students to the diverse world of microorganisms, including bacteria, viruses, fungi and protozoa. It examines the cell biology of microorganisms and looks at the specialised structures of different groups of microorganisms.

This unit will also examine methods for collection of microbial specimens from patients, Students will use a range of aseptic techniques to culture and grow a variety of microorganisms, and be able to understand their requirements for growth as well as use a range of biochemical tests to identify gram-positive and gram-negative bacteria.

Factors that affect the growth of microorganisms will be investigated, using a range of measurement techniques, and will be contextualised so that students understand how these can be manipulated within industry to ensure optimum yield.

The economic importance of bacteria will be explored, and students will gain an insight into how the metabolism of some microorganisms can be utilised for the benefit of humans.

Learning Outcomes

By the end of this unit, students will be able to:

1 Identify the molecular structures and functions found in different microorganisms

2 Carry out aseptic techniques to culture a range of microorganisms, and use biochemical tests to identify different bacterial species

3 Explore the factors that affect the growth of microorganisms

4 Evaluate the economic importance of bacteria.

Essential content

LO1 **Identify the molecular structures and functions found in different microorganisms.**

Identification techniques:

Light microscopy (phase contrast, oil immersion) advantages and disadvantages

Electron microscopy (scanning, transmission) advantages and disadvantages

Atomic force microscopy, advantages and disadvantages

Scanning force microscopy, advantages and disadvantages

Prokaryotes:

Structure and function of the capsule, cell wall, cell membrane, nucleoid, ribosomes, pilus, mesosome, ribosomes, cilia and flagella

Structural similarities and differences between bacteria and archaea.

Akaryotes:

Structure and function of the capsid, viral genome, neck and collar, tail sheath, tail fibres, base plate and tail pins.

Single cell Eukaryotes:

Fungi: structure and function of the hyphae, mycelium, cell wall, nucleus, membrane bound organelles and spores

Protozoa: microscopic, unicellular, heterotrophic, intracellular and extracellular digestion.

LO2 Carry out aseptic techniques to culture a range of microorganisms, and use biochemical tests to identify different bacterial species

Methods for specimen collection:

Types of specimen: blood cultures, serology, eye, nose and throat swabs, respiratory samples, urine samples, wound swabs, skin samples and biopsies.

Specimen collection, handling and transportation standard operating procedures (SOPs)

Bacterial hazard groups

Factors affecting results: collection to test time, temperature, sample collection time, appropriate sample and appropriate sample container.

Aseptic techniques:

Preparation of sterile agar; sterilisation techniques; pouring a plate; inoculation of agar plates and broths; pour plates; streak plates; lawn plates; growth on selective media; safe disposal methods.

Simple staining; gram staining.

Biochemical tests:

Identification of gram-positive bacteria: catalase test, mannitol salt agar, blood agar plates, nitrate broth, motility agar and starch hydrolysis test.

Identification of gram-negative bacteria: oxidase test; sugar broth with Durham tubes; nitrate broth; motility agar; MacConkey agar; Urease test.

LO3 **Explore the factors that affect the growth of microorganisms.**

Growth factors:

Temperature; pH; nutrients; moisture; aerobic and anaerobic conditions; osmotic pressure; chemical requirements; culture media

Methods and phases of microbial growth.

Measurement Techniques:

Direct methods: plate count; haemocytometer counts; viral plaque counts; serial dilutions; filtration; most probable number; direct microscopic counts

Indirect methods: turbidity; metabolic activity and dry weight.

Context:

Fermentation; dairy.

LO4 **Evaluate the economic importance of bacteria.**

Food processing

Biotechnology

Genetic engineering

Fibre retting

Digestion

Pest control

Medical applications.

Learning Outcomes and Assessment Criteria

Pass	Merit	Distinction
LO1 Identify the molecular structures and functions found in different microorganisms		
P1 State the advantages and disadvantages of the microscopy techniques used to identify microorganisms **P2** Identify the main structures found in prokaryotic, eukaryotic and akaryotic cells, using the light microscope and electron micrographs	**M1** Describe the function of prokaryotic and eukaryotic cell structures	**D1** Compare and contrast the structures found in prokaryotes and eukaryotes and relate their structures to their functions
LO2 Carry out aseptic techniques to culture a range of microorganisms and use biochemical tests to identify different bacterial species		
P3 Describe the methods used for specimen collection **P4** Carry out aseptic techniques safely to cultivate microorganisms and use staining techniques to identify bacteria	**M2** Explain the principles behind each aseptic technique used	**D2** Evaluate the effectiveness of the different biochemical techniques used to identify different bacterial species

Pass	Merit	Distinction
LO3 Explore the factors that affect the growth of microorganisms		**D3** Justify how the results obtained could be used to increase yields in the fermentation or dairy industry
P5 Carry out techniques to cultivate microorganisms under varying growth conditions **P6** Undertake a range of techniques to measure the growth of microorganisms	**M3** Calculate and compare the growth rates of microorganisms under varying conditions	
LO4 Evaluate the economic importance of bacteria.		**D4** Review the effectiveness of bacteria in biotechnology and genetic engineering
P7 Identify bacteria that have economic importance to humans **P8** Explain why bacteria are used in a range of Industries	**M4** Illustrate how bacteria can be used for medical benefits	

Recommended resources

Textbooks

BARER, M., IRVING, W. (2018) *Medical Microbiology*. 19th ed. Amsterdam: Elsevier.

FUNKE, B.R., TORTORA, G.J., CASE, C.L., WEBBER, D., BAIR, W. (2018) *Microbiology: An Introduction*. 13th ed. Harlow: Pearson.

KRIEG, N.R., PELCZAR, M.J., CHAN, E.C.S. (2010) *Microbiology (An Application Based Approach)*. New Delhi: Tata McGraw Hill Education Private Ltd.

MADIGAN, M.T., BENDER, K.S., BUCKLEY, D.H., SATTLEY, W.M., STAHL, D.A. (2018) *Brock Biology of Microorganisms.* 15th ed. New York: Pearson Education Ltd.

PANDEY, A., NEGI, S., SOCCOL, C.R. (2016) *Current Developments in Biotechnology and Bioengineering: Production, Isolation, Purification of Industrial Products.* Amsterdam: Elsevier.

SLONCZEWSKI, J.L., FOSTER, J.W. (2017) *Microbiology: An Evolving Science.* 4th ed. New York: W.W. Norton and Company.

WOOLVERTON, C.J., WILLEY, J., SHERWOOD, L. (2017) *Prescott's Microbiology.* 10th ed. New York: McGraw Hill Education.

Web

Microbes.info	Microbiology Information Portal General, environmental, food, industrial and medical microbiology (General reference)
Microbiologyonline.org	Microbiology Online Microbes and basic principles: safety information and practical advice (General reference)
Microbiologysociety.org	Microbiology Society Current research and information (General reference)

Links

This unit links to the following related units:

Unit 4: Cell Biology

Unit 53: Industrial Microbiology

Unit 19: Managing Food Preparation and Production Systems

Unit code	**F/617/5376**
Unit level	**4**
Credit value	**15**

Introduction

Food production is the process whereby raw ingredients are transformed into prepared food products with longer shelf lives. Fruits, vegetables, grains, meat and fish are processed into the types of food products that are available for sale in supermarkets or served in restaurants. The level of food processing involved may vary from minimal, such as cleaning and packaging, to complicated, involving a considerable amount of additives and ingredients.

The aim of this unit is to enable students to examine different approaches and methods applied to food production, planning, preparation and management in a professional kitchen environment and in factory production. Students will also acquire a basic knowledge of the important factors associated with food processing and food quality assurance.

The unit focuses on enabling head and executive chefs, as well as kitchen and plant managers, to ensure that teams, management structure, resources and knowledge are in place in the correct balance to ensure that cost effective, profitable, efficient and safe preparation and production of food is achieved, according to the organisation's style and business targets.

Learning Outcomes

By the end of this unit, students will be able to:

1 Explain the different types of, and influences on, the design of food preparation and production systems

2 Identify the key principles and methods for planning food preparation and production

3 Explain the resources required to deliver a consistent, safe and timely food production operation

4 Describe a variety of methods to monitor food production, identify variances and action to be taken to ensure a safe and efficient operation.

Essential content

LO1 **Explain the different types of, and influences on, the design of food preparation and production systems**

Different types of food preparation and production systems:

Definition of food systems and the factors that influence the different types of food preparation and production systems, e.g: assembly line, production kitchens, centralised, section, galley kitchens

The advantages and disadvantages of the different food preparation and production systems.

Influences on food production system design:

The factors that influence the production systems, e.g. the type of cuisine offered, seasonal availability of foodstuff, culinary trends

The design and layout of the kitchen: purpose of the kitchen, size and style, ergonomics, ventilation, utilities and equipment

The design of a food processing plant: location, building structure, LEED (Leadership in Energy and Environmental Design) requirements/certification

The layout of a food processing plant based on: product (site selection, materials, equipment); product mix (sanitation, packaging, hygienic zones, separation of lines, welfare areas); production volume (redundancy, multiple operation lines, design for peak demand)

Efficiencies, e.g. efficient and safe work flow, energy efficiency

Regulations and legislative requirements: food safety, hygiene and Health and Safety, maintenance and cleaning

Receiving stock and storage requirements

Cost considerations.

LO2 **Identify the key principles and methods for planning food preparation and production**

Key principles:

The processes for procurement of food ingredients and commodities, including purchasing specifications and appropriate suppliers

How to prepare menus, recipes and standardised systems and operating procedures (SOPs) to ensure consistency and quality of food

How to establish protocols for cross-contamination to prevent allergies, cleaning, pest control, chemical control, use and storage of utensils, personal protective equipment use, food holding and storage, food handling, supplier delivery and storage.

Planning methods:

Importance of collating information about customer requirements experience

Training needs of staff to plan menus according to the equipment and facilities available

Accounting for the sources of produce aligned to menu planning

Sourcing produce at a price that allows optimum profit margins

Cost efficiencies that involve calculating the sales mix and the balance of price and offers

Calculating profit margin ratios in accordance with organisational policy and return on investment (ROI)

The use of training plans to maximise staff productivity and performance to deliver quality food to consistent brand standards

Allocation of people and resources to required tasks according to the style of service and the menu

Appropriate team structure in the different food preparation and production systems

The importance of contingency plans.

LO3 **Explain the resources required to deliver a consistent, safe and timely food production operation**

Key roles and responsibilities for the effective management of the kitchen and food production systems:

Managing different resources: human, financial and physical.

Human:

Training and development of kitchen and production team members

Delivering consistent and timely food production operations

Maintaining kitchen equipment on an on-going basis

Managing food safety systems in accordance with current legislative requirements

The importance of scheduling and implementing monitoring, staff training, maintenance or repair work in ways which minimise disruption to customers.

Financial:

Cost/benefit considerations towards meeting the needs and expectations of the customer and business

Cost necessary to adhere to brand standards, where appropriate

Budget planning, and control of food production and resources

Using key performance indicators (KPI) to establish how effectively key business objectives are achieved.

Physical:

The effective management of kitchen equipment and resources, in line with legislative and operational requirements

The necessity for regular servicing and maintenance to have minimal impact on operations

Management of food safety systems to adhere to legislation.

LO4 **Describe a variety of methods to monitor food production, identify variances and action to be taken to ensure a safe and efficient operation**

Variety of monitoring methods:

How to carry out and record inspections, observations and equipment readings

Mechanisms for monitoring production yield, portion control and costs to achieve budgetary targets and business objectives

The monitoring of stock rotation and waste

Risk analysis and assessment for food safety

Food sampling techniques

Performance management methods to monitor and evaluate staff performance

Monitoring the implementation of improvement strategies to maximise productivity and profit

Health and safety procedures and compliance of regulations for working in a kitchen/food production line and using equipment

Food presentation to maintain standards and quality

The benefits of variance analysis to assist with managing budgets and budgetary control.

Learning Outcomes and Assessment Criteria

Pass	Merit	Distinction
LO1 Explain the different types of, and influences on, the design of food preparation and production systems		
P1 Explain a range of different types of food preparation and production systems **P2** Explore the influences on the design of a range of food preparation and production systems	**M1** Compare and contrast a range of food preparation and production systems and how they have been designed to meet different business and customer requirements	**D1** Evaluate how the seasonal availability and culinary trends affect the quantity and costing of food produced in food preparation and production systems
LO2 Identify the key principles and methods for planning food preparation and production		
P3 Explain the key underlying principles for planning food preparation and production **P4** Identify the key methods for planning food preparation and production	**M2** Explore the importance of collating information about customer requirements experience giving examples of how this information could be used for the benefit of the business	**D2** Compare specific examples of different approaches to planning food preparation and production to meet differing business requirements and ensure good return on investment (ROI)

Pass	Merit	Distinction
LO3 Explain the resources required to deliver a consistent, safe and timely food production operation		**D3** Develop standard operating procedures (SOPs) to ensure food production meets business key performance indicators (KPIs)
P5 Describe the resources required to deliver a consistent, safe and timely food production operation **P6** Outline the processes and procedures required to ensure resources are managed effectively and efficiently to meet overall customer and business needs	**M3** Review examples of standard operating procedures (SOPs) and specifications used to manage resources in line with key performance indicators (KPIs)	
LO4 Describe a variety of methods to monitor food production, identify variances and action to be taken to ensure a safe and efficient operation		**D4** Compare methods used to monitoring food production, their success in identifying potential variances and their impacts, and how these are dealt with
P7 Describe various methods used for the monitoring of food production **P8** Explain how variances in food production can be identified and dealt with to ensure a safe and efficient operation	**M4** Analyse the benefits of variance analysis in assisting with managing budgets and budgetary control	

Recommended resources

Textbooks

BALI, P.S. (2014) *Food Production Operations*. 2nd ed. New Delhi: Oxford University Press.

BESSELING, P., KALYANKAR, C., MONTES SAAVEDRA, E. (2015) *Hazard and Risk Analysis in Food Processing: New Approaches Towards HACCP and Food Safety*. 2nd ed. Scotts Valley, CA: CreateSpace Independent Publishing Platform.

CAMPBELL-PLATT, G. (2017) *Food Science and Technology*. 2nd ed. Hoboken, NJ: Wiley-Blackwell.

DRAZ, J., KOETKE, C. (2015) *The Culinary Professional*. 3rd ed. Tinley Park, IL: Goodheart-Wilcox.

FELLOWS, P. (2013) *The Complete Manual of Small-scale Food Processing*. Rugby: Practical Action Publishing.

FELLOWS, P.J. (2016) *Food Processing Technology: Principles and Practice*. 4th ed. Amsterdam: Elsevier/Woodhead Publishing.

FOSKETT, D., PASKINS, P., PENNINGTON, A., RIPPINGTON, N. (2016) *The Theory of Hospitality and Catering.* 13th ed. London: Hodder Education.

GALANAKIS, C. (Ed) (2019) *Saving Food: Production, Supply Chain, Food Waste and Food Consumption*. Cambridge, MA: Academic Press (Elsevier).

HAYES, D., MILLER, A., NINEMEIER, J.D. (2011) *The Professional Kitchen Manager.* Harlow: Pearson Education Ltd.

LABENSKY, S.R., HAUSE, A.M., MARTEL, P.A. (2018) *On Cooking: A Textbook of Culinary Fundamentals*. 6th ed. Harlow: Pearson Education Ltd.

THOMAS, C., NORMAN, J.N., KATSIGRIS, C. (2014) *Design and Equipment for Restaurants and Food Service: A Management View.* Hoboken, NJ: John Wiley & Sons, Inc.

WINCH, T. (2007) *Growing Food: A Guide to Food Production*. Dordrecht: Springer.

Web

foodanddrinktechnology.com	Food and Drink Technology News and articles (General reference)
food.gov.uk	Food Standards Agency Business and Industry (General reference)
foodmanagement.today	Food Management Today News and articles (General reference)
foodprocessing.com	Food Processing News and articles (General reference)

Links

This unit links to the following related units:

Unit 14: Food Technology

Unit 53: Industrial Microbiology

Unit 54: Materials in Contact with Food

Unit 20: Introduction to Material Properties and Applications

Unit code	**J/617/5377**
Unit level	**4**
Credit value	**15**

Introduction

Many industries are dependent on materials, and those working within this sector need an awareness of the materials available to them. The range is great and varied, and continually increasing as new and emerging technologies demand ever more sophisticated materials. Indeed, to retain a competitive edge, the constant development of materials and their potential to be adapted, is key. So for a range of sectors, including industry, textiles, consumer goods and many other types of manufacturing, materials play a fundamental role.

For a given product to achieve its desired potential and to work effectively, it is important to select an appropriate material for its manufacture. In order to ascertain the most appropriate material, it is first necessary to understand the requirements of the product and the conditions under which it will operate. By acknowledging these desired properties, it is then possible to select the material best suited for the product.

Increasingly it is common to find that an array of several material types is necessary for even the simplest application or product. A good knowledge of how these materials behave, both independently and in conjunction with each other, and an awareness of how properties can be altered by treatments, processing or additives, is of prime importance to ensure the product is fit for purpose.

This unit will provide students with the necessary background knowledge to identify material types and develop an awareness of the range and potential capabilities of materials at their disposal. Students will be introduced to the structure of differing material groups and how this affects the properties, physical nature and performance characteristics of common materials in various applications. How properties can be modified will also be addressed, as will the advances in material technology that bring new capabilities to industry.

Note regarding delivery of this unit: This unit has been designed to consider the use of materials across a range of sectors, including, but not limited to, manufacturing, food and drink, technology and textile industries. The Essential Content section has been designed intentionally to be broad; however, it is for individual Centres to focus on the relevant material types for a particular manufacturing sector. The use of e.g. within the Essential Content allows for Centres to select and focus on particular areas of delivery.

Learning Outcomes

By the end of this unit, students will be able to:

1. Define the properties necessary for a given product to function as required under its intended service conditions
2. Describe the properties of a material and show how these are affected by its structure
3. Determine the material most suited for a given application
4. Describe the methods by which a material can be modified to enhance its use for a particular application.

Essential content

LO1 **Define the properties necessary for a given product to function as required under its intended service conditions**

Define the needs of the product in terms of properties:

Mechanical

Chemical

Electrical

Thermal

Magnetic

Optical and aesthetic

Colourfastness

Dye acceptance

Comfort

Value for money

Recyclability.

Define the properties in terms of their characteristics:

Hardness

Toughness

Ductility

Conductivity

Durability

Resistance to stains

Resistance to environmental factors

Insulating capability

Flammability

Resistance to fatigue or corrosion.

LO2 Describe the properties of a material and show how these are affected by its structure

Material categories, e.g.:

Polymers: commodity plastics, engineering plastics, elastomers, bioplastics

Metals: ferrous, non-ferrous, alloys

Ceramics: glass, traditional, advanced

Composites: long and short glass-reinforced polymers, carbon-reinforced polymers, reinforced ceramics, nano-reinforcement

Natural materials: wool, cotton, hemp, coir, silk

Emerging specialist materials: aerogels, shape-memory alloys, superhydrophilic materials, self-healing materials, multi-functional materials, biomaterials.

Material structure:

Polymers: thermoplastic, thermoset, amorphous, crystalline

Metals: crystalline structures – body-centred and face-centred cubic lattice and hexagonal close-packed structures; characteristics and function of ferrous metals; non-ferrous phase diagrams

Ceramics: molecular structure – electrostatic covalent and ionic bonding

Composites: matrix and reinforcement forms

Textiles: yarn structure – distribution of fibres within the yarn, quantity of fibres within the cross section, orientation and position of fibres, fibre length, degree of twist.

LO3 **Determine the material most suited for a given application**

General factors to be considered:

Functional demands of product design

Compatibility of multiple material components in a given application, under a range of expected conditions

Recyclability of the product, particularly where multiple component parts are required.

Categorisation of materials by their properties:

Physical, e.g.: thermal, optical, magnetic, electrical, handling

Mechanical and surface/environmental, e.g.: resistance to oxidation and/or corrosion, durability, resistance to damage, resistance to stains, resistance to shrinkage

Aesthetic and sensory, e.g.: colour, comfort, feel, ease of handling, fragility.

The effect of secondary processes or treatments on material properties, e.g.:

Heat treatment and mechanical processes

Surface modifications, such as painting and electroplating.

Service life of the product and the conditions under which it will operate, e.g.:

Durability of materials; resilience to change of temperature, moisture etc

Repairability versus obsolescence; possibility of replacing parts.

Economic factors in selection, e.g.:

Forms of supply

Cost and availability

Viability of producing the quantities required.

Impact of environmental concerns, public perception and government policy/legislation on material selection, e.g.:

Procurement from sustainable sources, e.g. rainforest-friendly, fair trade; best practice in mining and raw material manufacture; carbon footprint of raw material manufacture; proposed legislation on ecocide

Packaging and whether biodegradable, recyclable or reusable

Relevant regulations on safety of products.

LO4 **Describe the methods by which a material can be modified to enhance its use for a particular application**

Options available to enhance specific properties, e.g.:

mechanical manipulation

processing adaptations

heat treatments

weaving techniques.

Additive inclusion, e.g.:

particulate fillers

reinforcements (nano-particles to long fibres)

antioxidants

antiozonates.

Learning Outcomes and Assessment Criteria

Pass	Merit	Distinction
LO1 Define the properties necessary for a given product to function as required under its intended service conditions		**D1** Evaluate any potential limitations binding this product in terms of e.g. quantities required and environmental considerations
P1 Describe the features of a relevant product in terms of its function and/or service requirements	**M1** Analyse the functions, defined in engineering terms, required for a given product when in service	
LO2 Describe the properties of a material and show how these are affected by its structure		**D2** Evaluate why the behaviour of a material is considered such an important factor when selecting a material for a given product or application
P2 Explain the properties of a given material set and show how structure influences these properties	**M2** Investigate emerging materials and suggest ways these may enhance the range of materials on offer	

Pass	Merit	Distinction
LO3 Determine the material most suited for a given application		**D3** Evaluate how government policy/legislation, public opinion and environmental factors influence the selection of a material for an application
P3 Explain the properties that make a material suitable for a given product **P4** Explore how the material(s) of choice would be expected to behave in service	**M3** Analyse the considerations required when selecting a material for a given application, particularly in terms of compatibility with e.g. adjoining materials, the user, secondary treatments or processes	
LO4 Describe the methods by which a material can be modified to enhance its use for a particular application.		**D4** Evaluate material modification through the incorporation of secondary phases or using other manufacturing manipulations
P5 Explain how a particular material can be modified to enhance its behaviour to achieve a specified change in the performance of that material	**M4** Investigate the advantages of modifying a material over simply selecting another material	

Recommended resources

Textbooks

BRYANT, R., BRYANT, S. (Eds). (2019) *Blackstone's Handbook for Policing Students*. 13th ed. Oxford: Oxford University Press.

HANNIBAL, M. (2002) *The Law of Criminal and Civil Evidence*. Harlow: Pearson Education Ltd/Longman.

LANGFORD, A.M., DEAN, J.R., HOLMES, D., REED, R., WEYERS, J., JONES, A. (2019) *Practical Skills in Forensic Science*. 3rd ed. Harlow: Pearson Education Ltd.

MILNE, R., BULL, R. (2008) *Investigative Interviewing: Psychology and Practice*. 2nd ed. Hoboken, NJ: Wiley-Blackwell.

SHEPHERD, E., GRIFFTHS, A. (2013) *Investigative Interviewing: The Conversation Management Approach*. 2nd ed. Oxford: Oxford University Press.

Web

college.police.uk	College of Policing APP – Investigation – Reference material (General reference)
college.police.uk	College of Policing Body-worn video guidance (Report)
college.police.uk	College of Policing Code of Ethics (Report)
college.police.uk	College of Policing Media relations (General reference)
global.oup.com/academic	Oxford University Press Academic Blackstone's Police Manuals Online: Sergeants to Inspectors revision (General reference – manual)
gov.uk/government/publications	UK Government Website – Publications Criminal Procedure and Investigations Act Code of Practice (Report – Code of Practice)

Links

This unit links to the following related units:

Unit 1: Fundamentals of Laboratory Techniques

Unit 5: Fundamentals of Chemistry

Unit 24: Sampling and Sample Preparation

Unit 34: Forensic Evidence Collection and Preservation

Unit 21: Criminal Investigation

Unit code	**L/617/5378**
Unit level	**4**
Credit value	**15**

Introduction

Criminal Investigations are fundamental to law enforcement. They may be carried out in relation to crimes that are known to have been committed, to identify whether a crime has actually been committed or not, and to ascertain if criminal proceedings need to be commenced. Investigations may also be carried out into crimes that the police believe may be committed, for example, when premises or individuals are kept under observation. Criminal Investigations can be either reactive or proactive.

This unit will provide students with an awareness of the principles of criminal investigation, managing criminal investigations, effective case management and the role of forensic science within this process. Students will examine principles, legislation and considerations relating to conducting investigations. They will research the key theories relating to conducting an investigation and handling evidence and exhibits, and consider principles of best practice. Students will research the legal system and explore the role of expert evidence in court.

On completion of the unit students will be better prepared to assist police in investigations in a role such as crime scene investigator.

Learning Outcomes

By the end of this unit students will be able to:

1 Investigate principles, processes and legislation related to criminal investigation

2 Analyse the requirements of effective scene management and professional forensic evidence gathering

3 Explain the process and purpose of disclosure

4 Describe the structure and workings of criminal courts and the role of expert evidence.

Essential content

LO1 **Investigate principles, processes and legislation related to criminal investigation**

Principles of investigation:

Proportionate, transparent, mindful of equality, safeguarding, ethical – College of Policing guidance

Types of criminal investigation: volume crime, acquisitive crime, serious crime, major incidents, crimes against the person, crimes against society, cyber crime

Safeguarding issues (child and adult)

Ethical considerations

Evidence: sufficient, relevant, circumstantial, admissibility, Police and Criminal Evidence Act (PACE) provisions, best evidence

National Decision Model

European Convention on Human Rights considerations, such as prohibition of discrimination, proportionality.

Process and best practice:

Reactive and proactive investigations

Stages of an investigation

Planning the investigation

Conducting an investigation

Other agencies involved in investigations, such as: Crown Prosecution Service, National Crime Agency (NCA), Security Services, Bank, National Ballistics Intelligence Service (NABIS)

The use and development of investigative hypotheses

Investigative strategies: search; house-to-house; intelligence; physical evidence; Automatic Number Plate Recognition (ANPR); trace, interview, eliminate (TIE); search warrants; press appeals; multi-agency working.

Investigative mind set:

Definition of an investigator

Knowledge and skills required

Using investigative evaluation and developing and testing case theory.

Legislation governing criminal investigation, e.g. in the UK:

Regulation of Investigatory Powers Act 2000

Criminal Procedure and Investigations Act 1996

Police and Criminal Evidence Act 1984.

LO2 **Analyse the requirements of effective scene management and professional forensic evidence gathering**

Scene preservation:

Cordons

Environmental factors, e.g.: weather

Control of the scene

Evidence handling

Documentation to be completed

Communication issues

Achieving Best Evidence (ABE)

Identifying suspects

Risk assessments

Crime scene technology.

Nature of investigation:

For example, in the UK: Professionalising Investigation Programme (PIP)

PIP1 – priority and volume crime investigations

PIP2 – serious and complex investigations.

Forensic considerations:

Specialist roles, e.g.: Crime Scene Investigators, Army Specialists, Fire Service

Cross contamination issues

Digital crime scene

Identifying crime scenes

Risk assessments

Storage, Replay and Disposal of Digital Evidential Images.

Evaluation of evidence:

Types of evidence

Use of digital evidence (CCTV, body worn cameras)

Digital evidence (computers)

Forensic evidence

Cross contamination

Storing and transporting exhibits

Reviewing information.

Intelligence and information:

Material, information, intelligence, evidence

Intelligence systems

Correct storage of information

Regulation of Investigatory Powers Act 2000.

LO3 **Explain the process and purpose of disclosure**

Prosecution disclosure, e.g. in the UK:

Criminal Procedure and Investigations Act 1996 (CPIA) – main statutory disclosure provisions

Other legislation and guidance: Police and Criminal Evidence Act 1984, Disclosure Manual 2005, Murder Investigation Manual 2006

The Prosecution Team Manual of Guidance (for the preparation, processing and submission of prosecution files); purpose of manual; forms.

Defence disclosure, e.g. in the UK:

Criminal Procedure and Investigations Act 1996 (CPIA) – statutory requirements

Defence statements: Crown Prosecution Service procedure, police actions and certification, further Crown Prosecution Service actions for additional revealed material

Notification of intention to call defence witnesses

Faults in defence compliance

Seeking inferences at trial.

LO4 **Describe the structure and workings of criminal courts and the role of expert evidence**

Magistrates Court:

Types of offence: summary, triable either way, indictable only

Magistrates, lay person

Legal advisor

Crown Prosecution Service

Other prosecuting agencies, e.g.: HMRC, Department for Work and Pensions

Defence solicitors

Sentencing

Examination-in-chief

Cross examination.

Crown court:

Indictable only offences

Triable either way offences

Seriousness of offences (class 1, 2 and 3)

Types of judge

Judicial independence and immunity

Jury

Sentencing.

Courts of Appeal:

Appeal court hierarchy

Right to appeal

Leave to appeal

Appeals process.

Trial process:

Charges read out

Plea taken

Prosecution case

Evidence: evidence-in-chief, cross-examination, re-examination

Defence case

Closing speeches.

Giving evidence:

Types of witness: witness of fact, expert witness

Definition of expert evidence

Duty of an expert witness: Criminal Procedure Rule 33

Criminal procedure rules: Rules and Practice Directions 2015

Streamlined Forensic Reporting (SFR)

Reports

Oral evidence

Examination-in-Chief

Cross-examination

Forensic Science Regulator guidance on legal obligations.

Learning Outcomes and Assessment Criteria

Pass	Merit	Distinction
LO1 Investigate principles, processes and legislation related to criminal investigation		**LO1 and LO2**
P1 Explain the principles, processes and best practice that guides police practice during any criminal investigation **P2** Identify the main purpose of legislation governing criminal investigation	**M1** Compare the impact of three pieces of legislative process or codes of practice on an investigation	**D1** Evaluate the role of forensic science in criminal investigations
LO2 Analyse the requirements of effective scene management and professional forensic evidence gathering		
P3 Explain how to secure the scene of different identified crime scenes **P4** Explain the types of evidence that might be gathered from different crime scenes and how it should be preserved and handled	**M2** Analyse the issues in securing different crime scenes, including how to collect, store and prevent cross-contamination of evidence	

Pass	Merit	Distinction
LO3 Explain the process and purpose of disclosure		**LO3 and LO4** **D2** Evaluate the legal obligations applying to expert witnesses acting in the criminal justice system, e.g. the Forensic Science Regulator guidance in England and Wales
P5 Explain the statutory disclosure provisions as set out in legislation, e.g. in the UK the Criminal Procedure and Investigations Act 1996	**M3** Analyse the effect disclosure has on cases at court	
LO4 Describe the structure and workings of criminal courts and the role of expert evidence.		
P6 Outline the types of criminal offence and the courts that deal with them **P7** Explain the process of a criminal trial	**M4** Analyse the role and purpose of an expert witness	

Recommended resources

Textbooks

BRYANT, R., BRYANT, S. (Eds). (2019) *Blackstone's Handbook for Policing Students*. 13th ed. Oxford: Oxford University Press.

HANNIBAL, M. (2002) *The Law of Criminal and Civil Evidence*. Harlow: Pearson Education Ltd/Longman.

LANGFORD, A.M., DEAN, J.R., HOLMES, D., REED, R., WEYERS, J., JONES, A. (2019) *Practical Skills in Forensic Science*. 3rd ed. Harlow: Pearson Education Ltd.

MILNE, R., BULL, R. (2008) *Investigative Interviewing: Psychology and Practice*. 2nd ed. Hoboken, NJ: Wiley-Blackwell.

SHEPHERD, E., GRIFFTHS, A. (2013) *Investigative Interviewing: The Conversation Management Approach*. 2nd ed. Oxford: Oxford University Press.

Web

college.police.uk	College of Policing APP – Investigation – Reference material (General reference)
college.police.uk	College of Policing Body-worn video guidance (Report)
college.police.uk	College of Policing Code of Ethics (Report)
college.police.uk	College of Policing Media relations (General reference)
global.oup.com	Oxford University Press Academic Blackstone's Police Manuals Online: Sergeants to Inspectors revision (General reference – manual)
gov.uk	UK Government Website – Publications Criminal Procedure and Investigations Act Code of Practice (Report – Code of Practice)

Links

This unit links to the following related units:

Unit 1: Fundamentals of Laboratory Techniques

Unit 5: Fundamentals of Chemistry

Unit 24: Sampling and Sample Preparation

Unit 34: Forensic Evidence Collection and Preservation

Unit 22: Theories and Causes of Crime

Unit code	**R/617/5379**
Unit level	**4**
Credit value	**15**

Introduction

There are many roles an individual can have when working in the criminal justice sector: frontline, support staff, directly with offenders, or behind the scenes. In all roles, it can be beneficial to have an appreciation of the theories that seek to explain offending behaviour.

This unit gives students the opportunity to study criminology, the theories around it and how it relates to police work. Students will be encouraged to apply the theories they have studied to policing situations. In particular, students will research different types of crime and apply theories to assess the possible reasons that lead to crimes being committed. Students will explore the effect that crime has on our communities, on individuals and on the wider society. They will investigate crime reporting and recording, public perception and public confidence, and the methods, strategies and initiatives police forces use to address crime and disorder.

On successful completion of this unit students seeking a career with the police or as forensic investigators will have an underpinning knowledge-base of the possible explanations of criminal behaviour.

Learning Outcomes

By the end of this unit, students will be able to:

1 Describe the main psychological theories explaining criminal behaviour

2 Explore the main sociological theories related to social inequality and criminal behaviour

3 Describe psychological and sociological theories to different crimes

4 Describe the role of the police in the prevention and control of crime and disorder.

Essential content

LO1 **Describe the main psychological theories explaining criminal behaviour**

Psychology:

Theoretical study of human thought, emotion, mind and behaviour; applied psychology, including self-help, improving mental health, performance enhancement.

Individual level theories:

Criminality rooted in biological and psychological differences, e.g.: Eysenck's Personality Theory, Cognitive Development Theory.

Approaches:

Biological, e.g.: Lombroso, Sheldon, extra Y chromosome

Cognitive, e.g.: Kohlberg, Eysenck

Humanistic, e.g.: Maslow, Rogers, Cattell's 16 Personality Factors (16PF)

Behaviourist, e.g.: Skinner

Psychodynamic, e.g.: Freud.

Other theories:

Psychological theories of crime, e.g.: Bowlby's case series '44 juvenile thieves', maternal deprivation, social learning theory

Validity of theories in explaining criminal behaviour

Criminal (top down approach) and geographical profiling (bottom up approach).

Causal factors:

Genetic, parental and family (including domestic violence), substance misuse, racism and hate crimes, stereotypes, religion, etc.

Social pressures, e.g.: poverty, unemployment, substance misuse, homelessness, racism, stereotypes

Influences, e.g.: peer pressure, fashion and trends; on individuals and groups including ethnicity, religion, media; internet.

LO2 **Explore the main sociological theories related to social inequality and criminal behaviour**

Sociological factors affecting crime:

Poverty, homelessness, lack of education, environment, unemployment, peer pressure, family criminality, social climate, housing, financial influences, etc.

Types of theory:

Societal or Macro level – crime is a consequence of social structure rather than genetics or personality, e.g.: Marxist Conflict Theory, Strain Theory

Community or local level – crime is caused by the geographical area, e.g.: Chicago School, Differential Opportunity Theory

Group and influence theories – associates determine delinquency, e.g.: Routine Activity Theory, differential association theories.

Sociological theories:

Chicago School/Social Disorganisation Theory – Shaw and McKay (1942), spatial mapping of crimes, areas of socio-economic deprivation and disadvantage

Social Control Theory – Hirschi (1969), crime caused by weak or broken social norms; conformity and obedience, e.g.: Zimbardo and Milgram studies

Strain Theory – Merton (1957), gap between cultural goals and structural means to achieve causes crime, adapted from Durkheim's theory of anomie, Agnew types of negative strain; strain increasing the likelihood of violence, factors affecting the reaction to strain

Rational Choice Theory – definition, e.g.: Beccaria; Cornish and Clarke (1986), individuals make a decision to commit crime, where and when, benefits and disadvantages are weighed.

LO3 **Describe psychological and sociological theories to different crimes**

Types of crime:

Acquisitive crime, crimes against the person, crimes against society, cyber crime, violent crime, hate crime, crimes of dishonesty, drug offences, vehicle crime, property crime, burglary, criminal damage, robbery, theft and handling, etc.

Different ways of categorising, e.g.: police recording, surveys.

Impact of crime:

On victims: emotional, physical, financial, psychological, short-term and long-term, vulnerable populations

On communities: public perception, media reporting, fear of crime, community mobilisation, value of property, reputation of areas.

Psychological explanations:

Bowlby's Juvenile Delinquency and the 44 thieves, maternal deprivation, social learning theory, etc.

Sociological explanations:

Chicago School, Social Disorganisation theory, Social Control Theory, Strain Theory, Rational Choice Theory, etc.

Contributory factors:

Peer pressure, fashion and trends, conformity, obedience, poverty, homelessness, lack of education, environment, unemployment, peer pressure, family criminality, social climate, housing, financial influences, substance misuse, beliefs, religion, etc.

Drivers of crime:

Opportunity, character, effectiveness of Criminal Justice System (CJS) as a deterrent, profit, drugs, alcohol.

LO4 **Describe the role of the police in the prevention and control of crime and disorder**

Police reporting and recording:

incidents, crimes

Categorisation and classification of crimes

Crime outcomes, crime detection.

Surveys:

The Crime Survey for England and Wales; British Crime Survey; others

Purpose, trends, comparison with recorded crime statistics.

Public perception of crime:

Socio-economic backgrounds, ethnicity, demographics, local geography, immigrant communities, multiculturalism, consent (consensus) versus coercion, role of media.

Police response to crime:

Police force structures

Community policing

Response policing

Policing firearms incidents

Public disorder policing

Investigation of crime.

Legislation, e.g. in the UK:

Crime and Disorder Act 1998

Police Reform and Social Responsibility Act 2011.

Evidence based strategies:

Using crime statistics, National Intelligence Model (NIM).

Examples of local and national crime reduction strategies:

SmartWater

Immobilise: The National Property Register

Advertising campaign on rape

The Prevent agenda.

Learning Outcomes and Assessment Criteria

Pass	Merit	Distinction
LO1 Describe the main psychological theories explaining criminal behaviour		**LO1, LO2 and LO3**
P1 Explain a range of different psychological theories for crime and deviant behaviour	**M1** Analyse the core belief of psychological theories for crime and deviant behaviour	**D1** Apply one psychological and one sociological theory of crime to evaluate a particular type of offending (e.g. violence, sexual, domestic violence, youth offending, terrorism, hate crime)
LO2 Explore the main sociological theories related to social inequality and criminal behaviour		
P2 Explain the sociological factors linked to crime and deviant behaviour **P3** Illustrate a range of sociological theories that explain crime and deviant behaviour	**M2** Compare two sociological theories for crime and deviant behaviour, highlighting the similarities and differences	
LO3 Describe psychological and sociological theories to different crimes		
P4 Explain the different types and categories of crime	**M3** Analyse the impact crime has on individuals and communities	
LO4 Describe the role of the police in the prevention and control of crime and disorder		
P5 Explain the role of the police in the prevention and control of crime and disorder	**M4** Analyse a range of methods, strategies and initiatives used by the police to address crime and disorder	**D2** Evaluate the impact of a particular crime prevention or reduction initiative, and assess its effectiveness in increasing community safety

Recommended resources

Textbooks

BULLOCK, K., TILLEY, N. (2012) *Crime Reduction and Problem Oriented Policing*. London: Routledge.

DAVIES, G.M., BEECH, A.R. (Eds). (2008) *Forensic Psychology.* 3rd ed. Hoboken, NJ: Wiley-Blackwell.

JONES, S. (2009) *Criminology.* 4th ed. Oxford*:* Oxford University Press.

MARSH, I. (2006). *Theories of Crime.* Abingdon: Routledge.

NEWBURN, T. (2017) *Criminology*. 3rd ed. Abingdon: Routledge.

SHARROCK, W., HUGHES, J.A., PRATT, A. (2003) *Understanding Modern Sociology.* London: SAGE Publications Ltd.

Journals

FARRINGTON, D.P., TTOFI, M.M., PIQUERO, A.R. (2016) 'Risk, promotive, and protective factors in youth offending: Results from the Cambridge study in delinquent behaviour', *Journal of Criminal Justice,* 45, pp. 63–70.

Web

www.pep-web.org	Psychoanalytic Electronic Publishing International Journal of Psycho-Analysis (1944), 25:107-128 Forty-Four Juvenile Thieves: Their Characters and Home-Life (II) (Journal)

Links

This unit links to the following related unit:

Unit 23: Psychology in the Forensic Setting

Unit 23: Psychology in the Forensic Setting

Unit code	**J/617/5380**
Unit level	**4**
Credit value	**15**

Introduction

Psychological research and theory is practically applied throughout organisations working within the crime and justice sector. Those working in this field need to build an awareness of the practical application of psychology within different forensic settings and at different stages of the criminal justice process.

This unit explores the role of psychological techniques within different stages of the criminal justice process: the identification of offenders, the support of victims and witnesses in retrieving memories, and in the management and treatment of offenders. Students will also examine the factors that increase the risk of offending, as well as the factors that prevent and protect individuals from engaging in criminality. Topics explored within this unit include criminal investigative analysis techniques such as offender profiling, crime pattern analysis and case linkage, memory – specifically eyewitness memory, sentencing and programme options for managing offenders.

On successful completion of this unit, students wanting to work in the role of a forensic service provider will have knowledge of how psychological theories are practically applied throughout the criminal justice process, including the use of forensic science in the identification of offenders and interpretation of crime scenes.

Learning Outcomes

By the end of this unit students will be able to:

1 Identify the techniques used to assist in the identification of offenders

2 Explore how psychology applies to eyewitness memory and the retrieval of memories

3 Describe the application of psychology in the management and treatment of offenders

4 Investigate risk and protective factors for offending.

Essential Content

LO1 **Identify the techniques used to assist in the identification of offenders**

Criminal investigative analysis:

Offender profiling

FBI approach

Geographical approach

Statistical profiling

Clinical approach

Usefulness of profiling

Suitable crimes.

Case linkage:

Comparative case analysis

Trends, patterns, hotspots.

The application of forensic science:

Locard's exchange principle

Scene examination strategy

Scene investigation: gathering, analysis and interpretation of trace, e.g.: fingerprints, DNA, fibres, footwear marks, digital evidence, drugs, blood

Scene preservation and the prevention of cross-contamination

LO2 **Explore how psychology applies to eyewitness memory and the retrieval of memories.**

Memory:

Recall, recognition

Memory stores, e.g.: working memory, short-term memory, long-term memory

Retrieval.

Stages of memory:

Three stages: acquisition, retention, retrieval.

Variables that can interfere with memory:

Acquisition factors, e.g.: duration of event, illumination, nature of event, target factors

Retention factors, e.g.: retention interval, discussion, repeated testimony

Retrieval factors, e.g.: leading questions, style of recall

Other factors, e.g.: witness age, witness confidence.

How victims and witnesses are supported:

Interviewing, e.g.: the cognitive interview, memory retrieval in court

Rules of questioning, types of questions.

LO3 **Describe the application of psychology in the management and treatment of offenders**

Sentencing:

Purpose of punishing crimes

Community and custodial sentences

Sentencing guidelines.

Assessing offenders:

Aim of risk and need assessments

Actuarial assessments

Static and dynamic risk factors

Clinical assessment

Advantages and disadvantages

Specific risk and need assessment tools, e.g.: psychometric testing, Offender Assessment System (OASys), Psychopathy CheckList − Revised (PCL-R), Risk Matrix 2000, Violence Risk Appraisal Guide (VRAG), Sexual Offences Risk Appraisal Guide (SORAG), Historical Clinical Risk Management 20 (HCR 20), Structured Assessment of Risk and Need (SARN), Spousal Assault Risk Assessment (SARA).

Treatment of offenders:

'What Works?' report, Offending Behaviour Programmes (OBPs), individual group therapy, therapeutic communities, behaviour modification.

LO4 **Investigate risk and protective factors for offending**

Risk factors:

What does this mean?

Family, e.g.: poor supervision and discipline, history of criminality, anti-social parental attitudes, low income, poor housing

School, e.g.: low achievement, aggressive behaviour, lack of commitment

Community, e.g.: disadvantaged neighbourhood, disorganisation and neglect, availability of drugs, high population turnover

Personal, e.g.: hyperactivity and impulsivity, low intelligence and cognitive impairment, lack of social commitment, positive attitudes towards drugs and offending, early involvement in drugs and crime, friendships with peers involved in crime and drug misuse.

Factors most closely linked to reoffending:

Thinking and behaviour, lifestyle, education.

Protective factors:

What does this mean?

Individual, e.g.: female gender, resilient temperament, sense of self-efficacy, positive and outgoing disposition, high intelligence

Social bonding, e.g.: stable, warm, affectionate relationship with one or both parents, link with tutors and other prosocial adults

Healthy standards, e.g.: positive behaviour, norms and values held by the community, parents and tutors, opportunities to be involved and receive praise.

Preventing offending:

What works?

Structured, evidence-based interventions

Link between youth offending and adult offending.

Learning Outcomes and Assessment Criteria

Pass	Merit	Distinction
LO1 Identify the techniques used to assist in the identification of offenders		
P1 Explain how offender profiling and case linkage are used to assist in the identification of offenders	**M1** Analyse how Locard's principle of exchange and forensic science techniques assist in the identification of offenders	**D1** Evaluate the usefulness and accuracy of offender profiling, case linkage and forensic science in identifying offenders
LO2 Explore how psychology applies to eyewitness memory and the retrieval of memories		
P2 Explore the stages of memory and the factors that influence the accuracy of eyewitness memory at each of the three stages	**M2** Assess how victims and witnesses are supported in retrieving memories through effective questioning	**D2** Evaluate the most effective methods of questioning victims and witnesses to ensure accurate retrieval of memories
LO3 Describe the application of psychology in the management and treatment of offenders		
P3 Describe the sentencing options and programmes available for dealing with offenders **P4** Explain some of the methods used to assess offenders to determine appropriate management and treatment	**M3** Assess the 'What Works' debate, considering the evidence for effective community- and prison-based programmes aimed at reducing reoffending	**D3** Evaluate the effectiveness of accredited programmes aimed at reducing reoffending
LO4 Investigate risk and protective factors for offending		
P5 Investigate the risk and protective factors that research has highlighted as linked to the risk of people offending	**M4** Analyse the importance of identifying risk and protective factors for juvenile offending with regard to future adult offending	**D4** Evaluate how knowledge of risk and protective factors can be used by the public services to deal with crime both proactively and reactively

Recommended resources

Textbooks

AINSWORTH, P. (2001) *Offender Profiling and Crime Analysis*. Devon: Willan Publishing.

ALISON, L. (2005) *Forensic Psychologists Casebook: Psychological Profiling and Criminal Investigation*. Devon: Willan Publishing.

CANTER, D., ALISON, L. (2016) *Profiling in Policy and Practice.* London: Routledge.

HOWITT, D. (2018) *Introduction to Forensic and Criminal Psychology*. 6th ed. Harlow: Pearson Education Ltd.

LAMPINEN, J.P., NEUSCHATZ, J.S., CLING, A.D. (2017). *The Psychology of Eyewitness Identification.* London: Routledge.

SHAPIRO, D.L., NOE, A.M. (2015) *Risk Assessment: Origins, Evolution, and Implications for Practice.* London: Springer.

WEISBURD, D., FARRINGTON, D.P., GILL, C. (2016). *What Works in Crime Prevention and Rehabilitation: Lessons from Systematic Reviews*. London: Springer.

Web

app.college.police.uk	College of Policing APP content, intelligence management, analysis, investigation, investigative interviewing (General reference)
justice.gov.uk	UK Government website – Justice Offenders, before and after release, offender behaviour programmes (OBPs) (General reference)

Links

This unit links to the following related unit:

Unit 22: Theories and Causes of Crime

Unit 24: Sampling and Sample Preparation

Unit code	**L/617/5381**
Unit level	**4**
Credit value	**15**

Introduction

Sample collection, preparation and storage depend on the type of samples and the desired analysis. It is best to always check prior to collecting samples what is required in terms of sample processing, transport, and storage.

The aim of this unit is to provide students with knowledge in the main sampling methods and techniques, as well as sample preparation methods, in a wide range of fields from clinical and non-clinical to biological and chemical areas. This will include the strategy of sampling, requirements for sampling, and specific sample preparation methods. In addition, the content of this unit focuses on the process and quality assurance during the sample preparation stage of different samples including cell and tissue samples, protein samples, solid phase extraction, solid phase microextraction, sea samples, water and soil samples.

Attention is paid to proper understanding of the advantages and disadvantages of different sample preparation methods for the different types of samples. Theoretical knowledge will be linked with other units.

On completion of this unit students will be better prepared to work in any scientific industry that requires the collection, packaging, transportation and preservation of samples such as in analytical, chemical, forensic, criminal, environmental, biomedical and other similar investigative roles.

Learning Outcomes

By the end of this unit, students will be able to:

1 Describe the types of sampling and sampling techniques

2 Explain cell, tissue and clinical sampling methods and techniques

3 Explain sample collection and preparation for protein analysis

4 Review sample preparation methods in chemistry, forensic and environmental sciences.

Essential Content

LO1 **Describe the types of sampling and sampling techniques.**

Introduction:

Population, sampling, randomisation

Safety requirements, sampling for analysis

Types of sampling:

Probability and nonprobability sampling

Sample size and frame

Power calculation

Sampling methods:

Simple random sampling, systematic sampling, stratified sampling, matched-pairs sampling, etc.

Convenience, purposive, snowball, quotas, theoretical sampling

Analytical perspectives of sampling, sample preparation

LO2 **Explain cell, tissue and clinical sampling methods and techniques**

Sampling methods and techniques:

Endoscopy, sigmoidoscopy, colposcopy, bronchoscopy, laryngoscopy, gastroscopy, arthroscopy needle biopsy, punch biopsy, shave biopsy, curettage, evacuation, excision vs incision.

Surgical removal, surface collection (scraping, impression smears, swabs, lavage, pap smear, tissue biopsy, screening, aspiration, skin tests for allergic reactions, etc.)

Sampling errors:

Compression, stretching, drying, talc, iron, sutures / staples, contamination, vascular damage, perforation, infection, tumour, dissemination.

LO3 **Explain sample collection and preparation for protein analysis**

Introduction to protein sample preparation:

Protein sample preparation: techniques and applications

Influence and consideration of sample type and source on sample disruption.

Protein electrophoresis, Western blotting, bicinchoninic acid (BCA), proteomics, ELISA (enzyme-linked immunosorbent assay)

Basic description of cell lysis and total protein extraction, methods of disruption, extraction, fractionation and quantification, workflow design considerations.

Protein extraction and representative applications:

General goal, experimental use, practical uses, therapeutic use, diagnostic use, biotechnology purposes.

Source of specimen or sample type:

Cell lysis and its procedure selection strategy; methods; physical, cell and tissue disruption of sample.

LO4 **Review sample preparation methods in chemistry, forensic and environmental sciences**

Difficulties and advances in sampling procedures:

Limited in quantity, environmentally exposed, contamination, contain PCR inhibitors, etc.

Solid phase and solid phase microextraction methods (SPME):

Accelerants, explosive traces, drugs and poisons from biological specimens and other forensic applications

Trace evidence recovery and contact DNA in the laboratory:

Techniques to search for and identify blood, saliva and semen.

Characterisation of soil environment:

Sampling and sample preparation

Field sampling, sampling plan, methods and tools, storage and transport

Air drying, sieving, crushing.

Learning Outcomes and Assessment Criteria

Pass	Merit	Distinction
LO1 Describe the types of sampling and sampling techniques		**D1** Analyse probability and non-probability sampling techniques, considering the most common sampling mistakes
P1 Identify the types of sampling methods for research studies and sampling techniques **P2** Explain the different processes of selecting a sample for research studies	**M1** Compare probability and non-probability sampling as well as their different types	
LO2 Explain cell, tissue and clinical sampling methods and techniques		**D2** Evaluate the different methods and techniques used to collect samples, considering the risks, preparations, advantages and disadvantages
P3 Outline the different methods and techniques used to collect samples **P4** Describe how different techniques are used to collect samples for different purposes	**M2** Compare the various procedures and techniques used to obtain bodily fluids or tissue for analysis	

Pass	Merit	Distinction
LO3 Explain sample collection and preparation for protein analysis		**D3** Evaluate the different protein analysis techniques and the challenges that need to be tackled in proper sample preparation of each
P5 Describe the process of protein sample collection and preparation **P6** Outline the different sources of protein sample collection and the challenges that need to be tackled in proper sample preparation	**M3** Explain the protein sample collection, stabilisation, extraction, considering the workflow design and general concerns	
LO4 Review sample preparation methods in chemistry, forensic and environmental sciences.		**D4** Compare the sample preparation techniques used in chemistry, forensic and environmental sciences, considering the limitations and quality assurance/quality control of each
P7 Describe the difficulties and advances in sampling procedures in chemistry, forensic and environmental sciences **P8** Explain the analytical instrumentation methods for forensic evidence and environmental particulates	**M4** Review the sampling considerations and challenges of the analytical instrumentation methods for the forensic evidence and environmental particulates	

Recommended resources

Textbooks

BRYMAN, A., CRAMER, D. (1994) *Quantitative Data Analysis for Social Scientists*. 2nd ed. London: Routledge.

GALL, M.D., GALL, J.P., BORG, W.R. (2006) *Educational Research: An Introduction*. 8th ed. New York: Pearson Education Ltd.

HANSEN, S.H., PEDERSEN-BJERGAARD, S. (Eds). (2015) *Bioanalysis of Pharmaceuticals: Sample Preparation, Chromatography and Mass Spectrometry*. Chichester: Wiley-Blackwell.

MICIC, M. (Ed). (2018) *Sample Preparation Techniques for Soil, Plant, and Animal Samples*. New York: Humana Press (Springer).

NICKERSON, B. (Ed). (2014) *Sample Preparation of Pharmaceutical Dosage Forms: Challenges and Strategies for Sample Preparation and Extraction*. New York: Springer-Verlag.

POSCH. A., BRUBACHER, M.G., PAULUS, A. (2005) 'Tools for sample preparation and prefractionation in two-dimensional gel electrophoresis', In: SMEJKAL, G.B., LAZAREV, A. (Eds). *Separation methods in Proteomics*. Boca Raton, FL: CRC Press, pp. 107–133.

STEVENSON, D., WILSON, I.D. (Eds). (2013) *Sample Preparation for Biomedical and Environmental Analysis (The Chromatographic Society Symposium Series)*. New York: Springer.

STOEPPLER, M. (Ed). (2012) *Sampling and Sample Preparation: Practical Guide for Analytical Chemists*. New York: Springer Science & Business Media.

Journals

NEUMAN, W.L., ROBSON, K. (2007) 'Basics of social research: Qualitative and quantitative approaches', *Power*, 48, p.48.

Web

labmodules.soilweb.ca	Soil Lab Modules Soil salinity and soil sampling (Research)
thermofisher.com	ThermoFisher Scientific Overview of Protein Assays Methods (Report)
wolfson.huji.ac.il	The Wolfson Centre for Applied Structural Biology Protein Sample Preparation Handbook (Report – handbook)

Links

This unit links to the following related units:

Unit 1: Fundamentals of Laboratory Techniques

Unit 21: Criminal Investigation

Unit 34: Forensic Evidence Collection and Preservation

Unit 39: Environmental Monitoring and Analysis

Unit 51: Specialist Scientific Techniques and Experimentation

Unit 57: Infectious diseases and diagnosis

Unit 58: Epidemiology of Communicable Diseases

Unit 25: Personal and Professional Development for Scientists

Unit code	**R/617/5382**
Unit level	**4**
Credit value	**15**

Introduction

Personal and professional development is of the utmost importance within the science industries due to the constant advancements and changes in science and technology, legislation and practices. It is also essential for career progression. Over time, it has become the responsibility of employees to identify their own strengths and areas for improvement and suggest ways in which they can develop their skills to meet the needs of the organisation and to facilitate career progression.

This unit is designed to enable students to assess and develop a range of personal and professional skills. It aims to help students develop the ability to self-appraise, become confident in managing their own skills, promote future personal and career development, and achieve their goals for career progression within the science industries.

The students will initially consider the range of relevant careers available within the public, private and voluntary sectors, and explore the skill and experience requirements of different careers within science. They will then evaluate their own knowledge, skills, experience, practice, values and beliefs in relation to working in the science industries; focus on their own personal and professional development; produce a development plan by considering their own qualities, skills, experience, and current and future needs; and produce a professional portfolio.

On successful completion of this unit, the students will be able to draw on a range of sources of information and use appropriate tools to assess their personal and professional development, including their vocational experience and other relevant experiences such as their formal study, employment and/or voluntary activity. They will also be able to plan appropriate methods to meet their personal and professional development needs through training and professional development. Furthermore, they will be able to review the effectiveness of these plans in relation to specific roles within the science industries.

Learning Outcomes

By the end of this unit, students will be able to:

1 Explore the skill and experience requirements of careers within the science industries

2 Assess own personal and professional skills

3 Produce a personal and professional development plan

4 Produce a personal and professional development portfolio.

Essential content

LO1 **Explore the skill and experience requirements of careers within the science industries**

Careers within the science industries:

Key science pathways: biology; biotechnology; forensic science; chemistry; environmental sustainability; water and wastewater; food science, technology and nutrition; polymer science and technology; biomedical science; pharmaceutical science; health informatics; bioinformatics; medical technology

Sectors: public, private, voluntary, public/private partnerships

Employers: local, national and international (public, private and voluntary)

Employment contracts: full-time, part-time, fixed-term contract, zero-hours contract, apprenticeships, self-employment (independent, subcontracted).

Skill requirements:

Communication skills, e.g.: effective listening, respect of others' opinions, negotiation, persuasion, assertiveness, presentation skills (including the use of ICT)

Working with others, e.g.: teamwork, flexibility/adaptability, social skills, leadership, co-operation

Time management, e.g.: organisational skills, time management, prioritising workloads, setting work objectives, using time effectively

Other attributes, e.g.: reliability, commitment, resilience, empathy, emotional intelligence, self-discipline, creativity, problem-solving, initiative, confident, motivated

Other technical skills, e.g.: computer literacy, operating scientific equipment, administering test procedures, following strict guidelines.

Availability of skills:

Skills balance: current and future needs, skills mismatch and gaps, over- vs under-supply, over- vs under-skilled, over- vs under-qualified professionals.

LO2 **Assess own personal and professional skills**

Skills assessment techniques:

Methods of assessment. e.g.: questionnaires, interview, observation

Self-appraisal, e.g.: skills audit (personal profile using appropriate self-assessment tools), SWOT analysis (strengths, weaknesses, opportunities, threats).

Own skills and experience:

Communication skills, e.g.: effective listening, respect of others' opinions, negotiation, persuasion, assertiveness, presentation skills (including the use of ICT)

Working with others, e.g.: teamwork, flexibility/adaptability, social skills, leadership, co-operation

Time management, e.g.: organisational skills, time management, prioritising workloads, setting work objectives, using time effectively

Other attributes, e.g.: reliability, commitment, resilience, empathy, self-discipline, creativity, problem-solving, initiative, confident, motivated

Other technical skills, e.g.: computer literacy, operating scientific equipment, administering test procedures, following strict guidelines

Experience, e.g.: paid, voluntary, recreational, relevance to the sciences industry.

LO3 **Produce a personal and professional development plan**

Setting goals:

S.M.A.R.T. goals (specific, measurable, attainable, relevant, time-bound), learning goals, employment goals, short/medium/long term goals.

Development plan:

Contents of plan: current skills and abilities, aims and objectives, goals, needs and expectations, strengths, areas for improvement, skills/knowledge/qualifications required, action plans, learning programme/activities, achievement and review dates, future needs

Education, e.g.: formal academic qualifications (HNC/HND/BSc/MSc/PhD)

Training, e.g.: career-based or vocational qualifications, apprenticeships

Short courses, e.g.: health and safety, updating laboratory skills, using scientific instruments, learning new scientific techniques, improving computer literacy, project/product management, conflict management, assertiveness training, time management, bookkeeping, team leadership

Learning from others, e.g.: observation, mentoring, supervision, tutorials, informal networks, team members, line managers, other professionals

Continuous Professional Development (CPD): training vs development, personal needs (based on skills audit and/or future plans), employer needs (based on skills gaps and/or company goals), attending conferences, seminars and workshops, working toward professional accreditation

Networking: building professional relationships, becoming an active member of a professional body/institute, talk with like-minded professionals, promote yourself, career opportunities, industry trends and best practices, etc.

LO4 **Produce a personal and professional development portfolio**

Portfolio building to support plan:

Portfolio presence, e.g.: need for planning, choice of medium (online or paper-based), pitfalls of non-professional online presence.

Developing portfolio, e.g.: CV, online profile (e.g. LinkedIn), business cards, personal statement, qualification and training certificates, record of training, evidence of experience, development plan.

Maintaining portfolio: updating contents, relevance of portfolio to career goals, continuous review, maintaining contents in relation to development plan.

Review development portfolio and own learning:

Reflective practice, e.g.: Kolb Learning Cycle, Gibbs Reflective Cycle, Brookfield Lenses

Effectiveness: strengths, areas for improvement, recommendations for future development, completion of aims and objectives, links to SWOT analysis

Monitoring and evaluation of effectiveness, e.g.: interviews, observation, peer assessment

Evaluation of progress, e.g.: recording progress, updating portfolio, responding to feedback, resetting aims, objectives and goals.

Learning Outcomes and Assessment Criteria

Pass	Merit	Distinction
LO1 Explore the skill and experience requirements of careers within the science industries		**D1** Analyse availability and imbalance of skills within the science industries and suggest how your findings may affect your choice of career path
P1 Review different job opportunities within the science industries **P2** Assess the skill and experience requirements of careers within the science industries	**M1** Compare and contrast the skill and experience requirements of careers within the science industries	
LO2 Assess own personal and professional skills		**D2** Justify areas for development making reference to the 'person specification' and 'job description' for a specific role that you would intend to apply for in the science industries
P3 Complete a personal SWOT analysis, identifying strengths, weaknesses, opportunities and threats **P4** Assess own suitability for a career in the science industries	**M2** Evaluate own suitability for a specific role in the science industries identifying shortcomings and areas for development	
LO3 Produce a personal and professional development plan		**D3** Justify the contents of own personal and professional development plan in relation to the 'person specification' for a specific role relevant to own intended career path in the science industries
P5 Design own personal and professional development plan for intended career path in the science industries **P6** Analyse different training and development opportunities	**M3** Explain the importance of networking to professional development and career progression indicating the steps one must take for effective networking	

Pass	Merit	Distinction
LO4 Produce a personal and professional development portfolio.		**D4** Evaluate own personal and professional development portfolio, identify areas for improvement, and explore how it will facilitate career progression within the science industries
P7 Describe the most appropriate form(s) that own portfolio should take **P8** Develop a personal and professional development portfolio which will include a CV, profile on professional social network, and business cards	**M4** Justify the process intending to follow in order to create, maintain and update own portfolio	

Recommended resources

Textbooks

BRYMAN, A., CRAMER, D. (1994) *Quantitative Data Analysis for Social Scientists*. 2nd ed. London: Routledge.

GALL, M.D., GALL, J.P., BORG, W.R. (2006) *Educational Research: An Introduction*. 8th ed. New York: Pearson Education Ltd.

HANSEN, S.H., PEDERSEN-BJERGAARD, S. (Eds). (2015) *Bioanalysis of Pharmaceuticals: Sample Preparation, Chromatography and Mass Spectrometry*. Chichester: Wiley-Blackwell.

MICIC, M. (Ed). (2018) *Sample Preparation Techniques for Soil, Plant, and Animal Samples*. New York: Humana Press (Springer).

NICKERSON, B. (Ed). (2014) *Sample Preparation of Pharmaceutical Dosage Forms: Challenges and Strategies for Sample Preparation and Extraction*. New York: Springer-Verlag.

POSCH. A., BRUBACHER, M.G., PAULUS, A. (2005) 'Tools for sample preparation and prefractionation in two-dimensional gel electrophoresis', In: SMEJKAL, G.B., LAZAREV, A. (Eds). *Separation methods in Proteomics*. Boca Raton, FL: CRC Press, pp. 107–133.

STEVENSON, D., WILSON, I.D. (Eds). (2013) *Sample Preparation for Biomedical and Environmental Analysis (The Chromatographic Society Symposium Series)*. Springer.

STOEPPLER, M. (Ed). (2012) *Sampling and Sample Preparation: Practical Guide for Analytical Chemists*. Springer Science & Business Media.

Journals

NEUMAN, W.L., ROBSON, K. (2007) 'Basics of social research: Qualitative and quantitative approaches', *Power*, 48, p.48.

Web

labmodules.soilweb.ca	Soil Lab Modules Soil salinity and soil sampling (Research)
thermofisher.com	ThermoFisher Scientific Overview of Protein Assays Methods (Report)
wolfson.huji.ac.il	The Wolfson Centre for Applied Structural Biology Protein Sample Preparation Handbook (Report – handbook)

Links

This unit links to the following related units:

Unit 1: Fundamentals of Laboratory Techniques

Unit 21: Criminal Investigation

Unit 34: Forensic Evidence Collection and Preservation

Unit 39: Environmental Monitoring and Analysis

Unit 51: Specialist Scientific Techniques and Experimentation

Unit 57: Infectious diseases and diagnosis

Unit 58: Epidemiology of Communicable Diseases

Unit 26: Managing Scientific Projects

Unit code	**Y/617/5383**
Unit level	**4**
Credit value	**15**

Introduction

This unit provides an understanding and experience of project management principles, methodologies, tools and techniques that may be used for the management of scientific projects in the industry and the public sector to ensure successful scientific endeavours that relate to academic research, organisational research and development, or consultancy.

Through this unit students will learn what constitutes a project, the role of a project manager and the project team, as well as that of the project stakeholders. The criteria for the success or failure of a project will be examined, project management systems will be evaluated, and the elements involved in project termination and appraisal will be reviewed.

Students will be able to analyse project requirements and plan the activities needed to carry out a project. This includes how to set up, cost, plan, execute, control and monitor a project, and how to carry out project reviews using a specialist project management software package. Together with factors associated with effecting project change and minimising risk, students will also appreciate how the project fits into the strategy or business plan of an organisation that focuses in the science sector.

Learning Outcomes

By the end of this unit, students will be able to:

1 Explain the concept of project management, and the roles of the project team and major stakeholders

2 Develop a project strategy plan that defines the key policies, procedures and priorities for a scientific project

3 Undertake the planned project activities to generate outcomes that satisfy the requirements of the scientific project

4 Communicate the project outcomes and reflect on the value gained from conducting the project.

Note: LOs 2-4 must be based on a project scenario that relates to the specific pathway studied. The Assessment Criteria may also be tailored to the workplace of a particular student assuming they work in a relevant field within Applied Sciences.

Essential content

LO1 **Explain the concept of project management, and the roles of the project team and major stakeholders**

Project management:

Definitions for project and project management

Definitions and relationships between: project, program, portfolio and their associated management

Defining project success, the need for formal project management, project management framework, best practice

The systems approach to project management: system's philosophy, systems analysis, and systems management

The triple constraint of project management: cost, time, scope

The three sphere model for systems management: business, organisations, technology

Organisational structures: functional, project-based, matrix

The key stages of project management: conception and initiation, planning, execution, performance monitoring, project closure.

The project manager:

Definition and role evolution, knowledge areas, interpersonal skills, responsibilities, attributes, competencies, managerial skills, managing project teams.

The project team:

Selection of project team members based on specific skills required

Duties: contribution to overall project objectives, completing individual deliverables, providing expertise, interacting with users to establish and meet business needs, documenting the process, testing.

Stakeholders:

Definitions, types, key differences and relationships with the project, the sponsor(s), support staff, customers, users, suppliers, opponents to the project

Stakeholders' power, interest, client influences, funding institutions, shareholders

Local authority, professionals, consultants, public interests, end user, owner, conflict of interest

Stakeholder collaboration and communication

Stakeholder governance and management.

Professional bodies, recognition and standards:

The project management profession: history, track record, employability

Professional bodies representing project managers

International project management standards

Ethics and professional conduct in project management

Techniques and guides, including PRINCE2 (PRojects IN Controlled Environments) and Project Management Body Of Knowledge (PMBOK) Guide

Project management software

Certifications: PMP, PRINCE2.

LO2 **Develop a project strategy plan that defines the key policies, procedures and priorities for a scientific project**

Conception and initiation phase of the project:

Customer requirements

Project stakeholder analysis

Scoping a project: defining objectives, scope, purpose and deliverables to be produced

The business case

Steps and documentation required in the initiation phase.

The project planning phase:

The planning flowchart

Developing the project plan, including planning for timescales and time management, cost, procurement, quality, change, risk and issues

The work breakdown structure

Use of bar and Gantt charts for effective planning

Risk: management, planning, identification, qualification, quantification, response planning, critical chain management, buffer allocation, reserves

Estimating: methods, activities, productivity, availability, cost, errors.

LO3 **Undertake the planned project activities to generate outcomes that satisfy the requirements of the scientific project**

Project execution phase:

Selecting appropriate methods of information gathering, data collection and material resourcing

The distinct phases that support a coherent and logical argument

Use of secondary research to inform a primary empirical study

Qualitative and quantitative research methods.

Field work:

Selecting a sample of the consumer market, businesses or individuals (those who meet certain characteristics relevant to the research theme) that will be used to gather data (qualitative or quantitative)

Sampling approaches and techniques, including probability and nonprobability sampling.

Ethics, reliability and validity:

All research should be conducted ethically − how is this achieved and reported?

Research should also be reliable (similar results achieved from a similar sample) and valid (the research should measure what it aimed to measure).

Analysing information and data:

Using data collection tools, such as interviews and questionnaires

Using analytical techniques, such as trend analysis, coding or typologies.

Monitoring and control:

Purpose of monitoring and control, managing expectations, status meetings

Managing scope change, change impact analysis, change approval, change control

Scheduling: managing schedules, schedule crashing, fast-tracking

Statusing and managing cost

Managing risk

Earned value management (EVM): metrics, cost projections, schedule projections

Managing quality: expected quality, deming cycle, fit-for-purpose, peer reviews, user reviews, user review management tools

Problem resolution: solution options, persuasion techniques

Periodic reports (weekly/monthly).

Project closure:

Acceptance: in closing, change management, scope verification, scenario based scope verification, practical delivery criteria, transition to operations

The lessons learned process

Team closure: people transition, project celebration

Final project report.

LO4 **Communicate the project outcomes and reflect on the value gained from conducting the project**

Communicating outcomes:

Consider the method (e.g. written, verbal) and the medium (e.g. report, online, presentation)

Both method and medium will be influenced by the project research and its intended audience.

Convincing arguments:

All findings/outcomes should be convincing and presented logically where the assumption is that the audience has little or no knowledge of the project process

Developing evaluative conclusions.

Critical and objective analysis and evaluation:

Secondary and primary data should be critiqued and considered with an objective mindset

Objectivity results in more robust evaluations where an analysis justifies a judgement.

Reflection for learning and practice:

The difference between reflecting on performance (research process, information gathering and data collection) and evaluating a project (quality of research argument and use of evidence).

The cycle of reflection:

To include reflection in action and reflection on action

How to use reflection to inform future behaviour, particularly directed towards sustainable performance

Reflective writing by focusing on personal development and the research journey in a critical and objective way.

Avoiding Generalisation: Outcomes should be specific and actionable.

Learning Outcomes and Assessment Criteria

Pass	Merit	Distinction
LO1 Explain the concept of project management and the roles of the project team and major stakeholders		**D1** Assess the importance of ethics and professional conduct in project management in the science sector
P1 Define project management and its relationship to program and portfolio management **P2** Identify the roles of the project manager, project team and stakeholders	**M1** Analyse the effect that the triple constraint of project management has on the success of a project	
LO2 Develop a project strategy plan that defines the key policies, procedures and priorities for a scientific project		**D2** Produce a comprehensive project management plan, milestone schedule and project schedule for monitoring and completing the aims and objectives of the project
P3 Develop a project management plan with clear aims and objectives and aspects of cost, scope, time, quality, communication, risk and resources **P4** Develop a work breakdown structure and Gantt chart to provide timeframes and stages for completion	**M2** Investigate the effect that risk has on the success of a project in science if it is estimated inappropriately and monitored incorrectly	

Pass	Merit	Distinction
LO3 Undertake the planned project activities to generate outcomes that satisfy the requirements of the scientific project		**D3** Evaluate the success of the project plan making recommendations for improvements
P5 Undertake project activities, recording progress against the original project plan **P6** Carry out small-scale research by applying qualitative and quantitative research methods appropriate for meeting project aims and objectives	**M3** Explore alternative methods to monitor and meet project milestones, justifying the selection of chosen method(s)	
LO4 Communicate the project outcomes and reflect on the value gained from conducting the project.		**D4** Evaluate and reflect on the project outcomes, the decision-making process and changes or developments of the initial project management plan to support justification of recommendations and learning during the project
P7 Communicate appropriate recommendations as a result of research and data analysis to draw valid and meaningful conclusions **P8** Reflect on the value of undertaking the research to meet stated objectives and own learning and performance	**M4** Justify the selection of appropriate tools and techniques for accuracy and authenticity to support recommendations	

Recommended resources

Textbooks

BENNETT, N., AXELOS. (2017) *Managing successful projects with PRINCE2*. 7th ed. Norwich: The Stationery Office (TSO).

D'HERBEMONT, O., CESAR, B. (2020) *Managing Sensitive Projects: A Lateral Approach.* Abingdon: Routledge.

DIONISIO, D.S. (2019) *Microsoft Project 2019 For Dummies*. Hoboken, NJ: John Wiley & Sons, Inc.

KERZNER, H. (2017) *Project Management: A Systems Approach to Planning, Scheduling, and Controlling.* 12th ed. Hoboken, NJ: John Wiley & Sons, Inc.

KERZNER, H. (2018) *Project Management Best Practices: Achieving Global Excellence*. 4th ed. Hoboken, NJ: John Wiley & Sons, Inc.

LOCK, D. (2014) *The Essentials of Project Management*. 4th ed. Abingdon: Routledge.

OFFICE OF GOVERNMENT COMMERCE (2009) *Managing Successful Projects with Prince2*. Norwich: The Stationary Office (TSO).

PINTO, J.K. (2018) *Project Management: Achieving Competitive Advantage*. Global Edition. 5th ed. Harlow: Pearson Education Ltd.

PROJECT MANAGEMENT INSTITUTE (2017) *A Guide to the Project Management Body of Knowledge*. 6th ed. Newtown Square, PA: Project Management Institute.

SPRINGER, M. (2019) *Project and Program Management: A Competency-Based Approach.* 4th ed. West Lafayette, IN: Purdue University Press.

STARK, E. (2016) *Agile Project Management QuickStart Guide: A Simplified Beginners Guide To Agile Project Management.* Albany: Clydebank Media.

WINGATE, L.M. (2014) *Project Management for Research and Development: Guiding Innovation for Positive R&D Outcomes*. Boca Raton, FL: Taylor Francis Group/CRC Press/Auerbach Publications.

Web

apm.org.uk	Association for Project Management (General reference)
prince2.com	Prince2 Accredited training organisation (Training)
pmi.org	Project Management Institute (General reference)

Links

This unit links to the following related units:

Unit 3: Regulation and Quality in the Applied Sciences

Unit 12: Managing Environmental Resources

Unit 25: Personal and Professional Development for Scientists

Unit 28: Applied Sciences Research Project

Unit 51: Specialist Scientific Techniques and Experimentation

Unit 61: Science Laboratory Management

Unit 62: Organisations and Change Management

Unit 63: Entrepreneurship and New Business Development

Unit 27: Analysis of Scientific Data and Information

Unit code	**D/617/5384**
Unit type	**Core**
Unit level	**5**
Credit value	**15**

Introduction

The ability to apply mathematical techniques in the analysis and evaluation of scientific data and information is of utmost importance in the scientific sector. Knowledge and confidence in handling varying sizes of data enables scientists to understand and explain the reasons behind behaviours and reactions, as is the ability to validate and identify errors in experimental results. Statistical trends and projections will also support the development of science and enable scientists to further support developments and/or proactively deal with potentially unwanted issues in science.

This unit aims to further develop the knowledge gained from studying the *Unit 2: 'Scientific Data Handling Approaches and Techniques'* and extends it to a higher level of ability for use in industry and research. It includes: further statistical analysis of scientific data and information; use of matrix methods to solve systems of linear equations relevant to science applications; use of differential and integral calculus to solve scientific problems; and graphical and numerical methods as well as ways of assessing limitations and concluding results on realistic scientific examples.

On successful completion of this unit students will be able to use mathematical and statistical techniques, matrices, differential and integral calculus, graphical and numerical methods, and validation techniques to support their work in the science sector.

Learning Outcomes

By the end of this unit, students will be able to:

1 Analyse scientific data using statistics.

2 Use matrix methods to solve systems of linear equations relevant to science applications.

3 Examine how differential and integral calculus can be used to solve scientific problems.

4 Approximate solutions of contextualised examples with graphical and numerical methods, and assess limitations and concluding results.

Essential Content

LO1 **Analyse scientific data using statistics**

Descriptive statistics:

Measures of central tendency, e.g. mode, median, mean; measures of dispersion, e.g. 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: e.g. z-test, Student's t-test, F-test, Pearson's chi-squared (x^2) test, Pearson's product moment correlation coefficient; significance levels; power of the test; one-tailed and two-tailed tests.

Trends, projections and forecasts

LO2 **Use matrix methods to solve systems of linear equations relevant to science applications**

Matrix methods:

Introduction to matrices and the matrix notation

The process for addition, subtraction and multiplication of matrices

Vector-Matrix Form

Introducing the determinant of a matrix and calculating the determinant for a 2x2 matrix.

Solving for the unknowns in a matrix:

Using Cramer's Rule by taking a square matrix to find determinants

Using the inverse of a square matrix to solve linear equations

Gaussian elimination to solve systems of linear equations (up to 3x3

Using matrices to solving examples in specialist science pathways.

Solving scientific problems involving matrices:

Examples specific to the specialist pathway.

LO3 **Examine how differential and integral calculus can be used to solve scientific problems**

Differential calculus:

Definitions and concepts

Definition of a function and of a derivative, graphical representation of a function, notation of derivatives, limits and continuity, derivatives; rates of change, increasing and decreasing functions and turning points

Differentiation of functions, including: standard functions/results; using the chain, product and quotient rules; second order and higher derivatives

Types of function: polynomial, logarithmic, exponential and trigonometric (sine, cosine and tangent), inverse trigonometric and hyperbolic functions.

Integral calculus:

Definite and indefinite integration

Integrating to determine area

Integration of common/standard functions and by substitution and parts

Exponential growth and decay

Types of function: algebraic, including partial fractions and trigonometric (sine, cosine and tangent) functions.

Solving scientific problems involving calculus:

Examples specific to the specialist pathway.

LO4 **Approximate solutions of contextualised examples with graphical and numerical methods, and assess limitations and concluding results**

Graphical and numerical methods:

Standard curves of common functions, including quadratic, cubic, logarithm and exponential curves

Systematic curve sketching knowing the equation of the curve

Using sketches to approximate solutions of equations

Numerical analysis using the bisection method and the Newton–Raphson method

Numerical integration using the mid-ordinate rule, the trapezium rule and Simpson’s rule.

Assessing limitations and concluding results:

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

Learning Outcomes and Assessment Criteria

Pass	Merit	Distinction
LO1 Analyse scientific data using statistics		**D1** Critically analyse the application of different statistical tests using suitable examples
P1 Assess the use of descriptive statistics to establish whether data conforms to a normal distribution **P2** Apply significance testing to establish whether a hypothesis is correct	**M1** Discuss the application of one-tailed and two-tailed tests	
LO2 Use matrix methods to solve systems of linear equations relevant to science applications		**D2** Analyse the applications of matrix algebra with the solutions you derived
P3 Explore matrix operations relevant to science applications **P4** Apply matrix algebra to solve a system of linear equations to scientific problems	**M2** Calculate the inverse matrix for given 3x3 matrices to solve a set of 3 linear equations	
LO3 Examine how differential and integral calculus can be used to solve scientific problems		**D3** Research real-world applications of exponential growth and decay models to evaluate how closely they correlate
P5 Determine rates of change for algebraic, logarithmic and circular functions using the quotient, product and chain rules **P6** Use integral calculus to solve practical problems relating to the applied sciences	**M3** Formulate predictions of exponential growth and decay models, using integration methods	

Pass	Merit	Distinction
LO4 Approximate solutions of contextualised examples with graphical and numerical methods, and assess limitations and concluding results		**D4** Critique the use of numerical estimation methods, commenting on their applicability and the accuracy of the methods
P7 Estimate solutions of sketched functions using graphical and numerical estimation methods **P8** Assess the accuracy of a model and the results obtained using the outcomes of processing carried out on experimental data	**M4** Solve scientific problems and formulate mathematical models, using graphical and numerical integration **M5** Discuss validity and confirmation of experimental results obtained prior to concluding	

Recommended resources

Textbooks

AITKEN, M., BROADHURST, B., HLADKY, S. (2009) *Mathematics for Biological Scientists.* New York: Garland Science (Taylor & Francis Group).

FRANCIS, P.G. (2013) *Mathematics for Chemists*. New York: Springer.

HOLMES, S., HUBER, W. (2019) *Modern Statistics for Modern Biology*. Cambridge: Cambridge University Press.

MONK, P., MUNRO, L.J. (2010) *Maths for Chemistry: A Chemist's Toolkit of Calculations.* 2nd ed. Oxford: Oxford University Press.

MOORE, D.S., MCCABE, G.P., CRAIG, B.A. (2017) *Introduction to the Practice of Statistics.* 9th ed. New York: W.H. Freeman (Macmillan Publishers).

SINGH, K. (2011) *Engineering Mathematics Through Applications*. 2nd ed. Basingstoke: Palgrave Macmillan.

STEINER, E. (2008) *The Chemistry Maths Book*. 2nd ed. New York: Oxford University Press USA.

STROUD, K.A. (2009) *Foundation Mathematics.* Basingstoke: Palgrave Macmillan.

STROUD, K.A., BOOTH, D.J. (2013) *Engineering Mathematics*. 7th ed. Basingstoke: Palgrave Macmillan.

Web

mathcentre.ac.uk	Mathcentre (Tutorials)
mathtutor.ac.uk	Mathtutor (Tutorials)

Links

This unit links to the following related units:

Unit 1: Fundamentals of Laboratory Techniques

Unit 2: Scientific Data Handling Approaches and Techniques

Unit 5: Fundamentals of Chemistry

Unit 14: Food Technology

Unit 21: Criminal Investigation

Unit 26: Managing Scientific Projects

Unit 28: Applied Sciences Research Project

Unit 33: Analytical Techniques for Forensic Science

Unit 51: Specialist Scientific Techniques and Experimentation

Unit 59: Genetic Analysis

Unit 28: Applied Sciences Research Project (Pearson-set)

Unit code	**H/617/5385**
Unit type	**Core**
Unit level	**5**
Credit value	**30**

Introduction

Completing a piece of research is an opportunity for students to showcase their intellect and talents. It integrates knowledge with different skills and abilities that may have not been assessed previously, which may include seeking out and reviewing original research papers, designing their own experimental work, solving problems as they arise, managing time, finding new ways of analysing and presenting data, gaining further skills appropriate to their research, writing an extensive report, and presenting it in front of an audience. Research can always be a challenge but one that can be immensely fulfilling, an experience that goes beyond a mark or a grade but extends into long-lasting areas of personal and professional development.

This unit introduces students to the skills necessary to deliver a complex, independently conducted research project that fits within the context of applied sciences, such as: biology; biotechnology; forensic science; chemistry; environmental sustainability; water and wastewater; food science, technology and nutrition; and polymer science and technology. The students will develop skills such as critical thinking, analysis, reasoning, interpretation, decision-making, information literacy, innovation, creativity, collaboration, adaptability, written and oral communication.

On successful completion of this unit, students will be able to deliver a complex and independent research project in line with the original objectives, explain the critical thinking skills associated with solving scientific problems, consider multiple perspectives in reaching a balanced and justifiable conclusion, make recommendations based on their findings, suggest ways for further research and/or development of the topic, and communicate effectively a research project’s outcome, both in writing and in front of an audience.

The unit is assessed by a Pearson-set assignment. Students will choose their own project based on a theme provided by Pearson (this will change annually). The project must be related to their specialist pathway of study. This will enable students to explore and examine a relevant and current topical aspect of applied sciences in the context of an organisational or academic environment and their chosen specialist pathway.

Learning Outcomes

By the end of this unit, students will be able to:

1 Examine research methodologies and approaches appropriate to applied sciences, as part of the research process

2 Conduct and analyse research relevant to the applied science research project topic chosen

3 Communicate the outcomes of the research project to identified stakeholders

4 Reflect on the application of research methodologies and concepts.

Essential Content

LO1 **Examine research methodologies and approaches appropriate to applied sciences, as part of the research process**

Developing a research proposition:

The importance of developing methodical and valid propositions as the foundation for a research project

Rationale: the purpose and significance for research question or hypothesis

The value of the philosophical position of the researcher and the chosen methods

Use of Saunders' research onion as a guide to establishing a methodological approach.

Literature review:

Conceptualisation of the research problem or hypothesis

The importance of positioning a research project in the context of existing knowledge

Significance and means of providing benchmarks by which data can be judged.

Qualitative, quantitative and mixed method research:

Key theoretical frameworks for research

Advantages and limitations of qualitative and quantitative research approaches and methods.

Health, safety, and risk assessment in relation to project work:

Potential hazards e.g. risk assessment, COSHH analysis, expectation and responsibilities, etc.

List of requirements:

Equipment (e.g. time using instruments, glassware, specialist equipment, etc.)

Materials (e.g. chemicals, bacterial cultures, polymer samples, food samples, etc.)

Technical support (e.g. advice on how to use specific equipment, supervision for fieldwork, preparation of materials, etc.)

Time management:

Gantt chart or similar time management tools to support planning

LO2 **Conduct and analyse research relevant to the applied science research project topic chosen**

Research as a process:

Research has distinct phases which support a coherent and logical argument. This includes using secondary research to inform a primary, empirical, study.

Selecting a sample:

The importance of gathering data and information (qualitative or quantitative) to support research analysis

Selecting sample types and sizes that are relevant to the research

Considering sampling approaches and techniques, including probability and nonprobability sampling.

Ethics, reliability and validity:

Research should be conducted ethically. How is this achieved and reported?

Research should also be reliable (similar results would be achieved from a similar sample) and valid (the research measures what it aimed to measure).

Analysing data:

Using data collection tools such as interviews and questionnaires

Using analytical techniques such as trend analysis, coding or typologies.

LO3 **Communicate the outcomes of the research project to identified stakeholders**

Stakeholders:

Who are they?

Why would they be interested in the research outcomes?

What communication method do they expect?

Communicating research outcomes:

Consideration of different methods of communicating outcomes (e.g. written word, spoken word) and the medium (e.g. report, online, presentation). The method and medium will be influenced by the research and its intended audience.

Convincing arguments:

No matter what the method/medium, all research should be convincing and presented logically where the assumption is that the audience has little or no knowledge of the research process

The importance of developing evaluative conclusions.

LO4 **Reflect on the application of research methodologies and concepts**

Reflection for learning and practice:

Difference between reflecting on performance and evaluating a research project. The former considers the research process; the latter considers the quality of the research argument and use of evidence

Reflection on the merits, limitations and potential pitfalls of the chosen methods.

The cycle of reflection:

To include reflection in action and reflection on action

Considering how to use reflection to inform future behaviour and future considerations.

Reflective writing:

Avoiding generalisation and focusing on personal development and the research journey in a critical and objective way.

Learning Outcomes and Assessment Criteria

Pass	Merit	Distinction
LO1 Examine research methodologies and approaches appropriate to applied sciences, as part of the research process		**LO1 and LO2**
P1 Produce a research proposal that clearly defines a research question or hypothesis supported by a literature review **P2** Examine appropriate research methods and approaches to primary and secondary research	**M1** Evaluate different research approaches and methodologies and make justifications for the choice of methods selected based on philosophical/theoretical frameworks	**D1** Critically evaluate research methodologies and processes in application to a research project in applied sciences to justify chosen research methods and analysis
LO2 Conduct and analyse research relevant to the applied science research project topic chosen		
P3 Conduct primary and secondary research, using appropriate methods for a research project in applied science that also considers ethical issues **P4** Apply appropriate analytical tools, analyse research findings and data	**M2** Discuss merits, limitations and pitfalls of approaches to data collection and analysis	

Pass	Merit	Distinction
LO3 Communicate the outcomes of the research project to identified stakeholders		**D2** Communicate critical analysis of the outcomes and make valid and justified recommendations
P5 Communicate research outcomes in an appropriate manner for the intended audience	**M3** Coherently and logically communicate outcomes to the intended audience, demonstrating how outcomes meet set research objectives	
LO4 Reflect on the application of research methodologies and concepts.		**D3** Demonstrate reflection and engagement in the research process leading to recommended actions for future improvement
P6 Reflect on the effectiveness of research methods applied for meeting objectives of the research project in applied sciences **P8** Consider alternative research methodologies and lessons learned in view of the outcomes	**M4** Provide critical reflection and insight that results in recommended actions for improvements and future research considerations	

Recommended resources

Textbooks

BELL, J., WATERS, S. (2018) *Doing Your Research Project: A Guide for First-time Researchers.* 7th ed. London: Open University Press.

COSTLEY, C., ELLIOT, G., GIBBS, P. (2010) *Doing Work Based Research: Approaches to Enquiry for Insider-researchers*. London: SAGE Publications Ltd.

DAVIES, M., HUGHES, N. (2014) *Doing a Successful Research Project: Using Qualitative or Quantitative Methods.* 2nd ed. London: Springer/Red Globe Press.

FINK, A. (2019) *Conducting Research Literature Reviews: From the Internet to Paper*. 5th ed. USA: SAGE Publications Inc.

FLICK, U. (2011) *Introducing Research Methodology: A Beginner's Guide to Doing a Research Project.* London: SAGE Publications Ltd.

GRAY, D. (2017) *Doing Research in the Real World*. 4th Ed. London: SAGE Publications Ltd.

SAUNDERS, M., LEWIS, P., THORNHILL, A. (2012) *Research Methods for Business Students.* 6th ed. Harlow: Pearson Education Ltd.

THOMAS, G. (2017) *How to Do Your Research Project: A Guide for Students*. 3rd ed. London: SAGE Publications Ltd.

Web

apm.org.uk	Association for Project Management (General reference)
sciencemag.org	Science Magazine (Research)

Links

This unit links to the following related units:

Unit 2: Scientific Data Handling Approaches and Techniques

Unit 26: Managing Scientific Projects

Unit 27: Analysis of Scientific Data and Information

Unit 29: Biochemistry of Macromolecules and Metabolic Pathways

Unit code	**K/617/5386**
Unit level	**5**
Credit value	**15**

Introduction

Biochemistry is the study of chemical substances and vital processes that occur in living organisms. It involves the study of the structure and function of cellular components, such as proteins, carbohydrates, lipids, nucleic acids, and other biomolecules, and of their functions and transformations during life processes. Its main objective is to understand how biomolecules relate to a particular process within a living cell.

In this unit the students will develop an understanding of how the structure and function of proteins are determined by the chemical structure and functional group chemistry of amino acids. The students will also learn how chemical structure and functional group chemistry enable phospholipids to form membranes.

The unit also enables students to develop an understanding of the key features of the main metabolic pathways and their relationship to one another. The students will develop an understanding of how enzymes regulate metabolic pathways. The students will also learn how enzymes may act as activators and inhibitors of other enzymes in the metabolic process.

The unit gives students the opportunity to develop a range of biochemical practical skills that involve separation, purification, identification and measurement. The students will also learn to analyse and display experimental results correctly and to form conclusions based on data analysis.

Learning Outcomes

By the end of this unit, students will be able to:

1 Discuss how the structural features of proteins and phospholipids are determined by their chemical structures

2 Explore techniques to separate and identify amino acids and proteins

3 Analyse the features of the main metabolic pathways

4 Explore the roles and characteristics of enzymes in controlling metabolic pathways.

Essential Content

LO1 **Discuss how the structural features of proteins and phospholipids are determined by their chemical structures**

How the amino acid sequence of a protein determines its secondary, tertiary and quaternary structure:

Four levels of protein structure

The role of proline in determining secondary structure

Chemical attractions between side chains in tertiary structures

Location of amino acids in globular proteins

Structure of collagen.

Nucleic acids:

structure of a strand of deoxyribonucleic acid (DNA), double helix and the role of hydrogen bonding, types of ribonucleic acid (RNA), protein biosynthesis

Structural Features of phospholipids that enable them to form membranes:

Molecular structure of a phospholipid

Amphipathic property of a phospholipid

Effect of fatty acid length and saturation on membrane fluidity

Movement of proteins.

LO2 **Explore techniques to separate and identify amino acids and proteins**

Plan methods to separate and identify amino acids and proteins:

Paper chromatography

Size-exclusion chromatography

Hydrophobic interactions

Affinity chromatography

Gel filtration chromatography

Polyacrylamide electrophoresis.

Undertake an amino acid separation and identification and a protein separation and identification:

Use two methods from:

Paper chromatography and R_f values

Size-exclusion chromatography

Hydrophobic interactions

Affinity chromatography

Gel filtration chromatography

Polyacrylamide electrophoresis.

LO3 **Analyse the features of the main metabolic pathways**

The main metabolic pathways:

Glycolysis

The citric acid cycle (CAC)

Oxidative phosphorylation

Pentose phosphate pathway

Urea cycle

Fatty acid ß-oxidation

Gluconeogenesis.

How the main metabolic pathways interact with each other:

Acetyl coenzyme a, the citric acid cycle and fatty acid ß-oxidation

Glucose 6-phosphate (g6p), glycolysis, glycogen synthesis and the pentose phosphate pathway

Fumarate, the citric acid cycle and the urea cycle.

LO4 **Explore the roles and characteristics of enzymes in controlling metabolic pathways**

The role of Enzymes in controlling metabolic pathways:

Roles of amino acids in active sites

Enzyme specificity

The six main classes of enzymes: oxireductases, transferases, hydrolases, lyases, isomerases, ligases

Enzyme compartmentalisation

Factors that can affect an enzyme's activity (temperature, pH)

Activators and inhibitors

Competitive and noncompetitive inhibition

Cofactors and coenzymes

How availability of cofactors and coenzymes regulate enzyme function

The role of phosphorylation in controlling enzyme activity

Feedback inhibition.

Investigate experimentally the optimum conditions for the activity of an enzyme:

Optimum temperature

Optimum pH

The effect of substrate concentration

The effect of enzyme concentration

Plots of products versus time

Plots of reaction rates versus time

Analysing the reaction rate graphs to determine Maximal Velocities (Vmax) and the Michaelis-Mensten constants (K_M).

Learning Outcomes and Assessment Criteria

Pass	Merit	Distinction
LO1 Discuss how the structural features of proteins and phospholipids are determined by their chemical structures		**LO1 and LO2**
P1 Discuss how the amino acid sequence of a protein determines its secondary, tertiary and quaternary structures **P2** Explain the structural features of phospholipids that enable them to form membranes **P3** Discuss the roles of the nucleic acids in protein biosynthesis with reference to the structural differences between DNA and different types of RNA	**M1** Analyse the levels of protein structure and the possible protein roles that will be produced from particular amino acid sequences	**D1** Critically analyse how a nucleic acid sequence will determine the structure and role of a protein
LO2 Explore techniques to separate and identify amino acids and proteins		
P4 Plan methods to separate and identify amino acids and proteins **P5** Undertake an amino acid separation and identification, and a protein separation and identification	**M2** Analyse the results obtained from the separations to correctly identify the amino acids and proteins used	

<table>
<tr><th>Pass</th><th>Merit</th><th>Distinction</th></tr>
<tr><td colspan="2">LO3 Analyse the features of the main metabolic pathways</td><td rowspan="5">LO3 and LO4

D2 Critically analyse how enzyme inhibition and activation regulates the metabolic flow in the main metabolic pathways</td></tr>
<tr><td>P6 Discuss the main metabolic pathways

P7 Discuss how the main metabolic pathways interact with each other</td><td>M3 Analyse the reactions of the molecules that interact between the main metabolic pathways and the classes of enzymes that control them</td></tr>
<tr><td colspan="2">LO4 Explore the roles and characteristics of enzymes in controlling metabolic pathways</td></tr>
<tr><td>P8 Discuss the role of enzymes in controlling metabolic pathways

P9 Investigate experimentally the optimum conditions for the activity of an enzyme</td><td>M4 Analyse the implications of the experimental data obtained on the characteristics of an enzyme in relation to its role in catalysing reactions</td></tr>
</table>

Recommended resources

Textbooks

DEVLIN, T.M. (2019) *Textbook of Biochemistry with Clinical Correlations.* 8th ed. Hoboken, NJ: John Wiley & Sons, Inc.

MATHEWS, C.K., VAN HOLDE, K.E., APPLING, D.R., ANTHONY-CAHILL, S.J. (2012) *Biochemistry.* 4th ed. New York: Pearson Education Ltd.

NELSON, D.L., COX, M.M. (2017) *Lehninger Principles of Biochemistry.* 7th ed. New York: W.H. Freeman.

STRYER, L., BERG, J.M., TYMOCZKO, J.L. (2002) *Biochemistry.* 5th ed. New York: W.H. Freeman.

VOET, J.G., PRATT, C.W., VOET, D. (2012) *Principles of Biochemistry.* 4th ed. Hoboken, NJ: John Wiley & Sons, Inc.

Web

biochemden.com	Biochemistry Den (General reference)
biochemweb.net	BioChemWeb.net (General reference)
khanacademy.org	Khan Academy Amino acids, proteins and enzymes (General reference)
metacyc.org	MetaCyc Metabolic pathways and regulation (General reference)

Links

This unit links to the following related units:

Unit 27: Analysis of Scientific Data and Information

Unit 30: Molecular Biology and Genetics

Unit 32: Biotechnology Techniques

Unit 36: Aromatic and Carbonyl Compounds

Unit 49: Principles of Pharmacology

Unit 59: Genetic Analysis

Unit 30: Molecular Biology and Genetics

Unit code	**M/617/5387**
Unit level	**5**
Credit value	**15**

Introduction

Molecular biology provides the practical technology to investigate genetic effects at a cellular and molecular level. Working at the level of molecules, the genetic code can be analysed and manipulated to generate information about the way in that the body works and the changes which occur in disease states. This area of science continues to inform about the risks of developing disease over a lifetime and to provide a scaffold for new therapies to be discovered.

The aim of this unit is to provide students with knowledge and understanding of the organizational structure of DNA, the principles of human inheritance and the role of molecular biology in the study and treatment of inherited disorders.

Working with nucleic acids requires a specific range of tools such as restriction enzymes as well as knowledge of the molecular structures that operate regulate genes and their expression within the cell.

Students will explore the different methods of manipulating nucleic acid (including analysis and modification), their application and the information and use of these technologies.

Students will explore the inheritance patterns of common genetic disorders and develop understanding of the changes in DNA that are associated with them including grounding in modern genetic techniques.

The knowledge, understanding and skill sets gained in this unit will help students to develop up-to-date knowledge that is both detailed and applied to human medicine. This will provide insight into careers in medical science, the pharmaceutical industry, healthcare and other subjects allied to medicine. Elements of the unit will allow students to engage with current research in the topic area.

Learning Outcomes

By the end of this unit, students will be able to:

1 Discuss the organisational structure and function of mammalian DNA and RNA

2 Apply technologies to manipulate nucleic acids

3 Illustrate inheritance patterns of diseases, using defined conventions

4 Discuss the way in which changes in DNA can be linked to inherited physical effects in humans.

Essential Content

LO1 **Discuss the organisational structure and function of mammalian DNA and RNA**

The central dogma of molecular biology:

DNA makes RNA makes protein

The triplet code

Process of transcription at the nucleolus

Role and form of mRNA

Process of translation at the ribosome

The triplet code

Role and forms of tRNA

Fidelity of information.

The structure of genes:

Coding and non-coding regions

Motifs and regulatory sequences

Enhancer and silencer sequences.

Regulation of gene expression:

Patterns of gene expression lead to cellular specialisation

Transcription factors − proteins regulate DNA

Housekeeping genes, silent genes and active genes.

LO2 **Apply technologies to manipulate nucleic acids**

Isolation of DNA:

Preparing DNA from cells

Purification of DNA

Assay of quantity and quality of DNA, using spectrophotometry.

Manipulating DNA:

Restriction digests

Gel electrophoresis

Process of cloning DNA.

Detecting DNA:

Southern blotting

Footprinting

Expression, using vectors and gene transfer.

LO3 **Illustrate inheritance patterns of diseases, using defined conventions**

Interpretation and representation of information about inheritance:

Genetic diagrams

Punnett squares

Pedigrees (software could be used to produce these)

Use of technical terms.

Patterns of inheritance:

Autosomal recessive disorders

Autosomal dominant disorders

Co-dominant disorders

Sex-linked disorders

Epistasis.

LO4 **Discuss the way in which changes in DNA can be linked to inherited physical effects in humans.**

Minor alterations in DNA can cause serious effects:

*P*oint mutations change the amino acid sequence of proteins (sickle cell anaemia, Huntington's disease)

Mechanism of alterations in amino acid sequence cause profound effects

A range of mutations can lead to the same disease (cystic fibrosis)

Inheritance and the risk of cancer (BRCA genes, oncogenes from viruses, telomerase).

Learning Outcomes and Assessment Criteria

Pass	Merit	Distinction
LO1 Discuss the organisational structure and function of mammalian DNA and RNA		**D1** Critically evaluate the importance of nucleic acids being copied from an existing template to cellular function
P1 Illustrate the ways in which the organisational structure of DNA and RNA relates to the efficient functioning of the cell **P2** Discuss the role that DNA plays in cells becoming specialised for their function in the body	**M1** Analyse the molecular processes that allow cells to efficiently function in response to changes in their environment	
LO2 Apply technologies to manipulate nucleic acids		**D2** Critically evaluate methodologies used to clone and express DNA in different organisms
P3 Apply methods to isolate, quantify and measure the purity of DNA **P4** Report on procedures used to modify DNA	**M2** Compare methods used to analyse DNA sequences *in vitro*	
LO3 Illustrate the inheritance patterns for diseases, using defined conventions		**D3** Evaluate the ways in which epistasis can manifest in phenotype
P5 Illustrate the inheritance patterns for dominant and recessive diseases, using genetic diagrams **P6** Predict outcomes of genetic crosses, using the Punnett square	**M3** Review complex information (including pedigrees) to account for inheritance patterns of sex-linked disorders	

Pass	Merit	Distinction
LO4 Discuss how changes in DNA can be linked to inherited physical effects in humans.		**D4** Critically evaluate genetic risk factors in the lifetime development of serious diseases, such as cancers
P7 Illustrate the effect on protein structure as a result of a change in a single base pair in DNA **P8** Show how the pathologies of serious diseases result from a change in a single base pair of DNA	**M4** Evaluate, using a named example, the way in which there can be a range of changes to a single gene that result in a similar disease pathology	

Recommended resources

Textbooks

ALLISON, L.A. (2011) *Fundamental Molecular Biology*. 2nd ed. Oxford: Wiley-Blackwell.

BROWN, T.A. (2015) *Introduction to Genetics: A Molecular Approach.* Boca Raton, FL: CRC Press/Garland Science.

LEWIS, R. (2017) *Human Genetics: The Basics.* 12th ed. Abingdon: Routledge.

Web

en.wikibooks.org	Wikibooks – open access An Introduction to Molecular Biology (General reference)
genetics.org.uk	The British Genetics Society (General reference)
cambridge.org	Cambridge Journals – Cambridge Core Genetics (Research)

Links

This unit links to the following related units:

Unit 1: Fundamentals of Laboratory Techniques

Unit 4: Cell Biology

Unit 6: Anatomy and Human Physiology

Unit 17: Fundamentals of Biochemistry

Unit 32: Biotechnology Techniques

Unit 43: Investigating the Properties of Food Molecules

Unit 59: Genetic Analysis

Unit 51: Specialist Scientific Techniques and Experimentation

Unit 56: Stem Cell Biology

Unit 59: Genetic Analysis

Unit 31: Immunology

Unit code	**T/617/5388**
Unit level	**5**
Credit value	**15**

Introduction

Immunology is the study of the immune system which protects the body from infection. The study of immunology has led to many breakthroughs in the understanding and treatment of human disease, such as the development of vaccines against many diseases, treatment of autoimmune disorders and new therapies for cancer.

Research in the discipline of immunology has produced many Nobel prize winners and contributed heavily to the field of medicine, including the discoveries of blood groups, antibodies and the causes of diseases, such as AIDS.

The central ideas key to immunology are that the body has both inborn and learned processes (the adaptive response) to protect itself. Critical to understanding is the idea that the human body can minutely detect foreign substances and differentiate them from 'self', a process that is damaged in autoimmune disorders where self-reactivity occurs.

This unit will allow students to develop a detailed knowledge of how the immune system works to defend the body against other microorganisms, in particular viruses and pathogens. The unit will offer a clear perspective on the components of the normal human immune system in both its innate and adaptive forms.

In this unit, students will gain knowledge of the way in which the range of the immune response is derived developmentally, and how the self-reactivity of autoimmune disorders can occur.

The knowledge, understanding and skill sets gained in this unit will help students relate to fields within the medical professions and develop their interests in choosing a career in this area.

Learning Outcomes

By the end of this unit students will be able to:

1 Explore the nature of common pathogens.

2 Analyse the activity of the innate immune response.

3 Review the ways in which the adaptive immune response detects and responds to specific challenges.

4 Discuss the processes that lead to lymphocyte ontogeny in humans and the way in which autoimmunity can develop.

Essential Content

LO1 **Explore the nature of common pathogens**

Development of germ theory:

Contributions of variolation, Jenner, Snow, Pasteur and Koch

Transmission of disease (routes of infection, with examples)

Categories of disease.

Nature of infection:

Bacterial cells as pathogens

Viruses

Other pathogens, such as single cells organisms (protoctists), parasites and prions.

LO2 **Analyse the activity of the innate immune response**

Innate immunity:

Non-specific but present from birth

Processes are ancient in evolution and shared across many species

Mechanisms of automatic response on contact with 'non-self' material.

First line of defence against the entry and spread of infection:

Barriers such as skin and secretions, mucus membranes

Blood coagulation

Role of neutrophils as sacrificial cells.

Second line of defence:

Inflammation − rugor, calor, turgor, dolor, how these are mediated and their function in protecting the body

Fever – mechanism of change in body temperature, function of fever, consequences of fever to health

NK (natural killer) cells may be covered

Complement activation

Role of chemokines such, as interleukins and interferons.

LO3 **Review the ways in which the adaptive immune response detects and responds to specific challenges**

Adaptive immunity:

Not present at birth but requires exposure to pathogens

Highly specific, develops beyond 6 month's of age

Precise recognition of non-self and changed self (cancers and cells infected with virus).

Reaction of antigen with antibody:

Structure of antibodies

Binding of antibody to specific antigen.

Role of T and B cells – the anamnestic response:

T cells have several subtypes, each with defined functions

B cells mediate humoral immunity

Clonal selection and clonal expansion to produce appropriate antibodies

Contribution of cell surface glycoproteins to recognition (MHC and antigen presentation)

Contribution of regulatory soluble factors (cytokines) to immune response.

Donated versus learned immunity:

Vaccination produces an anamnestic response

Breastfeeding and targeted monoclonal antibodies are donated immunity and do not generate an anamnestic response.

LO4 **Discuss the processes that lead to lymphocyte ontogeny in humans and the way in which autoimmunity can develop.**

Lymphocyte ontogeny:

Development and maturation of lymphocytes

Gene shuffling to produce an infinite range of B and T cell receptors.

Mechanisms of preventing self reactivity:

B and T cells work together

Role of antigen presentation and immune display (MHC Class I & II).

Immune basis of autoimmune disorders:

Hashimoto's thyroiditis

Coeliac disease

Rheumatoid arthritis.

Learning Outcomes and Assessment Criteria

Pass	Merit	Distinction
LO1 Explore the nature of common pathogens		
P1 Differentiate the structure of bacterial cells from those of eukaryotes **P2** Compare the nature of viruses with that of other pathogens, such as bacteria	**M1** Illustrate the challenges to the immune system posed by viral pathogens	**D1** Review the risks to health posed by infection with named pathogenic organisms
LO2 Analyse the activity of the innate immune response		
P3 Review the role of the barriers, clotting and neutrophils in the body **P4** Discuss the role of Inflammation and fever in the body's defences	**M2** Analyse the contribution of the range of barriers, to include the complement, clotting and kinin cascades	**D2** Assess the contribution of the innate immune system in neonates

Pass	Merit	Distinction
LO3 Review the ways in which the adaptive immune response detects and responds to specific challenges		**D3** Discuss the way in which different classes of major histocompatibility antigens regulate the activity of the adaptive immune system
P5 Explore the role of T cells in adaptive immunity **P6** Assess the contribution of B cells to the adaptive immune response	**M3** Analyse the ways in which T and B cells work together to mediate the adaptive immune response	
LO4 Discuss the processes that lead to lymphocyte ontogeny in humans and the way in which autoimmunity can develop		**D4** Critically review theories of the mechanism by which self-reactivity is limited in the mature immune system
P7 Interpret theories that account for the development of lymphocyte ontogeny **P8** Explore mechanisms by which a named autoimmune disorder can develop	**M4** Compare the theories relating to the successful maturation of lymphocytes in humans	

Recommended resources

Textbooks

DELVES, P.J., MARTIN, S.J., BURTON, D.R., ROITT, I.M. (2017) *Roitt's Essential Immunology*. 13th ed. Oxford: Wiley-Blackwell.

PLAYFAIR, J.H.L., CHAIN, B.M. (2012) *Immunology at a Glance*. 10th ed. Oxford: Wiley-Blackwell.

Web

cell.com	Cell Press Trends in immunology (Articles)
immunology.org	British Society for Immunology (General reference)
roitt.com	Roitt's Essential Immunology Resources (General reference)

Links

This unit links to the following related units:

Unit 4: Cell Biology

Unit 6: Anatomy and Human Physiology

Unit 17: Fundamentals of Biochemistry

Unit 18: Microbiological Techniques

Unit 29: Biochemistry of Macromolecules and Metabolic Pathways

Unit 30: Molecular Biology and Genetics

Unit 57: Infectious Diseases and Diagnosis

Unit 58: Epidemiology of Communicable Diseases

Unit 59: Genetic Analysis

Unit 32: Biotechnology Techniques

Unit code	**A/617/5389**
Unit level	**5**
Credit value	**15**

Introduction

Biotechnology is any technological application that uses biological systems, living systems, living organisms or derivatives thereof, to make or modify products or processes for specific use. Biotechnology is used in many industries, including biological research, health care, agriculture and manufacturing. It is a combination of knowledge and techniques from many of the biological sciences. These include molecular biology and genetics, biochemistry, cell biology and microbiology. Chemistry also forms an important component of biotechnology, since many of the techniques in biochemistry rely on chemical interactions.

This unit will introduce the student to the main techniques used in Biotechnology. The students will learn how to grow and maintain cells in culture, gain experience of how to amplify DNA, using the polymerase chain reaction. They will also learn the steps involved in genetic engineering and will be given the opportunity to carry out a genetic transformation. The unit will also introduce the students to the chromatography techniques used to separate and purify proteins. The students will learn the importance of good laboratory practice (GLP) in following procedures.

Learning Outcomes

By the end of this unit students will be able to:

1 Explore methods of growing eukaryotic cells in culture

2 Carry out a polymerase chain reaction

3 Undertake a genetic transformation

4 Investigate the methods used to separate and purify proteins.

Essential Content

LO1 **Explore methods of growing eukaryotic cells in culture**

Discuss the methods used to grow cell eukaryotic cells in culture:

Cell lines

Cell types and culture characteristics (primary cultures, continuous cultures, monolayers, suspension cultures)

Different types of media and their uses

The cell environment (basic constituents of media, inorganic salts, buffering systems, carbohydrates, amino acids vitamins, serum, carbon dioxide, humidity, temperature)

Aseptic techniques and contamination control

Confluency and subculture

Cryopreservation

Mycoplasma.

Apply appropriate techniques to maintain, grow and subculture eukaryotic cells in culture:

Application of quality control procedures

Application of correct aseptic techniques

Preparation of cell culture media

Subculture of cells.

LO2 **Carry out a polymerase chain reaction**

Discuss the techniques involved in PCR and its application in the biotechnology industry:

The three stages of PCR: denaturation, annealing, extension

Components of a PCR reaction: template DNA, nucleotides (dNTPS), PCR buffer, magnesium chloride ($MgCl_2$), water, forward and reverse primers, DNA polymerase

PCR optimisation

Primer design

Cycling parameters

Types of PCR: conventional PCR, real time or quantitative PCR, reverse transcriptase PCR, multiplex PCR, degenerate PCR, nested PCR, fast PCR

Applications in industry: genetic modification of plants, DNA sequences, PCR in medicine, PCR in pharming, PCR in forensics

Undertake a polymerase chain reaction:

Set up PCR reactions

Use a thermal cycler

Perform an agarose gel electrophoresis, using the PCR products

Analyse results on the agarose gel.

LO3 **Undertake a genetic transformation**

Discuss the methods used to introduce foreign DNA into a cell:

Structure and function of the plasmid

Shuttle plasmids

Calcium chloride transformation

Heat shock

Electroporation

Transfection

Biolistics

Selected of transformed cells

Transformation efficiency.

Carry out a bacterial genetic transformation:

Streak bacteria to isolate single colonies

Transform bacteria by calcium chloride transformation

Inoculate plates with transformed bacteria.

LO4 **Investigate the methods used to separate and purify proteins**

Review the methods used to separate and purify proteins:

SDS-PAGE

Other PAGE techniques: native PAGE, isoelectric focusing, two-Dimensional PAGE

Principles of chromatography

Size exclusion chromatography

Hydrophobic interaction chromatography

Ion exchange chromatography

Affinity chromatography.

Apply techniques to separate and purify proteins:

SDS-PAGE

Size exclusion chromatography

One technique from hydrophobic interaction chromatography, ion exchange chromatography and affinity chromatography.

Learning Outcomes and Assessment Criteria

Pass	Merit	Distinction
LO1 Explore methods of growing eukaryotic cells in culture		**LO1 and LO2**
P1 Review the methods used to grow eukaryotic cells in culture **P2** Apply appropriate techniques to maintain, grow and subculture eukaryotic cells in culture	**M1** Calculate the mean generation time of a population of eukaryotic cells grown in culture	**D1** Critically evaluate how the cell culture and polymerase chain reaction techniques carried out compare to industry standards.
LO2 Carry out a polymerase chain reaction		
P3 Review the techniques involved in PCR and its application in the biotechnology industry **P4** Undertake a polymerase chain reaction	**M2** Analyse the products produced from a polymerase chain reaction	

Pass	Merit	Distinction
LO3 Undertake a genetic transformation		**LO3 and LO4**
P5 Review the methods used to introduce foreign DNA into a cell **P6** Carry out and report on a bacterial genetic transformation	**M3** Evaluate statistically the transformation efficiency of a bacterial genetic transformation procedure	**D2** Critically evaluate the success of the purification of a protein produced from a bacterial genetic transformation using SDS-PAGE
LO4 Investigate the methods used to separate and purify proteins		
P7 Review the methods used to separate and purify proteins **P8** Apply techniques to separate and purify proteins	**M4** Evaluate experimentally if the protein produced as a result of a bacterial genetic transformation can be separated from a mixture of proteins using hydrophobic interaction chromatography	

Recommended resources

Textbooks

ALBERTS, B., JOHNSON, A., LEWIS, J., MORGAN, D., RAFF, M., ROBERTS, K., WALTER, P. (2015) *Molecular Biology of the Cell.* 6th ed. Abingdon: Garland Science (Taylor & Francis Group).

FRESHNEY, R.I. (2010) *Culture of Animal Cells: A Manual of Basic Techniques and Specialised Applications*. 6th ed. Hoboken, NJ: John Wiley & Sons, Inc.

GODBEY, W.T. (2018) *An Introduction to Biotechnology: The Science, Technology and Medical Applications.* London: Academic Press.

KIRK BROWN, J. (2011) *Biotechnology: A Laboratory Skills Course.* Hercules, CA: Bio-Rad Laboratories.

SEIDMAN, L.A., KRAUS, E.M., BRANDNER, D., MOWERY, J. (2010) *Laboratory Manual for Biotechnology and Laboratory Science: The Basics.* Harlow: Pearson Education Ltd.

SEIDMAN, L.A., MOORE C.J. (2008) *Basic Laboratory Methods for Biotechnology.* 2nd ed. Harlow: Pearson Education Ltd.

Web

austincc.edu	Austin Community College Biotechnology laboratory techniques (General reference)
biozone.co.nz	BIOZONE Biotechnology techniques (General reference)
ncbi.nlm.nih.gov	National Center for Biotechnology Information (General reference)
slideshare.net	SlideShare Biotechnology – basic techniques (General reference)
thermofisher.com	ThermoFisher Scientific Cell culture basics – documents and support (General reference)

Links

This unit links to the following related units:

Unit 27: Analysis of Scientific Data and Information

Unit 29: Biochemistry of Macromolecules and Metabolic Pathways

Unit 30: Molecular Biology and Genetics

Unit 33: Analytical Techniques for Forensic Science

Unit 49: Principles of Pharmacology

Unit 51: Specialist Scientific Techniques and Experimentation

Unit 52: Drug Development for Production

Unit 53: Industrial Microbiology

Unit 56: Stem Cell Biology

Unit 57: Infectious Diseases and Diagnosis

Unit 58: Epidemiology of Communicable Diseases

Unit 59: Genetic Analysis

Unit 33: Analytical Techniques for Forensic Science

Unit code	**A/617/5392**
Unit level	**5**
Credit value	**15**

Introduction

Crime scenes are likely to contain a variety of types of evidence that must be analysed for example footprints, tool marks, blood spatters, paint, glass, hair, fingerprints body fluids, DNA, insects and eggs, gunshot residue, accelerants and drugs of abuse. This unit provides an overview of many of the analytical techniques likely to be used.

Students should have the opportunity to investigate and discuss the use of as many techniques as possible. It is expected that part of the investigative process will involve practical work. Students should supplement their practical investigative work by searching the literature to find examples of how analysis is carried out in practice.

When analysing evidence, forensic scientists need to ensure that the evidence is not contaminated and that all appropriate procedures are followed. Students will need to become aware of the factors that affect the validity or evidence and of the types of evidence that are more reliable and definitive.

Learning Outcomes

By the end of this unit students will be able to:

1 Investigate the methods used to analyse fingerprints and pattern evidence

2 Discuss the biological techniques used in forensic science

3 Discuss the chemical techniques used in forensic science

4 Explore the analytical uses of presumptive and spot tests.

Essential Content

LO1 **Investigate the methods used to analyse fingerprints and pattern evidence**

Nature of the fingerprint:

Type of surface

Patent, plastic or latent prints

Method of visualising a fingerprint

Whole or part fingerprints

Possible distortion

Ageing (triangle of interaction)

Fingerprint lifts

Photographs of fingerprints.

Initial assessment:

Suitability of print for valid comparison.

Comparison:

Comparison with fingerprints from a suspect

Comparison with prints in a database

Visual comparison

Unusual features, e.g. scarring

Basic shape: loop, whorl, arch

Computer programmes for matching

Repeatability and reproducibility of comparison.

Pattern evidence:

Footprint analysis

Analysis of blood spatter patterns

Analysis of tool marks.

LO2 **Discuss the biological techniques used in forensic science**

Entomology:

Life cycle of blow fly

Estimation of time of death using stages in the insect life cycle.

Forensic anthropology:

Information from individual bones, e.g. height

Information from skeleton.

Body fluids:

Urine, saliva, semen, blood

Techniques for examining textiles and surfaces.

DNA:

Sources

Extraction

Amplification

Use of polymerase chain reaction (PCR)

Mitochondrial DNA

Nuclear DNA

DNA analysis from trace evidence

Interrogation of DNA databases

Sources of contamination of samples

Prevention of contamination of samples

Degree of conclusiveness of DNA evidence.

LO3 **Discuss the chemical techniques used in forensic science**

Analysis of paints and polymers:

Differential scanning calorimetry (DSC)

Infrared spectroscopy.

Toxicology and analysis of drugs of abuse:

Spot testing

Gas Chromatography (GC) and GC-mass spectroscopy

High performance liquid chromatography (HPLC)

Infrared spectroscopy

Bulk samples

Trace samples.

Gunshot residue:

Energy dispersive X-Ray (EDX/EDS) spectroscopy

Scanning electron microscope (SEM)

SEM-EDX

Characteristic combination of elements.

Explosives and accelerants:

Infrared spectroscopy

GC and GC-mass spectroscopy

HPLC.

Analysis of trace and bulk samples

LO4 **Explore the analytical uses of presumptive and spot tests.**

Presumptive/spot tests:

Body fluids: blood, semen, saliva, urine

Chemical substances: drugs, poisons, gunshot residue, explosives.

Learning Outcomes and Assessment Criteria

<table>
<tr><th>Pass</th><th>Merit</th><th>Distinction</th></tr>
<tr><td colspan="2">LO1 Investigate the techniques used in the analysis of fingerprints and pattern evidence</td><td rowspan="2">D1 Evaluate the reliability of fingerprint and pattern evidence</td></tr>
<tr><td>P1 Discuss how fingerprints from a crime scene may be matched with those of a known suspect and with those in a database

P2 Investigate and report on analysis of pattern evidence from staged crime scenes</td><td>M1 Review the most recent developments in fingerprints and pattern evidence analysis</td></tr>
<tr><td colspan="2">LO2 Discuss the biological techniques used in forensic science</td><td rowspan="2">D2 Evaluate the value of forensic entomology and analysis of DNA</td></tr>
<tr><td>P3 Illustrate how forensic entomology is used

P4 Compare the uses of nuclear and mitochondrial DNA in analysing evidence from a crime scene</td><td>M2 Assess the advances that have been made in forensic DNA analysis</td></tr>
<tr><td colspan="2">LO3 Discuss the chemical techniques used in forensic science</td><td rowspan="2">D3 Discuss the potential consequences from contaminated samples if the necessary steps are not taken to minimise contamination</td></tr>
<tr><td>P5 Discuss how gunshot residue is analysed

P6 Investigate how samples of one of the following types of evidence from a crime scene is analysed: paint, drugs of abuse, polymers, explosives, accelerants</td><td>M3 Evaluate the appropriateness of the chemical analysis techniques and methods used in forensic science</td></tr>
</table>

Pass	Merit	Distinction
LO4 Explore the analytical uses of presumptive and spot tests		**D4** Evaluate the scope for obtaining false positive results when using presumptive tests and spot tests
P7 Illustrate the use of presumptive tests in the analysis of body fluids and the use of different spot tests for the identification of different chemical substances **P8** Undertake three presumptive tests and three spot tests	**M4** Analyse the underlying principles behind the results of the selected presumptive tests and spot tests	

Recommended resources

Textbooks

BELL, S. (2013) *Forensic Chemistry: Pearson New International Edition.* 2nd ed. Harlow: Pearson Education Ltd.

BELL, S. (2019) *Forensic Science: An Introduction to Scientific and Investigative Techniques.* 5th ed. Boca Raton, FL: CRC Press.

BEVEL, T., GARDNER, R.M. (2001) *Bloodstain Pattern Analysis: With an Introduction to Crime Scene Reconstruction.* 2nd ed. Boca Raton, FL: CRC Press.

BLEAY, S.M., CROXTON, R.S., de PUIT, M. (2018) *Fingerprint Development Techniques: Theory and Application.* Hoboken, NJ: Wiley-Blackwell.

BUCKLETON, J.S., BRIGHT, J., TAYLOR, D. (Eds). (2016) *Forensic DNA Evidence Interpretation.* 2nd ed. Boca Raton, FL: CRC Press.

CHALMERS, J.M., EDWARDS, H.G.M. (2012) *Infrared and Raman Spectroscopy in Forensic Science.* Hoboken, NJ: Wiley-Blackwell.

DALUZ, H.M. (2018) *Fingerprint Analysis Laboratory Workbook.* 2nd ed. Boca Raton, FL: CRC Press.

ERICKSON, E. (2013) *Criminalistics Laboratory Manual: The Basics of Forensic Investigation.* Abingdon: Routledge.

FISHER, B.A.J., Tilstone, W.J., Woytowicz, C. (2009) *Introduction to Criminalistics: The Foundation of Forensic Science.* Burlington: Academic Press.

GENNARD, D. (2012) *Forensic Entomology: An Introduction.* 2nd ed. Chichester: Wiley-Blackwell.

GIRARD, J.E. (2018) *Criminalistics: Forensic Science, Crime and Terrorism.* 4th ed. Burlington: Jones and Bartlett Learning.

HOUCK, M.M. (Ed). (2015) *Forensic Chemistry (Advanced Forensic Science Series).* Oxford: Academic Press.

JACKSON, A.R.W., JACKSON, J.M., MOUNTAIN, H., BREARLEY, D. (2016) *Forensic Science.* 4th ed. Harlow: Pearson Education Ltd.

JUNGREIS, E. (1997) *Spot Test Analysis: Clinical, Environmental, Forensic and Geochemical Applications.* 2nd ed. New York: Wiley-Blackwell.

KINTZ, P., SALOMONE, A., VINCENTI, M. (Eds). (2015) *Hair Analysis in Clinical and Forensic Toxicology.* London: Academic Press.

KUMAR, A. (2018) *Contactless 3D Fingerprint Identification (Advances in Computer Vision and Pattern Recognition)*. Cham: Springer.

McCLINTOCK, J.T. (2014) *Forensic Analysis of Biological Evidence: A Laboratory Guide for Serological and DNA Typing.* Boca Raton, FL: CRC Press.

MELOAN, C., JAMES, R., SAFERSTEIN, R. (2014) *Lab Manual for Criminalistics: An Introduction to Forensic Science.* 11th ed. Harlow: Pearson Education Ltd.

RAMOTOWSKI, R. (Ed). (2013) *Lee and Gaensslen's Advances in Fingerprint Technology.* 3rd ed. Boca Raton, FL: CRC Press.

RIVERS, D.B., DAHLEM, G.A. (2014) *The Science of Forensic Entomology.* Chichester: John Wiley & Sons Ltd.

ROBERTSON, J. (Ed). (1999) *Forensic Examination of Hair (International Forensic Science and Investigation).* Boca Raton, FL: CRC Press.

ROBERTSON, J., ROUX, C., WIGGINS, K.G. (2017) *Forensic Examination of Fibres (International Forensic Science and Investigation).* 3rd ed. Boca Raton, FL: CRC Press.

ROBINSON, J.W., SKELLY FRAME, E.M., FRAME, G.M. (2014) *Undergraduate Instrumental Analysis.* 7th ed. Boca Raton, FL: CRC Press.

SAFERSTEIN, R. (2017). *Criminalistics: An Introduction to Forensic Science.* 12th ed. Harlow: Pearson Education Ltd.

SIEGEL, J.A. (Ed). (2016) *Forensic Chemistry: Fundamentals and Applications (Forensic Science in Focus).* Chichester/Hoboken, NJ: Wiley-Blackwell.

THE STATIONERY OFFICE. (2014) *Fingermark Visualisation Manual.* London: The Stationery Office.

WALLACE, J.S. (2018) *Chemical analysis of Firearms, Ammunition and Gunshot Residue (International Forensic Science and Investigation)* 2nd ed. Boca Raton, FL: CRC Press.

WHITE, P.C. (Ed). (2016) *Crime Scene to Court: The Essentials of Forensic Science.* 4th ed. Cambridge: The Royal Society of Chemistry.

Journals

DALBY, O., BUTLER, D., BIRKETT, J.W. (2010) 'Analysis of gunshot residue and associated Materials – a review', *Journal of Forensic Sciences*, 55 (4), pp. 924–943.

HRESHAK, A.K., McHUGH, J.A. (1990) 'Automated fingerprint recognition using structural matching', *Pattern Recognition*, 23 (8), pp. 893–904.

MELTON, T., DIMICK, G., HIGGINS, B., LINDSTROM, L., NELSON, K. (2005) 'Forensic mitochondrial DNA analysis of 691 casework hairs', *Journal of Forensic Sciences*, 50 (1), pp. 73–80.

Web

forensicmag.com	Forensic Magazine (Research)

Links

This unit links to the following related units:

Unit 1: Fundamentals of Laboratory Techniques

Unit 21: Criminal Investigation

Unit 24: Sampling and Sample Preparation

Unit 30: Molecular Biology and Genetics

Unit 32: Biotechnology Techniques

Unit 34: Forensic Evidence Collection and Preservation

Unit 35: Analytical Chemistry

Unit 50: Toxicology

Unit 51: Specialist Scientific Techniques and Experimentation

Unit 59: Genetic Analysis

Unit 34: Forensic Evidence Collection and Preservation

Unit code	**F/617/5393**
Unit level	**5**
Credit value	**15**

Introduction

Crime scene protocols for protecting, recording and processing evidence at a scene are essential to ensure confidence in the findings that are presented in a court of law. Forensic evidence can take many forms, e.g. fingerprints, blood, drugs of abuse and drug paraphernalia, documents and mobile phones; an objective approach to the identification of potential evidence is crucial to make sure no item of evidentiary value is overlooked

As technology advances and analysis methods become more sensitive, crime scene protocols and procedures for collecting and preserving evidence must keep pace to ensure the integrity of the evidence is maintained until legal processes are complete.

This unit offers opportunities for practical investigation of crime scene examination, the equipment used for collection and packaging of potential evidence, and preservation techniques that will maintain the integrity of the evidence throughout the course of the investigation.

Learning Outcomes

By the end of this unit, students will be able to:

1 Explore the measures employed to ensure the integrity and preservation of evidence collected from a crime scene

2 Investigate methods of collection of biological evidence

3 Investigate methods of collection of chemical evidence

4 Investigate methods of collection of physical evidence.

Essential Content

LO1 **Explore the measures employed to ensure the integrity and preservation of evidence collected from a crime scene**

Crime scene protocols:

Cordons and cordon logs

Health and safety

Measurements and sketches

Crime scene notes.

Photography/videography

Search patterns

Preliminary/secondary walkthrough

Sequential nature of evidence collection

Continuity of evidence

Crime scene report.

Packaging and labelling:

Bags: paper, plastic, tamperproof, content specific, e.g. drugs

Boxes

Containers: glass, plastic, metal

Weapon tubes

Paper wraps.

Preservation of biological, chemical and physical evidence:

At the crime scene

During forensic examination

Post forensic examination.

Cold cases:

Types of crime

Statutes of limitation and repose

Preservation of evidence

Witnesses' availability

Improvements in forensic science and technology.

Legislation:

Biological samples and stored DNA profiles

Return or destruction of items recovered as evidence.

LO2 **Investigate methods of collection of biological evidence**

Biological Evidence:

Entomology: live insects, eggs, larvae, soil

Anthropology, taphonomy and palynology; to include environmental conditions, skeletal remains, sampling all layers of site, pollens, diatoms

Bodily fluids: saliva, semen, blood, urine, vomit

Hair.

Scientific and technological developments in the collection and preservation of biological evidence

LO3 **Investigate methods of collection of chemical evidence**

Chemical Evidence:

Drugs of abuse and drug paraphernalia

Accelerants and explosives

Paint: wet, dry, chips, paint transfer, liquid

Foodstuff

Poisons.

Scientific and technological developments in the collection and preservation of chemical evidence

LO4 **Investigate methods of collection of physical evidence**

Physical evidence:

Impression marks: tool marks, footprints, fingerprints, tyre marks

Documents: photocopies, typewritten, laser printers, inkjet printers, handwritten, paper types, ink

Ballistics: firearms, shotgun cartridges, bullets and bullet casings, gunshot residue

Glass: flat, container, vehicle-related (windows, headlight/brake light, indicator covers)

Blood splatter

Fibres

IT: mobile phones, laptops, USB storage devices.

Scientific and technological developments in the collection and preservation of physical evidence

Learning Outcomes and Assessment Criteria

Pass	Merit	Distinction
LO1 Explore the measures employed to ensure the integrity and preservation of evidence collected from a crime scene		
P1 Explore how crime scene protocols contribute to the chain of continuity of evidence **P2** Investigate methods of preservation of biological, chemical and physical evidence **P3** Review the current legislation that applies to the retention of evidence	**M1** Justify the role that documentation of the crime scene plays in the chain of continuity of evidence **M2** Evaluate the importance of evidence preservation in cold case reviews	**D1** Discuss how the development of crime scene protocols has been affected by scientific and technological advancements
LO2 Investigate methods of collection of biological evidence		
P4 Explore methods of collection of biological evidence used in the processing of a simulated crime scene	**M3** Analyse the importance of environmental evidence in the collection of human remains	**D2** Evaluate recent scientific and technological developments in the methods of collection of trace biological evidence
LO3 Investigate methods of collection of chemical evidence		
P5 Explore methods of collection of chemical evidence used in the processing of a simulated crime scene	**M4** Analyse the effect of ageing and environmental conditions on the integrity of chemical evidence	**D3** Evaluate recent scientific and technological developments in the methods of collection of chemical evidence such as accelerants and explosives

Pass	Merit	Distinction
LO4 Investigate methods of collection of physical evidence.		
P6 Explore methods of collection of physical evidence used in the processing of a simulated crime scene	**M5** Analyse methods of visualisation of impression marks at a crime scene	**D4** Evaluate recent technological developments in the collection of digital forensic evidence

Recommended resources

Textbooks

BISHOP, M.R. (2008) *Insect Evidence: Basic Collection Procedures at the Death Scene. Bloomington*, IN: Xlibris Corp.

FISHER, B.A.J., FISHER, D.R. (2012) *Techniques of Crime Scene Investigation (Forensic and Police Science)*. 8th ed. Boca Raton, FL: CRC Press.

HAMMER, L. (2019) *Footwear and Tire Track Evidence Collection Manual.* Boca Raton, FL: CRC Press.

HOUCK, M.M. (Ed). (2017) *Forensic Anthropology (Advanced Forensic Science Series).* Amsterdam: Academic Press (Elsevier).

ICOVE, D. J., HAYNES, G. A., (2017) *Kirk's Fire Investigation (Brady Fire).* 8th ed. New York: Pearson.

MOZAYANI, A., PARISH-FISHER, C. (Eds). (2017) *Forensic Evidence Management: From the Crime Scene to the Courtroom*. Boca Raton, FL: CRC Press.

PFEFFERLI, P. (2015) *Forensic Evidence Field Guide: A Collection of Best Practices.* Amsterdam: Academic Press (Elsevier).

REIBER, L. (2019) *Mobile Forensic Investigations: A Guide to Evidence Collection, Analysis, and Presentation*. 2nd ed. New York: McGraw-Hill Education.

SUTTON, R., TRUEMAN, K., MORAN, C. (Eds). (2016) *Crime Scene Management: Scene Specific Methods*. 2nd ed. Chichester: Wiley-Blackwell.

Journals

AQUILA. F. et al. (2014) 'The role of forensic botany in crime scene investigation: Case report and review of literature', *Journal of Forensic Sciences*, 59 (3), pp. 820–824.

HESS, S., HAAS, C. (2017) 'Recovery of trace DNA on clothing: A comparison of mini-tape lifting and three other forensic evidence collection techniques', *Journal of Forensic Sciences*, 62 (1), pp. 187–191.

PLAZA, D.T. et al. (2015) 'Non-destructive biological evidence collection with alternative swabs and adhesive lifters', *Journal of Forensic Sciences*, 61 (2), pp. 485–488.

Web

gov.uk	UK Government website – publications Policy paper: Protection of Freedoms Act 2012: how DNA and fingerprint evidence is protected in law (Report)
westmercia.police.uk	West Mercia Police The Scenes of Crime Handbook (Forensic Science Service) (Report)

Links

This unit links to the following related units:

Unit 21: Criminal Investigation

Unit 24: Sampling and Sample Preparation

Unit 33: Analytical Techniques for Forensic Science

Unit 35: Analytical Chemistry

Unit code	**J/617/5394**
Unit level	**4**
Credit value	**15**

Introduction

Analytical chemistry is the study of the identification, separation and quantification of substances. Identification can be carried out using chromatography and spectroscopy; separation utilises chromatography; quantification can be carried out using titrations, spectroscopy and chromatography. Analytical chemistry is an essential discipline across many scientific fields, such as pharmacy, biology, environmental science, physics and engineering.

Before choosing an analytical method, one must understand the analytical process of defining the problem, conducting the correct analysis and interpretation and presentation of the analysis. The aim of this unit is to understand the analytical process and explore the three main areas of analytical chemistry: quantitative, qualitative and structural analysis using one or a combination of titrations, spectroscopy and chromatography. On completion of this unit, the student will be able to carry out and analyse the results of a number of analytical techniques and present their findings in an appropriate format.

In this unit the emphasis should be on the practical aspect of analytical chemistry, supported by an understanding of the principles behind the technique.

Learning Outcomes

By the end of this unit students will be able to:

1 Explore the analytical processes of quantitative, qualitative and characterisation analysis

2 Undertake separation techniques using chromatography

3 Report on the quantitative, qualitative and characterisation analysis of spectrometric techniques

4 Undertake quantitative analysis using titrations.

Essential Content

LO1 **Explore the analytical process of quantitative, qualitative and characterisation analysis**

Quantitative, qualitative and characterisation analysis:

Differences between the three methods and techniques used to determine each.

Applications of analytical methods:

Examples of the application of analytical methods.

The analytical process:

Define the problem, choice of method, sampling, sampling pre-treatment, quantitative and qualitative analysis, report of analysis, method validation.

Statistical analysis:

Measurement of central tendency, dispersion.

LO2 **Undertake separation techniques, using chromatography**

Principles of chromatography:

Extraction techniques, mobile phase, stationary phase, elution, rate of migration.

Paper, thin layer and column chromatography:

Principle, choice of mobile and stationary phase, detection, applications.

Gas chromatography (GC) and High Performance Liquid Chromatography (HPLC):

Sample injection, mobile and stationary phase, choice of columns, temperature control, detection methods, instrumentation, qualitative and quantitative analysis, internal standards and standard addition.

Gas chromatography (GC) and High Performance Liquid Chromatography:

Sample injection; mobile and stationary phases; sorption mechanisms; choice of columns; injection and oven temperature and temperature gradients (GC); choice of mobile phase, isocratic and gradient elution (HPLC); detection methods; instrumentation; retention time; peak area; internal standards; standard addition.

LO3 **Report on the quantitative, qualitative and characterisation analysis of spectrometric techniques**

Operation of a spectrometer:

Sources of radiation, prisms/gratings, wavelength selector, sample, detector, display.

Atomic absorption spectroscopy:

Principle, applications, calibration, use of Beer-Lambert law to determine unknown concentration.

Infrared spectrometry:

Principle, characteristic group frequencies, application in substance identification.

Ultraviolet-visible spectrometry:

Principle, applications, calibration, determination of $\lambda_{max.}$, use of Beer-Lambert law to determine unknown concentration.

Mass spectrometry:

Principle, fragmentation, molecular ion, M+1 peak, interpretation of mass spectra.

Nuclear magnetic resonance:

Principle, chemical shift, spin-spin coupling, integration, interpretation of nuclear magnetic resonance spectra.

LO4 **Undertake quantitative analysis, using titrations**

Titrations

Acid-base

Redox

Complexation

Precipitation

Potentiometric

Gravimetric.

Calibration:

Pipettes

Burettes

Volumetric flasks

Balances.

Statistical analysis

Measurement of central tendency

Dispersion.

Learning Outcomes and Assessment Criteria

Pass	Merit	Distinction
LO1 Explore the analytical process of quantitative, qualitative and characterisation analysis		**LO1, LO2 and LO3**
P1 Compare quantitative, qualitative and characterisation analysis, their interrelation and the applications of each **P2** Review various methods of statistical analysis in relation to the analytical process	**M1** Develop a plan for the analytical process for the analysis of two different compounds	**D1** Critically analyse the quantitative, qualitative and characterisation analysis of compounds of unknown structure and concentration carried out, using appropriate chromatographic and spectroscopic techniques
LO2 Undertake separation techniques, using chromatography		
P3 Undertake and report on an investigation into the principles of chromatography using paper chromatography or thin layer chromatography **P4** Report on the use of qualitative and quantitative analysis using either GC or HPLC for a specific analysis/analyses	**M2** Discuss the instrumentation involved in GC and HPLC and show how the different elements can be altered to suit the analytical process	

Pass	Merit	Distinction
LO3 Report on the quantitative, qualitative and characterisation analysis of spectrometric techniques		
P5 Plan, carry out and report on the quantitative determination of an analyte by ultra-violet visible spectroscopy or atomic absorption spectrophotometry **P6** Report on using percentage elemental composition and infrared, mass and nuclear magnetic resonance spectra to deduce the identity of an organic compound	**M3** Evaluate the characteristics and benefits of the spectroscopic techniques used	
LO4 Undertake quantitative analysis, using titrations.		**D2** Critically evaluate the reliability of each titrimetric technique undertaken
P7 Undertake and report on a range of titrations. **P8** Analyse statistical information from one titrimetric technique	**M4** Critically analyse the grouped results of a series of titrations, using a statistical analysis technique	

Recommended resources

Textbooks

CHRISTIAN, J.D., DASGUPTA, P.K. and SCHUG, K.A. (2013) *Analytical Chemistry*. 7th ed. Hoboken, NJ: John Wiley & Sons, Inc.

EVANS, E.H., FOULKES, M.E. (2019) *Analytical Chemistry: A Practical Approach*. Oxford: Oxford University Press.

KEALEY, D., HAINES, P.J. (2002) *Instant Notes in Analytical Chemistry*. Oxford: Taylor & Francis Group.

SKOOG, D.A., WEST, D.M., HOLLER, F.J., CROUCH, S.R. (2014) *Fundamentals of Analytical Chemistry.* 9th ed. Belmont: Brooks/Cole.

Web

chem.libretexts.org	Analytical chemistry (General reference)
sdbs.db.aist.go.jp	Spectral Database for Organic Compounds (General reference)

Links

This unit links to the following related units:

Unit 5: Fundamentals of Chemistry

Unit 7: Inorganic Chemistry

Unit 8: Organic Chemistry

Unit 9: Physical Chemistry

Unit 33: Analytical Techniques for Forensic Science

Unit 36: Aromatic and Carbonyl Chemistry

Unit 37: Solid State and Transition Metal Chemistry

Unit 38: Spectroscopy, Surface Chemistry and Equilibria

Unit 39: Environmental Monitoring and Analysis

Unit 36: Aromatic and Carbonyl Compounds

Unit code	**L/617/5395**
Unit level	**5**
Credit value	**15**

Introduction

Two of the main branches of organic chemistry are carbonyl compounds, which contain an sp^2 hybridized carbon atom that is joined to an oxygen atom by a double bond, and aromatic compounds, which contain a benzene ring.

The aim of this unit is to progress the skills developed, having previously studied an introductory organic chemistry course. The focus of this unit will be on the chemistry of aromatic and carbonyl compounds. Initially, the structure of aromatic and carbonyl compounds will be discussed and the experimental evidence for these structures will be examined. Some of the important reactions and mechanisms of aromatic and carbonyl compounds will then be investigated, and various aspects of chirality on organic compounds will be looked at. Practical activities will be undertaken to investigate the reactions and mechanisms studied, particularly those of aromatic and carbonyl compounds, which will help deepen the understanding of some of the theoretical aspects of the course.

Learning Outcomes

By the end of this unit, students will be able to:

1 Discuss the structure of aromatic and carbonyl compounds

2 Evaluate the reactions and mechanisms of aromatic and carbonyl compounds

3 Evaluate the structures and reactions of chiral compounds

4 Undertake a series of practical organic chemistry activities, using synthetic techniques and characterisation analysis.

Essential Content

LO1 **Discuss the structure of aromatic and carbonyl compounds**

The electronic structure of benzene:

Physical structure; methods of representation; bonding, sp^2 hybridisation, bond lengths, resonance, stabilisation – in terms of resonance energy or delocalisation energy; molecular orbital model.

Experimental evidence:

Hydrogenation enthalpy; bond lengths; resistance to typical electrophilic addition reactions.

Categorise aromatic hydrocarbon systems:

Identification of aromatic and anti-aromatic hydrocarbon systems using Hückel's rule to the following systems (planar, fully conjugated, monocyclic systems with $4n + 2$ π electrons).

Aromatic heterocycles:

Application of Hückel's rule to simple heterocyclic systems, e.g. pyridine, pyrrole, furan.

Experimental data:

Use of chemical and spectroscopic evidence to elucidate structures, e.g. characteristic ^1H NMR signals of aromatic hydrogens, characteristic infrared bands.

Acidity of carbonyl compounds:

Acidity of α-hydrogens and formation of enolate ions; enolisation of carbonyl compounds including aldehydes, ketones and esters; use of equilibrium constants as a measure of stability of carbonyl compound relative to corresponding enol; examples of stable enols, e.g. those that form intramolecular hydrogen bonds; acid catalysed α halogenations of aldehydes and ketones; halogenations of aldehydes and ketones in base, e.g. haloform reaction, iodoform test.

LO2 **Evaluate the reactions and mechanisms of aromatic and carbonyl compounds**

Mechanisms of electrophilic substitution:

Nitration; sulfonation; Friedel-Crafts alkylation; Friedel-Crafts acylation, halogenations, using halogen carrier.

Reactivity of substituted benzenes:

In electrophilic substitutions; effect of existing substituent on rate and position of further electrophilic substitution; nucleophilic substitution; effect of leaving groups.

Aldol addition and aldol condensation:

Base catalysed aldol addition reactions; dehydration of aldol addition products leading to formation of α, β-unsaturated carbonyl compounds; crossed aldol reactions, e.g. Claisen-Schmidt condensation.

Condensation reactions involving ester enolate ions:

Claisen condensation and crossed Claisen condensations.

Conjugate addition reactions:

Conjugate addition to α, β-unsaturated carbonyl compounds, e.g. α,β-unsaturated esters, α,β-unsaturated ketones, enolate ions, Michael addition, Robinson annulations; conjugate addition reactions versus carbonyl addition as an example of kinetic versus thermodynamic control.

LO3 **Evaluate the structures and reactions of chiral compounds**

Chiral molecules:

Molecules containing chiral carbon atoms; R/S notation, R/S nomenclature.

Optical rotation:

Simple calculations involving optical rotation and specific optical rotation; racemic mixtures.

Resolution of enantiomers:

Chemical and chromatographic resolution, separation of enantiomers.

Diastereoisomers:

Limited to examples with two chiral centres; physical properties.

Stereochemical representations:

Use of molecular models to demonstrate the stereochemical nature of molecules; Fischer and Newman projections; use of (R) and (S) sequence rules.

Reactions involving chiral compounds:

Examples of reactions that involve chiral compounds; formation of racemic mixtures; asymmetric synthesis.

Biological systems:

Examples of optical isomerism in biological systems, e.g. drug synthesis in the pharmaceutical industry, taste (flavours), sugars, amino acids, pesticides/fertilisers, natural products.

LO4 **Undertake a series of practical organic chemistry activities using synthetic techniques and characterisation analysis**

Carry out at least four experiments:

Examples: synthesis, qualitative analysis, quantitative analysis, characterisation analysis, kinetic studies, any other relevant investigation.

Minimising risks:

Hazards associated with chemicals such as flammable, toxic, harmful; examples of other hazards: high temperatures, use of glass equipment, risk minimisation e.g. use of alternative substances, reduction of quantities, selection of method of heating, selection of location, use of fume cupboard, wearing gloves, lab coat, safety glasses, methods for handling hot objects.

Preparative techniques:

Examples: vacuum filtration, recrystallisation, distillation, rotary evaporation, solvent extraction, drying.

Tests to determine purity:

Examples: melting points, boiling points, spectroscopic techniques such as infrared spectroscopy, ultraviolet-visible spectroscopy, chromatographic techniques.

Yields:

Theoretical and percentage yields.

Report:

Formal laboratory report, other methods of reporting, e.g. completion of a pro forma, preparation of a presentation, making a poster, writing an article.

Learning Outcomes and Assessment Criteria

Pass	Merit	Distinction
LO1 Discuss the structure of aromatic and carbonyl compounds		
P1 Explain the structure of benzene and the supporting evidence for that structure **P2** Justify the categorisation of compounds as aromatic and anti-aromatic using Hückel's rule **P3** Illustrate the acidity of carbonyl compounds by using suitable examples.	**M1** Justify the stability of carbonyl compounds compared to their corresponding enol	**D1** Critically evaluate the experimental evidence to support the structure of aromatic compounds
LO2 Evaluate the reactions and mechanisms of aromatic and carbonyl compounds		
P4 Compare electrophilic substitution of benzene and a range of substituted benzene compounds using mechanisms **P5** Explain nucleophilic substitution for substituted benzenes. **P6** Investigate different pathways for the synthesis of substituted benzene **P7** Explain the synthetic role of aldol reactions, ester enolate condensation reactions, alkylation of ester enolates and conjugate addition reactions.	**M2** Assess the mechanisms of reactions of aromatic and carbonyl compounds and the factors that determine the various steps of a mechanism	**D2** Critically evaluate the effect of substituents on the reactivity of aromatic compounds and the kinetic and thermodynamic control of reactions involving carbonyls

Pass	Merit	Distinction
LO3 Evaluate the structures and reactions of chiral compounds		**D3** Critically evaluate the role stereochemistry plays in biological systems, drug synthesis in the pharmaceutical industry, taste, sugars, amino acids, pesticides/fertilisers and natural products
P8 Explain +/- and R/S notation, use Fischer stereochemical representations and calculate specific rotation for R/S enantiomers **P9** Discuss the resolution and separation of enantiomers **P10** Discuss reactions involving optical activity and the importance of optical activity in biological systems	**M3** Analyse the synthetic uses of reactions of chiral compounds	
LO4 Undertake a series of practical organic chemistry activities using synthetic techniques and characterisation analysis.		**D4** Critically evaluate the results of the chosen practical organic chemistry activities
P11 Carry out and report on five practical organic chemistry activities **P12** Discuss the hazards associated with the chosen practical activities and the steps taken to reduce them	**M4** Discuss the underlying theory for the chosen practical organic chemistry activities	

Recommended resources

Textbooks

CLAYDEN, J., GREEVES, N., WARREN, S. (2012) *Organic Chemistry*. 2nd ed. Oxford: Oxford University Press.

KLEIN, D.R. (2013) *Organic Chemistry*. 2nd ed. Hoboken, NJ: Wiley.

SOLOMONS, T.W.G., FRYHLE, C.B., SNYDER, S.A. (2016) *Organic Chemistry*. 12th ed. Hoboken, NJ: Wiley.

TIMBERLAKE, K.C. (2018) *Chemistry: An Introduction to General, Organic, and Biological Chemistry*. 13th ed. Harlow: Pearson Education Ltd.

Web

chemhelper.com	Help with organic chemistry mechanisms (General reference)
chem.libretexts.org	Chemistry LibreTexts Library Bookshelves – Organic Chemistry (General reference)
chemtube3d.com	University of Liverpool – ChemTube3D Organic chemistry animations (for reactions and mechanisms) (General reference)
pdfdrive.com	PDF Drive – search engine Inorganic chemistry textbooks (General reference)

Links

This unit links to the following related units:

Unit 5: Fundamentals of Chemistry

Unit 7: Inorganic Chemistry

Unit 8: Organic Chemistry

Unit 9: Physical Chemistry

Unit 35: Analytical Chemistry

Unit 38: Spectroscopy, Surface Chemistry and Equilibria

Unit 37: Solid State and Transition Metal Chemistry

Unit code	**R/617/5396**
Unit level	**5**
Credit value	**15**

Introduction

Inorganic chemistry is the study of synthesis, reactions, structures and properties of compounds and elements. Inorganic chemistry deals with molecules that do not contain carbon-hydrogen bonds but overlaps with organic chemistry in areas such as organometallic chemistry. Inorganic compounds and elements play a crucial role in biological processes (so-called bioinorganic chemistry) where metallo-enzymes can activate small molecules such as O_2, H_2O_2, NO, H_2, CO and CO_2, which then act as oxygen transfer reagents, function as messenger molecules or form essential components of redox biology. Furthermore, on the basis of such catalytic reactivity, many metallo-drugs have been developed for the treatment of cancer, arthritis, multiple sclerosis and other autoimmune diseases.

The aim of this unit is to further develop skills studied from an introductory inorganic chemistry course. The student will begin by looking at the different models of bonding used in inorganic chemistry. Valence bond theory, molecular orbital theory and ligand field theory will be discussed. The following section will explore how solids state compounds are structured in the lattice, how these structures are determined, and the energies contained within the lattice. Group theory and symmetry which is used to predict Raman and infrared spectra and optical activity will also be examined. Finally, the student will undertake practical work that underpins some of the essential components of synthetic and characterisation analysis in inorganic chemistry.

Learning Outcomes

By the end of this unit, students will be able to:

1 Explore the different models of bonding

2 Explore the structures of solid state compounds

3 Discuss transition metal chemistry

4 Investigate a series of inorganic chemistry experiments.

Essential content

LO1 **Explore the different models of bonding**

Valence bond theory:

Homonuclear diatomic molecules, hybridisation, polyatomic molecules, d-block metal complexes.

Molecular orbital theory:

Homonuclear and heteronuclear diatomic molecules, polyatomic molecules, dblock metal complexes.

Crystal field theory:

Degeneracy of d-orbitals, effect of ligands, splitting of d orbitals in relation to the co-ordination of complexes

Ligand field theory:

Molecular orbitals for octahedral complexes.

LO2 **Explore the structures of solid state compounds**

Metallic crystal structures:

Body centred cubic (BCC), cubic close-packed (CCP), face-centred cubic (FCC), hexagonal close-packed structures (HCP), examples of metals adopting BCC, CCP and HCP, coordination number of BCC, CCP and HCP structures, unit cells, packing efficiency.

Ionic crystal structures:

Use of x-ray crystallography for determining structure, MX and MX_2 structures including coordination number, ionic radii, limiting radius ratios for NaCl and CsCl structures, structural predictions from radius ratio rule.

Theoretical model for ionic crystal lattice:

Forces of attraction and repulsion between point charges, use of Madelung constant, Born exponent, Born-Landé equation, calculation of lattice enthalpy, comparison of Born-Landé theoretical value of lattice energy with experimental values from Born-Haber cycle.

LO3 **Discuss transition metal chemistry**

Electron arrangements:

Distinction between the terms transition metal and d block metal as given by IUPAC definitions; the electronic arrangement of the first row d block metals Sc-Zn, including the deviation of Cr and Cu; order of filling (4s before 3d) and order of loss on cation formation (4s lost before 3d)

Chemistry of the first row d-block elements:

Trends in oxidation states, oxides and halides, redox reactions fo first row d block metals and their ions, use of standard reduction potentials, $[Cr_2O_7]^{2-}$ and $[MnO_4]^-$ as examples of powerful oxidising agents, hydrolysis e.g. $[Sc(H_2O)_6]^{3+}$ gives acidic solutions in water

Co-ordination chemistry:

Ligands, dendicity to include examples of monodentate, bidentate, tridentate and ethylene diamine tetra-acetic acid (EDTA) as a hexadentate ligand; formation of complexes, coordination numbers and coordination geometry limited to examples of tetrahedral, square planar, octahedral; notation for coordination complexes; naming coordination complexes; weak and strong field ligands; splitting of d orbitals; spectrochemical series; high and low spin complexes; magnetic properties of complexes

Isomerism in d-block metal complexes:

Stereoisomers (including square planar, octahedral, trigonal bipyramidal, high coordination numbers, double bonds, optical isomers), structural isomerism (including ionisation, hydrate, coordination, linkage), geometric and chiral complexes

Stability of complexes:

Ligand exchange, coordination equilibria, stability constants, stepwise formation constants, trends in formation constants, chelate effect

Catalysts:

Homogeneous and heterogeneous, catalytic efficiency, catalytic cycles, energetics, selectivity, lifetime, poisoning

Homogeneous catalysis:

Industrial e.g. alkene hydrogenation, hydroformylation (Oxo-process), methanol carbonylation (ethanoic acid synthesis), recent advances, polymer supported catalysts, biphasic catalysis.

Heterogeneous catalysis:

Surface properties, physisorption and chemisorption, desorption, catalytic converters, hydrogenation of alkenes, ammonia synthesis, oxidation of sulfur (IV) oxide, structure and applications of zeolites.

LO4 **Investigate a series of inorganic chemistry experiments.**

Carry out at least five experiments relevant to the theoretical topics:

Examples: synthesis of transition metal complexes, qualitative analysis, quantitative analysis, characterisation analysis, redox reactions, oxidation states of manganese and vanadium, acid and base reactions, ligand replacement in coordination compounds, stability of complexes, colour or magnetic behaviour of complexes, use of models, catalysis, electrochemistry, properties of transition metals (or groups of elements), investigation of symmetry, lattice energies, any other relevant investigation.

Minimising risks:

Hazards associated with chemicals such as flammable, toxic, harmful

Examples of other hazards: high temperatures, use of glass equipment, risk minimisation, e.g. use of alternative substances, reduction of quantities, selection of method of heating, selection of location, use of fume cupboard, wearing gloves, lab coat, safety glasses, methods for handling hot objects.

Preparative techniques:

Examples: vacuum filtration, recrystallisation, distillation, rotary evaporation, solvent extraction, drying.

Tests to determine purity:

Examples: melting points, boiling points

Spectroscopic techniques such as infrared spectroscopy, ultraviolet/visible spectroscopy, chromatographic techniques.

Yields:

Theoretical and percentage yields.

Report:

Formal laboratory report, other methods of reporting, e.g. completion of a pro forma, preparation of a presentation, making a poster, writing an article.

Learning Outcomes and Assessment Criteria

Pass	Merit	Distinction
LO1 Explore the different models of bonding		
P1 Apply valence bond theory to homonuclear diatomic molecules **P2** Apply molecular orbital theory to homonuclear and heteronuclear diatomic molecules **P3** Compare the crystal field model and the ligand field model for the bonding in the same transition metal complex	**M1** Apply valence bond theory to polyatomic molecules and d-block complexes **M2** Apply molecular orbital theory to polyatomic molecules and d-block complexes	**D1** Evaluate the role ligand field theory plays in explaining bonding in octahedral complexes
LO2 Explore the structures of solid state compounds		
P4 Discuss the various types of crystal structures in metals **P5** Discuss MX and MX_2 ionic crystal structures **P6** Compare theoretical calculated and experimental values of lattice energies	**M3** Discuss crystal structure determination of ionic MX and MX_2 compounds using experimental methods and estimations from the radius ratio rule	**D2** Undertake a numerical analysis and a critical evaluation of calculated and experimental values of lattice energies

Pass	Merit	Distinction
LO3 Discuss transition metal chemistry		**LO3 and LO4** **D3** Critically analyse the results of each investigation
P7 Discuss the redox chemistry of first row transition metals and their compounds **P8** Review the nomenclature, structure and isomerism of first row transition metal complexes, taking account of the charge and electronic configuration of the central metal ion and the range of possible ligands **P9** Justify the colour and magnetic properties of transition metal complexes using crystal field theory **P10** Discuss ligand replacement reactions and the stability of transition metal complexes **P11** Discuss the role of transition metals in catalysis	**M4** Explore the use of ligand field theory in explaining the behaviour of transition metal complexes	
LO4 Investigate a series of inorganic chemistry experiments.		
P12 Investigate and report on five practical activities	**M5** Discuss the underlying theory for the chosen practical activities	

Recommended resources

Textbooks

HOUSECROFT, C., SHARPE, A.G. (2018) *Inorganic Chemistry*. 5th ed. New York: Pearson Education Ltd.

MIESSLER, G.L., FISCHER, P.J., TARR, D.A. (2013) *Inorganic Chemistry*. 5th ed. Boston, MA: Pearson Education Ltd.

WELLER, M., OVERTON, T., ROURKE, J., ARMSTRONG, F. (2018) *Inorganic Chemistry*. 7th ed. Oxford: Oxford University Press.

WINTER, M.J., ANDREW, J.E. (2000) *Foundations of Inorganic Chemistry*. Oxford: Oxford University Press USA.

Web

chem.libretexts.org	Chemistry LibreTexts Library Bookshelves – Organic Chemistry (General reference)
chemtube3d.com	University of Liverpool – ChemTube3D Inorganic chemistry – basic solid state structures (table) Symmetry and 3-dimensional molecular models (General reference)
pdfdrive.com	PDF Drive – search engine Inorganic chemistry textbooks (General reference)

Links

This unit links to the following related units:

Unit 5: Fundamentals of Chemistry

Unit 7: Inorganic Chemistry

Unit 8: Organic Chemistry

Unit 9: Physical Chemistry

Unit 35: Analytical Chemistry

Unit 36: Aromatic and Carbonyl Chemistry

Unit 38: Spectroscopy, Surface Chemistry and Equilibria

Unit 38: Spectroscopy, Surface Chemistry and Equilibria

Unit code	**Y/617/5397**
Unit level	**5**
Credit value	**15**

Introduction

The four themes in this unit are chemical equilibrium, phase equilibrium, theoretical models in spectroscopy and surface chemistry. The chemical equilibrium topic allows students to undertake calculations and data analysis involving equilibrium constants. The interdependence of temperature, pressure composition and the physical states of substances is formalised in the phase equilibrium topic. Spectroscopy is well established as an analytical tool and understanding theoretical models gives an insight into the bases of the techniques. The special properties of surfaces have a wide range of applications.

Physical chemistry underpins manufacturing processes. This unit will allow students to explore some key concepts. It is important to understand how the volume, temperature and pressure of gases are related in order to control processes. Understanding equilibrium conditions allows processes to be manipulated to maximise yield. The number of phases present under different sets of conditions allows effective separation of components of a mixture by distillation or filtration.

Surface properties, like adsorption, are important in relation to catalysis, and understanding how surfactants behave has applications, not only in the detergent industry but also in preparation of nanoformulations. Many important products are colloidal and conditions must be optimised to ensure that colloids remain stable.

The topics covered in the unit are also important in biological systems, many of which operate close to equilibrium conditions.

Learning Outcomes

By the end of this unit, students will be able to:

1 Interpret the results of calculations in relation to chemical equilibrium

2 Discuss the applications of phase equilibrium

3 Review the theoretical models underpinning spectroscopy techniques

4 Illustrate applications of surface chemistry.

Essential content

LO1 **Interpret the results of calculations in relation to chemical equilibrium**

Equilibrium constants:

K_x mole fraction

K_p partial pressure

K_c concentration.

Calculations:

Calculation of K_x , K_p and K_c given values of numbers of moles, partial pressures and concentrations (or number of moles and volume) as appropriate

Interconversion of K_x , K_p and K_c

Calculations involving working out the equilibrium constant, given initial reactant amounts and amount of a product at equilibrium

Calculations based on $\Delta G = \Delta G^{\theta} + RT\ln K$ with $\Delta G = 0$ as a condition for chemical equilibrium and hence use of $\Delta G^{\theta} = -RT\ln K$

Calculation of K_p from values of ΔH^{θ} and ΔS^{θ}

Calculations and graphs based on the Van't Hoff Isochore:

$\ln K = -\Delta H^{\theta}/RT + \Delta S^{\theta}/R$

Slope of plots of lnK versus 1/T

$\ln(K_2/K_1) = -(\Delta H^{\theta}/R)(1/T_2 - 1/T_1)$.

Interpretation of the magnitude of equilibrium constant

Application of equilibrium principles in biological systems

Modification of the conditions for industrial equilibrium reactions to maximise yield, e.g. in Haber and Contact Processes

LO2 **Discuss the applications of phase equilibrium**

Kinetic theory of gases:

Inherent assumptions

Collision theory

Maxwell distribution of molecular speeds

Boyle’s law

Charles’s law

Avogadro’s hypothesis

Relationship between pressure and temperature

Ideal gas constant, R

Ideal gas equation $pV = nRT$

Real gases

Deviations from ideal behaviour

Gas equations other than the ideal gas equation, e.g. Van der Waals and virial equations

Calculations based on manipulating the ideal gas equation.

Interpretation of one-component phase diagrams:

Temperature versus pressure

Simple one-component systems, e.g. carbon dioxide, water, sulfur, diamond

Scales used

Phase boundaries

Triple point

Use of phase rule for prediction of the number of degrees of freedom at given points on phase diagrams

Interpretation of phase diagrams.

Clapeyron and Clausius-Clapeyron equations:

Calculations based on Clapeyron and Clausius-Clapeyron equations

Appreciation of the importance of the sign of the change in volume and the enthalpy associated with phase changes in the Clapeyron equation

Applicability of Clausius-Clapeyron equation

Inherent assumptions in Clausius-Clapeyron equation

Significance of equations to real situations.

Two-component liquid-vapour equilibria:

Mole fraction and percentage composition

Raoult's law for ideal binary mixtures

Examples of ideal binary mixtures

Vapour pressure/composition diagrams for ideal binary mixtures

Boiling point/composition diagrams for ideal binary mixtures

Calculation of the composition of the liquid phase composition of vapour phase in equilibrium, with liquid phase for an ideal binary mixture

Simple and fractional distillation of an ideal binary liquid mixture.

Positive and negative deviation from Raoult's law:

Vapour pressure/composition and boiling point/composition diagrams for binary mixtures, exhibiting positive or negative deviation from Raoult's law

Azeotropes

Simple and fractional distillation for non-ideal binary mixtures

Examples of binary mixtures exhibiting positive and negative deviation from Raoult's law.

Phase diagrams for binary mixtures involving solids and liquids:

Ideal mixtures in terms of interactions between components and enthalpy changes on mixing components

Interpretation of phase diagrams

Temperature/composition diagrams for substances that form a simple eutectic

Construction of temperature/composition diagrams from analysis of the temperature/time plots for heating mixtures of known composition

Practical work for two-component mixtures in the solid and liquid phases

Temperature/composition plot for a two-component mixture where a compound is formed.

Phase diagram for mixtures of two immiscible liquids:

Temperature/composition plot

Extension of temperature/composition plot to involve the vapour phase.

Application of phase diagrams in industry:

Distillation

Phenol number

Recrystallisation.

LO3 **Review the theoretical models underpinning spectroscopy techniques**

Spectroscopic techniques:

Microwave

Infrared

Visible and ultraviolet spectroscopy.

Key concepts:

Wavelength

Wavenumber

Frequency

Energy in relation to frequency

Planck constant

Electromagnetic spectrum

Beer-Lambert law

Energy within molecules: electronic, vibrational, rotational and translational

Quantised energy levels

Transitions between energy levels

Absorption and emission of radiation

Population of energy levels.

Rotational spectroscopy:

Rigid rotor model for diatomic molecules

Moment of inertia

Rotational quantum number J

Rotational constant B and its relationship to the moment of inertia

Energy of levels in terms of B

Population of levels

Selection rule

Differences in energy between levels

Spacing of lines (2B) in spectra

Calculation of bond length, knowing B.

Vibrational spectroscopy:

Simple harmonic oscillator model

Vibrational energy changes

Modes of vibration

Energy of levels

Population of levels

Selection rule

Fundamental vibrational frequency

Relationship of infrared spectra to presence of functional groups

Anharmonic oscillator model

Comparison between harmonic oscillator model and anharmonic oscillator model.

Vibrational rotational spectra:

Use of fine structure in vibrational spectra of diatomic molecules (e.g. HCl or CO) to determine moment of inertia and hence bond length

P and R branches.

Electronic transitions:

Energy changes between levels

Absorption of electronic energy for atomic/molecular structures

Chromophores in organic molecules

Typical energy associated with $\sigma \rightarrow \sigma^*$, $\pi \rightarrow \pi^*$, $n \rightarrow \sigma^*$, $n \rightarrow \pi^*$ transitions

Effect of solvent on ultraviolet frequencies (blue shift and red shift)

Effect of conjugated double bonds on wavelength of energy absorbed

Energy associated with d-d transition in transition metal complexes.

Applications:

Uses of vibrational and electronic spectra in qualitative analysis

Uses of vibrational and electronic spectra in quantitative analysis

Beer-Lambert law

Molar extinction coefficient for ‘allowed’ and ‘forbidden’ transitions

Molar extinction coefficient for aqueous solutions of Cu^{2+}, Co^{2+}, Ni^{2+}, MnO_4^-

Molar extinction coefficients for ultraviolet spectra of organic molecules

Comparison of infrared spectra with different functional groups

Comparison of ultraviolet spectra with different chromophores.

LO4 **Illustrate applications of surface chemistry**

Solid-gas interface:

Physical adsorption

Chemisorption

Meaning of the term 'isotherm'

Derivation of the Langmuir isotherm and inherent assumptions

Assumptions inherent in the Brunauer-Emmett-Teller (BET) isotherm

Simple surface catalysis of gas phase reactions, e.g. hydrogenation of ethene.

Nature and properties of surface-active agents:

Surface and interfacial tensions

Surface activity

Surfactants (anionic, cationic, non-ionic) with polar head-groups and non-polar tails

Counterions

Micelles

Reverse micelles

Critical micelle concentration (CMC)

Mixed micelles

Detergency

Change of contact angles and wetting

Turbidity

Light scattering

Uses of surfactants.

Charged interfaces:

Description of the electric double layer

Helmholtz, Gouy-Chapman and Stern models of the double layer with respect to ionic distribution and electrical potential.

Colloidal systems:

Classification of colloidal dispersions

Association colloids

Stability of colloidal dispersions

Polymer solutions

Applications of colloidal dispersions.

Learning Outcomes and Assessment Criteria

Pass	Merit	Distinction
LO1 Interpret the results of calculations in relation to chemical equilibrium		**D1** Devise a minimum of three different styles of questions and worked solutions for calculations involving equilibrium constants
P1 Present five calculations involving the equilibrium constants in line with the suggestions in unit content and comment on the outcomes **P2** Interpret the results of data manipulation on a minimum of two calculations using the Van't Hoff Isochore	**M1** Discuss the importance of equilibrium properties in process chemistry and in biological systems	
LO2 Discuss the applications of phase equilibrium		**D2** Critically evaluate the quality of the practical work undertaken to construct a two-component liquid/solid phase diagram
P3 Review one-component phase diagrams, the Clapeyron equation and the Clausius-Clapeyron equation clearly identifying their significance **P4** Investigate and discuss the industrial significance of two-component phase diagrams	**M2** Analyse how a two-component liquid/solid phase diagram is constructed from practical work involving cooling curves of mixtures of the two components	

Pass	Merit	Distinction
LO3 Review the theoretical models underpinning spectroscopy techniques		**D3** Evaluate the strengths and weaknesses of the theoretical models used to provide information
P5 Show how theoretical models may be used to provide information about molecules from vibrational, rotational and vibrational-rotational spectra **P6** By considering relevant chromophores, show how ultraviolet-visible spectroscopy may be used qualitatively and quantitatively	**M3** Design an appropriate report format for discussing the theoretical models	
LO4 Illustrate applications of surface chemistry.		**D4** Critically review theoretical models used in surface chemistry
P7 Illustrate the importance of surface chemistry to heterogeneous catalysis **P8** Illustrate the properties and applications of surfactants and colloidal systems	**M4** Evaluate the emerging applications of surface chemistry	

Recommended resources

Textbooks

ATKINS, P., DE PAULA, J. (2016) *Elements of Physical Chemistry*. 7th ed. Oxford: Oxford University Press.

ATKINS, P., KEELER, J., DE PAULA, J. (2017) *Atkins' Physical Chemistry*.11th ed. Oxford: Oxford University Press.

BOLGAR, P., LLOYD, H. *et al.* (2018) *Students Solutions Manual to Accompany Atkins' Physical Chemistry*. 11th ed. Oxford: Oxford University Press.

BUCAK, S., RENDE, D. (2013) *Colloid and Surface Chemistry: A Laboratory Guide for Exploration of the Nano World*. Boca Raton, FL: CRC Press.

BUTT, H-J., GRAF, K., KAPPL, M. (2013) *Physics and Chemistry of Interfaces*. 3rd ed. Weinheim: Wiley-VCH.

CHANG, R., TOMAN, J.W. (2014) *Physical Chemistry for the Chemical Sciences*. Mill Valley, CA: University Science Books.

DE NEVERS, N. (2012) *Physical and Chemical Equilibrium for Chemical Engineers*. 2nd ed. Hoboken, NJ: John Wiley & Sons, Inc.

GUPTA, M.C. (2001) *Atomic and Molecular Spectroscopy*. New Delhi: New Age International (P) Ltd.

HOFMANN, A. (2018) *Physical Chemistry Essentials*. Cham: Springer.

HOLLAS, J.M. (2002) *Basic Atomic and Molecular Spectroscopy*. Cambridge: The Royal Society of Chemistry.

JOB, G., RŰFFLER, R. (2016) *Physical Chemistry from a Different Angle: Introducing Chemical Equilibrium, Kinetics, Electrochemistry by Numerous Experiments*. Cham: Springer.

KAKKAR, R. (2015) *Atomic and Molecular Spectroscopy: Basic Concepts and Applications*. Delhi: Cambridge University Press.

KOLASINSKI, K.W. (2016) *Physical Chemistry: How Chemistry Works*. Chichester: John Wiley & Sons Ltd.

KONTOGEORGIS, G., KILL, S. (2016) *Introduction to Applied Colloid and Surface Chemistry*. Chichester: John Wiley & Sons Ltd.

KRONBERG, B., HOLMBERG, K., LINDMAN, B. (2014) *Surface Chemistry of Surfactants and Polymers*. Chichester: John Wiley & Sons Ltd.

PRICE, G. (2019) *Thermodynamics of Chemical Processes*. 2nd ed. Oxford: Oxford University Press.

Journals

HUDSON, R.L., PEREZ OSBURN, V., BRASHEAR, R. (1990) 'A eutectic mixture with medicinal applications', *The Journal of Chemical Education*, 67 (2), p. 156.

SHARMA, S., KUMAR, A., SINGH, V. (2012) 'Dependence of eutectic-composition on densities of components of binary eutectic mixtures of solid carboxylic acids', *Journal of Applied Chemistry*, 3 (1), pp. 18–22.

Web

chemguide.co.uk	ChemGuide – A Level information (General reference)
chem.libretexts.org	Chemistry LibreTexts Library Standard thermodynamic quantities (table) (General reference)
rsc.org	The Royal Society of Chemistry (General reference)

Links

This unit links to the following related units:

Unit 2: Scientific Data Handling Approaches and Techniques

Unit 5: Fundamentals of Chemistry

Unit 9: Physical Chemistry

Unit 27: Analysis of Scientific Data and Information

Unit 39: Environmental Monitoring and Analysis

Unit code	**D/617/5398**
Unit level	**5**
Credit value	**15**

Introduction

Environmental monitoring and analysis looks at the processes involved in monitoring changes to our environment. Accurate and regular monitoring allows us to establish a baseline, detect changes and observe trends. Areas that an environmental scientist might monitor include soil, air and water. After monitoring has taken place, the sample will need to be analysed in the laboratory. Different types of analysis are possible, including identification, separation and quantification. Identification can be carried out using chromatography and spectroscopy, separation utilises chromatography, and quantification can be carried out using titrations, chromatography and spectroscopy.

The aim of this unit is to help the student understand the processes involved in environmental monitoring and analysis. Firstly, the different types and sources of pollution that might be present in the environment that we are monitoring must be understood. This will help guide the selection of the appropriate method of chemical analysis from a range of analytical techniques. A sampling protocol must also be decided on, which will depend on the sample type and environment. The sample must then be collected and taken back to the laboratory for analysis.

Practical work should be incorporated into the unit, where possible. The student should be encouraged to use and understand the analytical techniques before carrying out sampling. If possible, site visits to appropriate industrial or governmental agencies should be encouraged.

Learning Outcomes

By the end of this unit, students will be able to:

1 Investigate the sources and effects of environmental pollutants

2 Review the various methods of environmental monitoring and chemical analysis

3 Plan an investigation into an environmental study

4 Carry out an environmental study using quantitative analysis.

Essential content

LO1 **Investigate the sources and effects of environmental pollutants**

Sources of environmental pollutants:

Deposited matter: soot, smoke, dust

Industrial pollutants: petroleum refineries, steel industry, power plants

Agricultural pollutants: fertilisers, herbicides, pesticides

Metals: lead, zinc, iron

Gases: carbon dioxide, carbon monoxide, oxides of sulphur and nitrogen

Sewage treatment: domestic and industrial effluent.

Effects of pollutants:

On human health, plants, climate, ecosystems.

LO2 **Review the various methods of environmental monitoring and chemical analysis**

Establish a baseline:

Collect baseline data for your environmental study using published data from a national/local environmental agency

Research trends in the data over the last number of years, using published data from a national/local environmental agency.

Monitoring:

Portable analytical equipment for air, soil and water analysis

Remote monitoring equipment for air, soil and water analysis.

Chemical analysis:

Chromatographic, spectroscopic, electrochemical and titrimetric techniques, determination of unknown concentration.

LO3 **Plan an investigation into an environmental study**

Preparation for sampling:

Sample type (e.g. water, soil, air), selection of an appropriate site, suitable containers, recording sheets, calibration of equipment, health and safety, type of sampling (e.g. composite or grab), transport and storage of samples.

Sampling procedure:

Use of a sampling procedure, e.g. as prescribed by an environmental agency of the government in own jurisdiction or a commercial analytical agency.

Quality control:

Blank samples, spiked samples, duplicate samples, reference samples.

LO4 **Carry out an environmental study using quantitative analysis**

Field trips:

Collection of samples, using sampling procedure to an appropriate site

Visit a commercial/governmental analytical laboratory to observe analytical processes and quality control systems.

Laboratory analysis of samples:

Conduct a series of tests suitable to sample type (e.g. water, soil, air).

Grouping of results:

Use of a spreadsheet to input all results from the class.

Statistical analysis:

Measurement of central tendency, dispersion.

Comparison of data with published data

E.g.: your local water supplier, the Department for Environment, Food and Rural Affairs (DEFRA) in the U.K.

Learning Outcomes and Assessment Criteria

Pass	Merit	Distinction
LO1 Investigate the sources and effects of environmental pollutants		
P1 Review the sources of various types of environmental pollutants	**M1** Assess the effect pollutants can have on human health	**D1** Critically evaluate the effect pollutants can have on ecosystems
LO2 Review the various methods of environmental monitoring and chemical analysis		**LO2, LO3 and LO4**
P2 Investigate the various methods of environmental monitoring and chemical analysis.	**M2** Justify the selection of monitoring and chemical analytical techniques for an environmental study of your choice	**D2** Report on an environmental study of your choice, including a statistical analysis and comparison with published data
LO3 Plan an investigation into an environmental study		
P3 Plan an investigation into an environmental study of your choice **P4** Justify the various factors that must be considered when carrying out sampling on the environmental study planned	**M3** Discuss how quality control will be incorporated into the planned environmental study	
LO4 Carry out an environmental study using quantitative analysis		
P5 Undertake a field trip to collect samples for the planned environmental study **P6** Undertake chemical analysis of your samples	**M4** Critically analyse the results of the chemical analysis of your samples and the samples of the group	

Recommended resources

Textbooks

BARBOOTI, M. (2015) *Environmental Applications of Instrumental Chemical Analysis.* Ontario: Apple Academic Press.

MILLER, G.T., SPOOLMAN, S. (2015) *Environmental Science*. 15th ed. Boston, MA: Cengage Learning.

PATNAIK, P. (2017) *Handbook of Environmental Analysis: Chemical Pollutants in Air, Water, Soil and Solid Wastes.* 3rd ed. Boca Raton, FL: CRC Press.

POPEK, E.P. (2017) *Sampling and Analysis of Environmental Chemical Pollutants: A Complete Guide.* 2nd ed. Amsterdam: Elsevier.

WRIGHT, R.T., BOORSE, D.F. (2017) *Environmental Science: Toward a Sustainable Future.* 13th ed. Boston, MA: Pearson.

Web

chem.libretexts.org	Chemistry LibreTexts Library Analytical chemistry (General reference)
epa.gov	United States Environmental Protection Agency (General reference)
epa.ie	Ireland's Environmental Protection Agency (General reference)
gov.uk	UK Environment Agency (General reference)

Links

This unit links to the following related units:

Unit 10: Principles of Ecology and their Applications

Unit 12: Managing Environmental Resources

Unit 27: Analysis of Scientific Data and Information

Unit 35: Analytical Chemistry

Unit 40: Water and Wastewater Management

Unit 40: Water and Wastewater Management

Unit code	**H/617/5399**
Unit level	**5**
Credit value	**15**

Introduction

This unit focuses on the uses of different grades of water, wastewater treatment and its regulation, and analysis of water or wastewater.

Water is a resource required by many industries. Different standards of purity are used, including drinking water and water recovered from processes. The water used for processes, depends on safety considerations and contamination issues. Water for making pharmaceuticals or biopharmaceuticals must be very pure. Contained water, used in a cooling system may still be effective, despite the presence of pollutants.

Those running industrial production or agricultural processes must be mindful of what happens to water. There may be a need to segregate significantly contaminated streams for special treatment. It may be possible to use slightly contaminated water in cooling. It may be necessary to dilute water to be discharged to ensure that consent limits are not breached. Some organisations will treat wastewater on site and discharge it directly to ground waters. Trade effluent from other organisations may flow through a sewer for treatment by a water treatment company.

Students undertaking this unit will investigate use and treatment of water and wastewater for organisations of interest to the student. Publicly available permits and consents should be studied. Students should visit different types of water and wastewater treatment sites and industrial or agricultural sites, to understand how water is used. Undertaking a study in relation to one specific context will provide students with the tools to analyse water use in other contexts.

Learning Outcomes

By the end of this unit students will be able to:

1 Discuss the quality of water used by industry

2 Discuss wastewater treatment

3 Explore regulation of wastewater

4 Carry out analysis of water or wastewater.

Essential Content

LO1 **Discuss the quality of water used by industry**

Sources of water, e.g.:

Rivers

Aquifers

Wells

Reservoirs

Substances found in water:

Natural (e.g. dissolved gases such as oxygen, nitrogen, carbon dioxide; nitrate, carbonate, microorganisms, soil minerals)

Pollutants (e.g. artificially added nitrate, heavy metals, organic matter)

Water grades and their typical compositions, e.g.:

Drinking water and drinking water standards

Reused/recycled e.g. from a process

Treated mains water

Deionised water

Distilled water

Water for injection.

Situations when particular grades of water may be appropriate, e.g.:

Very pure water for pharmaceutical manufacture

Less pure water for initial washing of wood for paper manufacture.

Investigation of grades of water used in a specific industry or manufacturing process:

Industrial visit

Discussion of stages of process and water grades used at each stage

Volumes of water used at each stage

In-house water treatment processes used to improve water quality

Grades of water bought in for particular parts of a process.

Minimisation of water use:

Metering

Modification of processes

Using less pure water, where possible.

Stages in the drinking water treatment process, e.g.:

Preliminary treatment

Coagulation and flocculation

Flotation

Clarification

Sedimentation

Filtration

Disinfection

Additional treatment

Disposal of waterworks wastes and sludge.

LO2 **Discuss wastewater treatment**

Wastewater collection:

Sewers

Surface water

Foul sewers.

Water treatment at a sewage works:

Preliminary treatment/screening

First settlement

Biological treatment (activated sludge/filter beds)

Second settlement

Tertiary treatment

Sludge disposal

Advanced anaerobic digestion.

Treatment of industrial wastewater/trade effluent, e.g.:

Production industries, including food

Collection/segregation of effluent streams

Differently coloured drain covers

Containment

Company-operated effluent pre-treatment/treatment plants

Removal of heavily contaminated streams for treatment by a subcontractor

Additional treatment processes

Specialist treatment processes, e.g. neutralisation.

Investigation specific contexts:

Industrial visits – following wastewater streams and investigating their treatment

Visits to different types of sewage works.

LO3 **Explore regulation of wastewater**

Relevant, current legislation, e.g.:

Water Industry Act 1991

Water Resources Act 1991

Environment Act 1995

The Urban Waste Water Treatment (England and Wales) Regulations 1994

Control of Pollution (Silage, Slurry and Agricultural Fuel Oil) Regulations (NI) 2003 SR 319

Control of Pollution (Silage, Slurry and Agricultural Fuel Oil) Regulations (England and Wales) 1991

Control of Pollution (Oil Storage) Regulations 2010 and Amendment (2011) (NI) 2010/2011 SR 412/385.

Regulators, e.g.:

Environment Agency

Natural Resources (Wales)

Department for Agriculture, Environment and Rural Affairs (Northern Ireland)

Water and wastewater treatment companies (discharges to sewer).

Features of regulation:

Trade effluent consents (to sewer from water companies)

Trade effluent registers – examples of consents

Limits in effluent consents, e.g.: organic load, suspended solids, separable oil and grease, ammonia, pH, sulphate, temperature, toxic metals, hydrogen cyanide, hydrogen sulphide, controlled substances, volume, flammable substances

Trade effluent charges: Mogden Formula

Water discharge and groundwater activities environmental permits

Permits to discharge on the public register

Comparisons of permits for water treatment works and for other industrial sites.

LO4 **Carry out analysis of water or wastewater**

Sampling:

Using industry standards

Research frequency of sampling by regulator/industry

Research analysis methods used by regulators and industry, e.g.:

Suspended solids

pH

Chemical oxygen demand (COD)

Conductivity

Toxic metals

Temperature

Microbiological profile.

Situations for manual and automatic analysis:

Constraints on automatic analysis techniques.

Comparison of reliability of centre methods with industry/regulator methods

Reasons for analysing water and wastewater:

Comparison of results with specifications for a process (water)

Comparison of results with specifications to ensure discharge consent limits or permit limits are not being exceeded

Building up a profile of results over time, to determine factors that may cause results to be outwith specifications.

Reporting out of specification results

Consequences of results being out of specification

Learning Outcomes and Assessment Criteria

Pass	Merit	Distinction
LO1 Discuss the quality of water used by industry		**D1** Analyse how the impact of water usage on the environment may be minimised
P1 Discuss the source, treatment and key quality parameters of drinking water used in a specific industrial or agricultural process **P2** Differentiate the key characteristics of water of a different standard to drinking water that is used in an industrial or agricultural process	**M1** Justify the characteristics of each grade of water used in the two processes	
LO2 Discuss wastewater treatment		**LO2 and LO3** **D2** Evaluate the rationale behind a particular system of charges for industrial wastewater treatment
P3 Discuss how domestic wastewater is collected and treated at a specific sewage works **P4** Discuss the composition and treatment of industrial effluent streams for a specific organisation	**M2** Compare the treatment of domestic and industrial wastewater	
LO3 Explore regulation of wastewater		
P5 Review the features of consents/permits to discharge controlled water for a wastewater treatment company and another organisation **P6** Analyse the industrial charging system of a commercial wastewater treatment company	**M3** Analyse the relationship between the typical composition of wastewater streams for a specific organisation and the terms of their consents/permits to discharge	

Pass	Merit	Distinction
LO4 Carry out analysis of water or wastewater		**D3** Critically evaluate how quality assurance of analysis ensures compliance with regulation
P7 Carry out analysis methods relevant to the water or wastewater for one of the organisations studied in this unit **P8** Justify the importance of this analysis to the organisation	**M4** Evaluate the extent to which the analysis can be automated	

Recommended resources

Textbooks

BINNIE, C., KIMBER, M., THOMAS, H. (2017) *Basic Water Treatment.* 6th ed. London: ICE Publishing.

DEPARTMENT FOR ENVIRONMENT, FOOD AND RURAL AFFAIRS (DEFRA) (2009) *Protecting Our Water, Soil and Air: A Code of Good Agricultural Practice for Farmers, Growers and Land Managers.* Norwich: The National Stationery Office.

DEPARTMENT FOR ENVIRONMENT, FOOD AND RURAL AFFAIRS (DEFRA) (2002) *Sewage Treatment in the UK.* London: DEFRA Publications.

DEPARTMENT FOR ENVIRONMENT, FOOD AND RURAL AFFAIRS (DEFRA) (2012) *Waste Water Treatment in the United Kingdom – 2012: Implementation of the European Union Urban Waste Water Directive – 91/271/EEC.* London: DEFRA.

THE OPEN UNIVERSITY (2016) *Potable Water Treatment.* Milton Keynes: The Open University.

PARSONS, S., JEFFERSON, B. (2006) *Introduction to Potable Water Treatment.* Hoboken, NJ: Wiley-Blackwell.

RUSSELL, D.L. (2019) *Practical Wastewater Treatment.* 2nd ed. Hoboken, NJ: Wiley.

WATER ENVIRONMENT FEDERATION (2012) *Basic Laboratory Procedures for the Operator-Analyst.* 5th ed. Alexandria: Water Environment Federation.

WORCH, E. (2019) *Drinking Water Treatment: An Introduction.* Berlin: De Gruyter.

Web

daera-ni.gov.uk	Department of Agriculture, Environment and Rural Affairs (Northern Ireland) (General reference)
dwi.defra.gov.uk	Drinking Water Inspectorate information leaflets Drinking water standards/regulations (Report)
gov.uk	UK Government website Department for Environment, Food and Rural Affairs (DEFRA) / Environment Agency (General reference)

naturalresources.wales	Natural Resources (Wales) Department for Agriculture, Environment and Rural Affairs (General reference)
netregs.org.uk	NetRegs Environmental legislation in relation to Northern Ireland and Scotland (General reference)
standingcommitteeofanalysts.co.uk	The Standing Committee of Analysts Methods – Microbiology of Drinking Water Methods – Microbiology of Sewage Sludge Methods – Microbiology of Water and Associated Materials (General reference)
Water companies:	
anglianwater.co.uk	Anglian Water (General reference)
niwater.com	Northern Ireland Water (General reference)
nwl.co.uk	Northumbrian Water (General reference)
southernwater.co.uk	Southern Water (General reference)
thameswater.co.uk	Thames Water (General reference)
unitedutilities.com	United Utilities (General reference)
dwrcymru.com	Welsh Water (General reference)

Links

This unit links to the following related units:

Unit 1: Fundamentals of Laboratory Techniques

Unit 3: Regulation and Quality in the Applied Sciences

Unit 12: Managing Environmental Resources

Unit 18: Microbiology Techniques

Unit 24: Sampling and Sample Preparation

Unit 35: Analytical Chemistry

Unit 39: Environmental Monitoring and Analysis

Unit 51: Specialist Scientific Techniques and Experimentation

Unit 52: Drug Development for Production

Unit 53: Industrial Microbiology

Unit 41: Conservation and Biodiversity

Unit code	**L/617/5400**
Unit level	**5**
Credit value	**15**

Introduction

Although life on Earth is ancient, the concept of biodiversity is a much more recent idea, introduced in the 1980's. There is considerable evidence for a global crisis for the environment and biodiversity provides a measure of the health of an ecosystem as well as a way to estimate monetary value of an area and so form links with its economic potential.

Conservation of biodiversity is necessary to limit the environmental damage done by human activities. Assessment of biodiversity aims to inform conservation policy to decrease species extinction.

The aim of this unit is to provide students with knowledge and understanding of the living environment, the principles of conservation and the importance of biodiversity, as a measure of ecosystem health

Students will explore the different methods of conservation, and their applications. The unit will cover the effectiveness of conservation and measures of biodiversity both descriptive and quantitative. The contribution of biodiversity to economic growth and industry will be considered.

The unit will equip students with a solid foundation of the concept of biodiversity and its conservation. Students will gain a broad view of conservation as a tool for entry to careers in estate management, environmental science and those sectors of industry that require an environmental profile. The unit will inform students to consider the impact of food production and their own role in environmental change.

Learning Outcomes

By the end of this unit students will be able to:

1 Review theories that account for the creation of biodiversity

2 Explore theories that account for the loss of biodiversity

3 Apply methods to assess biodiversity

4 Investigate methods for the conservation of biodiversity.

Essential Content

LO1 **Review theories that account for the creation of biodiversity.**

Creation of biodiversity:

The evolution of biodiversity

Evolutionary science

Diversification of species

Speciation.

The ecology of biodiversity:

Primary factors; history and age, geographical and physical

Ecosystem integrity and health

Speciation

Disturbance and succession

Dispersal and colonisation.

LO2 **Explore theories that account for the loss of biodiversity**

Extinction:

Causes of extinction

Estimating and predicting extinction

Despeciation

Ecosystem loss: destruction of habitat, pollution.

Effect of humans:

Human pressures on biodiversity, population growth and globalisation

Proximate causes

Ultimate causes: attitude, resource use

Economic impact of biodiversity.

LO3 **Apply methods to assess biodiversity**

Defining types of biodiversity:

Genetic methods such as protein electrophoresis, sequencing of nucleic acid and mapping

Taxonomic diversity (three-domain hierarchy and DNA).

Quantifying biodiversity:

Number of known species

Number of alleles in a population

Sampling

Problems of bias and estimation

Global patterns

Contribution of ecosystems.

LO4 **Investigate methods for the conservation of biodiversity**

Evolving concepts:

Funding sources and issues

Social, cultural and political factors

Role of protected areas (areas of outstanding natural beauty, national parks)

In situ and ex situ conservation.

The role of legislation:

International treaties, biotechnology rights and regulated trade

National legislation

Genetic resources

Species protection

Regulating damaging activities.

LO4 could be taught by using examples local to, or familiar to, the student cohort.

Learning Outcomes and Assessment Criteria

Pass	Merit	Distinction
LO1 Review theories that account for the creation of biodiversity		**D1** Critically evaluate factors that can contribute to ecosystem integrity
P1 Illustrate definitions of species diversity using named examples **P2** Review ecological factors that control biodiversity	**M1** Account for the role of biodiversity to ecosystem health	
LO2 Explore theories which account for the loss of biodiversity		**D2** Evaluate opportunities to protect and promote biodiversity in a specific target area
P3 Explore the role of human activities in the loss of species	**M2** Account for the continuing loss of species despite human intervention	
LO3 Apply methods to assess biodiversity		**D3** Critically analyse data sets to suggest ways in which biodiversity could be increased
P4 Explore measures of biodiversity **P5** Analyse data to assess biodiversity	**M3** Evaluate data on biodiversity to draw justified conclusions	
LO4 Investigate methods for conservation of biodiversity		**D4** Critically evaluate the effectiveness of in situ and ex situ methods of conservation of named species to preserving biodiversity in protected areas
P6 Review legislation, treaties and funding and their effect on conservation of biodiversity	**M4** Explore the role of attitude and culture to the success of conservation programmes	

Recommended resources

Textbooks

BOENIGK, J., WODNIOK, S., GLUCKSMAN, E. (2015) *Biodiversity and Earth History*. Berlin and Heidelberg: Springer-Verlag GmbH.

BROMHAM, L., CARDILLO, M. (2019) *Origins of Biodiversity: An Introduction to Macroevolution and Macroecology*. Oxford: Oxford University Press.

HAMBLER, C. (2013) *Conservation*. 2nd ed. Cambridge: Cambridge University Press.

JEFFRIES, M.J. (2006) *Biodiversity and Conservation*. London and New York: Routledge.

LOVEJOY, T.E., HANNAH, L., WILSON, E.O. (2019) *Biodiversity and Climate Change: Transforming the Biosphere*. New Haven, CT: Yale University Press.

Web

hindawi.com/journals/ijbd	Hindawi, open access The International Journal of Biodiversity (Research)
bdj.pensoft.net	Pensoft – science publisher The Biodiversity Data Journal (Research)
link.springer.com/journal/10531	Springer Link Journal: Biodiversity and Conservation (Research)
soilassociation.org	The Soil Association (General reference)
wildlifetrusts.org	The Wildlife Trusts (General reference)
worldwildlife.org	World Wildlife Fund (General reference)

Links

This unit links to the following related units:

Unit 2: Scientific Data Handling Approaches and Techniques

Unit 4: Cell Biology

Unit 10: Principles of Ecology and their Applications

Unit 11: Physiological Adaptation of Plants to Environmental Changes

Unit 19: Managing Food Preparation and Production Systems

Unit 24: Sampling and Sample Preparation

Unit 27: Analysis of Scientific Data and Information

Unit 30: Molecular Biology and Genetics

Unit 32: Biotechnology Techniques

Unit 39: Environmental Monitoring and Analysis

Unit 40: Water and Wastewater Management

Unit 42: Materials Life Cycle and the Circular Economy

Unit 59: Genetic Analysis

Unit 42: Materials Life Cycle and the Circular Economy

Unit code	**Y/617/5402**
Unit level	**5**
Credit value	**15**

Introduction

Environmental protection and issues of sustainability are ever more prevalent in today's society. Indeed, these issues are continually gaining in importance as awareness of such matters, and the potential harm the environment is subjected to, is increased. A great deal of the focus from these matters is levelled at the field of materials science and technology.

Concerns are associated with this particular discipline due to issues of extraction, energy consumption, chemical and water usage, greenhouse gas emissions, and mishandling or mismanagement of waste. Numerous global and national conferences, treaties and protocols have been set up to address this growing concern. Furthermore, philosophies aiming to counter the global concern for the environment, are gaining traction. Philosophies such as those relating to the circular economy, life cycle analysis and cradle to cradle, are gaining momentum. They are being adopted by corporations and manufacturers to an increasing level, partly driven by public demand.

This unit will look at the concepts behind sustainability with an investigation of a variety of protocols and agreements currently in place. It will also consider various models and philosophies driving the objective of a sustainable environment before examining new approaches to materials science and technology, particularly in the field of environmentally acceptable material development.

This unit aims to give the student a grounding in the current situation as regards the environment. It will also introduce the concepts, philosophies and protocols seeking to redress the current environmental imbalance felt to be in existence.

Learning Outcomes

By the end of this unit students will be able to:

1. Review the concept of sustainable development
2. Investigate the importance of the circular economy
3. Explore the relationship of life cycle analysis to issues of sustainability
4. Assess how the development or reuse of new or novel materials can benefit the environment.

Essential content

LO1 **Review the concept of sustainable development**

The need for sustainable development:

Background to the concept

Corporate adoption of sustainability

Impact of humans on the environment

Use of frameworks and models in advising action needed.

The scope and social context of sustainability:

Brundtland definition

Sustainability indicators

Issues concerning global populations including growth and predictions

Standard of living

Urbanisation and the balance of urban/rural space.

International groups and agreements:

The politics and economics of sustainability

Kyoto Protocol

United Nations strategy

Sustainability forum, such as COP21

European Union Emissions Trading Scheme.

LO2 **Investigate the importance of the circular economy**

Circular Economy definition:

Characteristics of linear and circular economies

Application to: polymers (plastics and rubbers); metals, including steel, aluminium and copper; paper and board; textiles; ceramics, including glass

Supply and demand, and its effects on resource distribution.

Central concepts:

The circular economy and its relation to design, including the concepts of ‘building to last’ and of biodegradable capabilities

Issues connected with planned obsolescence

Concepts of regenerative and degenerative approaches to manufacture (materials and energy)

Concept of transformation

Influence of costs/finances on the outcomes

Concepts of adopting a ‘worldwide view’.

Additional concepts:

Design from waste

Logistical approach, considering locality and global logistics

The role of technology

Impact on business models

Resource efficiency

Biomimicry

Urban mining

Blue economy.

LO3 **Explore the relationship of life cycle analysis to issues of sustainability**

Life cycle analysis:

Material resources and extraction: including their environmental impact; energy usage; resultant greenhouse gases.

Consider metal ore extraction such as aluminium, copper and precious metals.

Processing: particularly materials demanding increased levels of water and/or energy for processing

Consider paper products, metals and ceramics

Consider also the extraction of certain ores utilising toxins

Pollutants

Design

Minimising waste

Considering recycling/disassembly

Energy efficiency in production

Legislation

End-of-life usage and disposal

Retrieval of component parts

Directives targeted at particular goods such as electrical

Sustainable materials:

Consider the definition, i.e.: a metal can be sustainable as it can easily be sourced and recycled but not generally classed as such

Energy: Consider the availability and concept of green energy

Consider options such as wind power; tidal power; solar cells; fuel cells

End of life issues: Limitations to recycling through factors such as material choice; Biodegradable or compostable; Energy recovery.

Cradle-to-Cradle design:

Concept of Cradle-*to*-Cradle and its relation to design

Issues concerning recycling

Use of infinite renewable energy

Use of locally adaptable systems.

LO4 Assess how the development or reuse of new or novel materials can benefit the environment

Biodegradable materials in polymer manufacture:

Materials from plant-based derivatives, i.e.: biomass or bio-based

Synthesised from plant or biomass sources and/or a mix of biomass and petroleum-based materials (partially biomass)

Produced from microbes or bacteria.

Agricultural waste processed into other forms:

Fibre-based products used in, e.g.: packaging derived from: straw; plant stalks; bagasse.

Rethinking and utilising agricultural waste in the construction industry:

Aggregate utilised in, e.g.: concrete – derived from olive stones

Building materials derived from, e.g.: cellulose, hemp, peanuts, bananas, orange skin, moss

Construction bricks derived from, e.g.: straw, cornstalks, mushrooms (mushroom bricks).

Learning Outcomes and Assessment Criteria

Pass	Merit	Distinction
LO1 Review the concept of sustainable development		
P1 Interpret the given definitions and models associated with sustainable development. **P2** Demonstrate how humankind has impacted the environment	**M1** Discuss the impact of given treaties and protocols on the issue of the environment	**D1** Analyse the importance of corporate adoption of environmental strategies for sustainability
LO2 Investigate the importance of the circular economy		**LO2 and LO3**
P3 Evaluate and compare the issue of recycling at a linear and circular economy level **P4** Demonstrate how issues of energy, materials and money are important to the concepts of the circular economy	**M2** Discuss the concepts of the circular economy, and its relationship with the natural environment and economic growth	**D2** Critically compare the central philosophies behind the concepts of circular economy and cradle-to-cradle to establish areas of complementarity or conflict
LO3 Explore the relationship of life cycle analysis to issues of sustainability		
P5 Assess the sustainability of a given material and suggest how its credentials as such may be argued for or against **P6**. Explore the central concepts when considering the theory ‘cradle-to-cradle’	**M3** Analyse a selection of given methods for generating green energy, consider their potential and whether they mitigate any controversy, or drawbacks associated with them	

Pass	Merit	Distinction
LO4 Assess how the development or reuse of new or novel materials can benefit the environment.		**D3** Investigate the scope of agricultural material utilisation in the construction industry
P7 Investigate the use of biodegradable materials in plastics production and consider its relevance to environmental issues **P8** Explore the development of microbes and bacteria in the synthesis of polymer materials	**M4** Identify a given range of biomass products and explore their potential as a source of biomaterials	

Recommended resources

Textbooks

AINGER, C., FENNER, A. (2013) *Sustainable Infrastructures: Principles into Practice*. London: ICE Publishing.

BERNERS-LEE, M. (2010) *How Bad Are Bananas?* London: Profile Books.

BOYLE, G. (2012). *Renewable Energy*. 3rd ed. Oxford: Oxford University Press/Open University Press.

WEBSTER, K. (2017) *The Circular Economy: A Wealth of Flows*. 2nd ed, Cowes: Ellen MacArthur Foundation Publishing.

Web

consultancy.uk	Consultancy UK Circular economy in materials needed for sustainable growth (Report)
cop21paris.org	COP21 (General reference)
ellenmacarthurfoundation.org	Ellen MacArthur Foundation (General reference)
fairplanet.org	Fair Planet Cradle to Cradle – a concept for an ideal circular economy (Article)
plasticseurope.org	Plastics Europe Focus areas – Life cycle thinking (General reference)
populationinstitute.org	Population Institute Demographic Vulnerability report (Report)
un.org	United Nations UN and sustainability (General reference and reports)
wrap.org.uk	WRAP Wrap and the circular economy (General reference)

Links

This unit links to the following related units:

Unit 46: Polymer Processing and Manufacture

Unit 47: Polymer Materials and Properties

Unit 54: Materials in Contact with Food

Unit 43: Investigating the Properties of Food Molecules

Unit code	**D/617/5403**
Unit level	**5**
Credit value	**15**

Introduction

The aim of this unit is to develop knowledge of the properties of macromolecules found in foodstuffs. How these molecules are affected by food processing techniques will be accompanied by extensive practical work.

The unit looks at the structure and properties of the macromolecules, carbohydrates, proteins and lipids in food. Starting with an overview of the biochemical properties, students will then study the physical properties in relation to the processing of food. The applications of these processes will be demonstrated through practical work, based on the theory covered. Students will use the results to critically evaluate the relationship between the structures, properties and processes.

On completion of the unit, the student will be able to apply both the theory and practice of how food molecules are affected by processing to a range of career or academic situations. They will be able to work effectively in food science laboratories and other related industry, or progress into honours degree courses in this area.

Learning Outcomes

By the end of this unit, students will be able to:

1. Review the biochemical structures of macromolecules and enzymes
2. Assess how the properties of carbohydrates in foodstuffs are affected by processing
3. Investigate how the properties of proteins are of importance in food processing
4. Assess how the structures and properties of food lipids are affected during food processing.

Essential Content

LO1 Review the biochemical structures of macromolecules and enzymes

Carbohydrates:

Monosaccharides – ring and linear chain

Disaccharides – glycosidic bonds

Polysaccharides – soluble and non-starch polysaccharides (NSP), homo/heteroglycans, linear and branched chain.

Proteins:

Hydrophilic and hydrophobic nature

Zwitterions

Amino acids, peptide bonds

Polypeptides

Isoelectric point

Globular and fibrous.

Enzymes:

Mechanism of action

Occurrence of enzymes in food – phosphatase, lipase, pectinase, phenol oxidase, lipoxygenase.

Uses of enzymes in food processing – invertase, chymosin, amylases, glucose isomerase, glucose oxidase, lipase, lactase, proteases, pectinases.

Lipids:

Monoglycerides

Triglycerides

Fatty acid nomenclature

Saturated, monounsaturates and polyunsaturates

Cis and trans isomers.

LO2 **Assess how the properties of carbohydrates in foodstuffs are affected by processing**

Structures of food carbohydrates:

Sugar crystals, starch granules, amylopectin, glucose syrup, dextrose equivalents, modified starches, cellulose, pectin, carrageenan.

Properties of food carbohydrates:

Effect of modification of starch on end product

Hydrogen bond importance in the thickening and gelling processes

Role of pH, Calcium and chain formation in thickening and gelling

Properties of sugar syrups (glucose) sweetener, thickener, humectant.

Effects of processing:

pH, heat and browning.

LO3 **Investigate how the properties of proteins are of importance in food processing**

Food Proteins and the effect of processing:

Milk proteins, stability in heat, pH

Egg Proteins, stability in heat, pH, emulsification and the effects of age

Meat proteins, effects of heat, pH, changes caused by slaughter, post mortem and ageing of meat products.

LO4 **Assess how the structures and properties of food lipids are affected during food processing**

Lipid reactivity:

Phospholipids and emulsification

Hydrogenation – production of trans-fats and hydrogenated hard fats

Interesterification – effect on melting point

Rancidity – oxidative and hydrolytic, causes and prevention, uses of hydrolytic rancidity, measurement using peroxide value (PV) or free fatty acids (FFA).

Plasticity of lipids:

Crystal structures in fats – purposes and manipulation of these in butter and chocolate product production.

Learning Outcomes and Assessment Criteria

Pass	Merit	Distinction
LO1 Review the biochemical structures of macromolecules and enzymes		
P1 Review the biochemical structures of carbohydrates, proteins and lipids **P2** Investigate the activity of enzymes to demonstrate their mechanism of action in food processing techniques	**M1** Analyse how food is affected by the natural activity of enzymes contained within	**D1** Evaluate the role of enzymes within food processing

<table>
<tr><th>Pass</th><th>Merit</th><th>Distinction</th></tr>
<tr><td colspan="2">LO2 Assess how the properties of carbohydrates in foodstuffs are affected by processing</td><td rowspan="6">LO2. LO3 and LO4

D2 Critically evaluate, from the results of the practical investigations, how the properties of carbohydrates, proteins and lipids are affected by food processing</td></tr>
<tr><td>P3 Review the structures and properties of food carbohydrates

P4 Demonstrate practically, how the properties of carbohydrates are affected by processing</td><td>M2 Provide an analysis of the practical investigations into the properties of carbohydrates</td></tr>
<tr><td colspan="2">LO3 Investigate how the properties of proteins are of importance in food processing</td></tr>
<tr><td>P5 Assess the properties of proteins found in milk and eggs

P6 Plan and carry out a series of practical investigations to demonstrate how the properties of food proteins are affected by processing</td><td>M3 Analyse the effects of slaughter, post-mortem changes and ageing on meat muscle</td></tr>
<tr><td colspan="2">LO4 Assess how the structures and properties of food lipids are affected during food processing</td></tr>
<tr><td>P7 Discuss the causes, effects and prevention of oxidative and hydrolytic rancidity in foods

P8 Plan and carry out a series of practical investigations to demonstrate plasticity of lipids, and the effects of processing on crystal structures within chocolate</td><td>M4 Evaluate the effects of hydrogenation and interesterification on the structure and uses of food lipids</td></tr>
</table>

Recommended resources

Textbooks

BECKETT, S.T. (2018) *The Science of Chocolate.* 3rd ed. London: Royal Society of Chemistry.

COULTATE, T. (2015) *Food: The Chemistry of its Components*. 6th ed. London: Royal Society of Chemistry.

EDWARDS, W.P. (2000) *The Science of Sugar Confectionary.* London: Royal Society of Chemistry.

EDWARDS, W.P. (2007) *The Science of Bakery Products*. London: Royal Society of Chemistry.

Web

nutrition.org.uk	British Nutrition Foundation (General reference)
foodafactoflife.org.uk	Food, A Fact of Life (General reference)

Links

This unit links to the following related units:

Unit 13: Human Health and Nutrition

Unit 14: Food Technology

Unit 19: Managing Food Preparation and Production Systems

Unit 29: Biochemistry of Macromolecules and Metabolic Pathways

Unit 44: Advanced Health and Nutrition

Unit code	**K/617/5405**
Unit level	**5**
Credit value	**15**

Introduction

The food we consume directly affects how our bodies function. Our bodies need adequate nutrition, otherwise they can begin to function abnormally. We can optimise our physical and psychological wellbeing by consuming a healthy balanced diet.

Our genetic make-up may predispose us to developing certain health conditions therefore our nutritional requirements are unique. This unit aims to equip the student with the knowledge, skills and competencies to develop an advanced understanding of nutrition and its core principles. It is advised that students have a basic knowledge of nutrition before commencing this unit.

Initially, this unit will investigate the language and terminology of nutrition, giving students a deeper knowledge of micro and macro nutrients and of phytonutrition. It will enable them to relate nutrition to the homeostasis of specific body systems and to their associated pathophysiology. Students will gain knowledge and understanding of energy balance, and its relationship to physical performance, as well as the function of nutrients and their role in returning the body to optimal health.

This unit will enable the student to gain an in-depth knowledge of the digestive system and the importance of having a healthy gut, with special emphasis on the specific foods that can enhance a healthy gut. They will learn about the microbiome and the concept of nutrigenomics, and will gain a functional knowledge of nutrition and nutritional care for specific pathologies.

Learning Outcomes

By the end of this unit, students will be able to:

1 Explore the nutritional elements that help to sustain and maintain physiological homeostasis

2 Investigate the pathophysiological processes associated with disease

3 Explore the microbiome and associated terms relating to gut health

4 Investigate the area of nutrigenomics and discuss why this may affect the future of diet prescription.

Essential Content

LO1 Explore the nutritional elements that help to sustain and maintain physiological homeostasis

Nutritional factors affecting physical condition and performance:

Exercise, heart disease enzyme stimulation, free radical promotion, antioxidants, cholesterol and cancer.

The role of phytonutrients and phytochemicals:

Effects on the body.

Factors affecting energy production:

Circulation, hormone delivery, the role of fats and of vitamin D.

LO2 Investigate the pathophysiological processes associated with disease

Nutrients and their effect on the body systems:

The musculoskeletal system, the digestive system, the endocrine system, the nervous system, and the immune system

Nutrients to enhance the function of these systems, physical condition, metabolic processes, and to prevent injury and disease.

LO3 Explore the microbiome and associated terms relating to gut health

The microbiome, the microbiota:

Role of probiotics and prebiotics.

The concept of dysbiosis:

Gut-brain connection

Alkaline and acidic diets, food intolerance, etc.

LO4 **Investigate the area of nutrigenomics and discuss why this may affect the future of diet prescription**

Categories of ergogenic aids:

Examples: creatine, L-carnitine, caffeine, ginseng, beetroot juice, hormone aids, alcohol, gels, sports drinks, supplements, bars.

Controversial foods:

Examples: hydrogenated fats; food additives; e.g. aspartame; MSG; high fructose corn syrup; sugar; artificial colours; nitrates in meat.

Nutrigenomic diet prescriptions:

Genetic differences of human responses to foods

Matching foods to individual genotypes

Personalised nutrigenomic foods.

Learning Outcomes and Assessment Criteria

Pass	Merit	Distinction
LO1 Explore the nutritional elements that help to sustain and maintain physiological homeostasis		
P1 Explore how phytonutrients can affect body functions **P2** Discuss the nutritional elements that can be incorporated into the diet of an athlete for optimal performance	**M1** Analyse the factors that affect energy production, with reference to optimising physical condition	**D1** Justify, through evidence-based research, the notion that these nutritional changes can aid optimum health and physical condition
LO2 Investigate the pathophysiological processes associated with disease.		
P3 Demonstrate how nutrition can affect the functional ability of different body systems **P4** Investigate how specific nutritional considerations may prevent specific pathologies	**M2** Research a case study on a pathology that has used nutrition as a therapy to enhance the productivity of a chosen body system	**D2** Critically analyse the outcomes of your research findings
LO3 Explore the microbiome and associated terms relating to gut health		
P5 Research the microbiome and related terms **P6** Analyse the problems that may arise when dysbiosis occurs, to include information on the gut-brain connection	**M3** Examine the functions of different microbiota and recommend dietary supplementations for a healthy gut	**D3** Investigate the specific microbes that should be present in the gut in order for it to function at an optimal level

Pass	Merit	Distinction
LO4 Investigate the area of nutrigenomics and discuss why this may affect the future of diet prescription		**D4** Justify the use of ergogenic aids on physical condition, exercise and sports with reference to journal articles on performance
P7 Investigate different types of ergogenic food products **P8** Explore how nutrigenomics may affect the future of diet prescription	**M4** Analyse the effects, benefits and risks of taking ergogenic food products on the body	

Recommended resources

Textbooks

BEEN, A. (2017) *The Complete Guide to Sports Nutrition*. 8th ed. London: Bloomsbury Sport.

HOLFORD, P. (2004) *The Optimum Nutrition Bible*. London: Piatkus.

HOLFORD, P. (2010) *Optimum Nutrition For The Mind (e-book)*. London: Piatkus.

MAYER, E. (2016) *The Mind Gut Connection Wave*. New York: Harper Wave.

PERLMUTTER, D. (2015) *Brain Maker*. London: Yellow Kite.

Web

ncbi.nlm.nih.gov	National Center for Biotechnology Information (Articles and Research)
nutrition.org.uk	British Nutrition Foundation Nutrition science (General reference and Research)

Links

This unit links to the following related units:

Unit 6: Anatomy and Human Physiology

Unit 13: Human Health and Nutrition

Unit 45: Nutritional Diseases and Disorders

Unit 45: Nutritional Diseases and Disorders

Unit code	**T/617/5407**
Unit level	**5**
Credit value	**15**

Introduction

The aim of this unit is to develop knowledge on the range of nutritional diseases and disorders that occur in humans. The causes, symptoms and treatments of these conditions is important for anyone considering a future in the nutrition and dietetics industry. Whilst deficiency diseases were considered to be a past occurrence, it is now evident that they are still present within communities today.

Students will study a range of deficiency diseases, consider the causes, symptoms and evaluate the various methods of treatment. They will consider how diet affects the incidence of disease in the body, to include the effects of obesity on heart disease and diabetes. Students will evaluate nutritional disorders such as anorexia nervosa and bulimia in relation to their effects on physical and psychological health and finally, a review of the preventative measures being employed in the management of nutritional diseases.

On completion of this unit, students will have a detailed knowledge of nutritional diseases and disorders, which will enable them to work towards a career in nutrition and dietetics.

Learning Outcomes

By the end of this unit students will be able to:

1 Discuss the causes, symptoms, treatment and local impact of a range of nutrient related diseases

2 Explore the relationships between diet and related diseases of the human body

3 Discuss the effects of eating disorders on the physical and psychological health of the sufferer

4 Explore preventative strategies in the management of nutritional disease.

Essential content

LO1 **Discuss the causes, symptoms, treatment and local impact of a range of nutrient related diseases**

Deficiency of macronutrients:

Proteins: protein-energy malnutrition

Undernutrition (starvation)

Carbohydrates: energy deficiency, gallstones – non-starch polysaccharides (NSP)

Lipids: fatty acid deficiency – essential fatty acids (EFAs).

Deficiency of micronutrients – vitamins:

Thiamin B1: beriberi, hypoglycaemia, acidosis

Riboflavin B2: glossitis, cheilosis

Pyridoxine B6: dermatitis, neuropathy, seborrhea

Cyanocobalamin B12: megaloblastic anaemia,

Niacin: pellagra

Ascorbic acid: scurvy

Vitamin A retinol: susceptibility to infections, xerophthalmia, keratomalacia

Vitamin D cholecalciferol: rickets, osteomalacia; relate to ethnic minorities.

Vitamin E tocopherol: myalgia, cardiomyopathy

Vitamin K phylloquinone: haemorrhagic disease of the newborn, blood dyscrasia.

Deficiency of Micronutrients – Minerals:

Iron: iron deficiency, iron deficiency anaemia

Calcium: hypocalcaemia (see also Vit D), osteopenia, osteomalacia

Copper: oedema, anaemia, skeletal fracture/osteoporosis, depigmentation and crinkling of hair, menkes Syndrome

Fluoride: increased likelihood of dental Caries

Iodine: goitre

Sodium: low blood pressure, cramps (dehydration)

Potassium: cardiac weakness, chronic diarrhoea and wasting

Phosphate: renal glomerular failure

Zinc: dermatitis, alopecia, general delay of growth, hypogonadism.

Diseases of excess:

Vitamin A: hypervitaminosis, ligamentous ossification

Vitamin D: calcinosis (with calcium excess), hypercalcaemia

Calcium: hypercalcaemia, calcification of heart and kidneys in infants, hyperparathyroidism in adults

Copper: Wilson's disease, cirrhosis of the liver

Fluoride: calcification of ligaments, increased bone density of spine and pelvic bones, neurological damage

Iodine: possible hyperthyroidism

Iron: siderosis, nausea/vomiting/diarrhoea/collapse

Sodium: oedema, high blood pressure, renal Failure

Potassium: heart failure.

LO2 **Explore the relationships between diet and related diseases of the human body**

Obesity:

Causes: excess energy intake, endocrine disorders

Predisposition to other diet-related diseases: diabetes, coronary heart disease (CHD)

Management of Obesity.

Diabetes:

Causes: Insulin insufficiency, Pancreatitis, other factors

Interrelationship with obesity and CHD.

Management of diabetes.

Coronary heart disease:

Causes: congenital, diet-related

Interrelationship with obesity and diabetes

Management of CHD.

Bone disease:

Bone diseases: osteomalacia, osteopenia, osteoporosis

Dental disease: dental caries, periodontitis

Interrelationship with diet: calcium, phosphate, Vitamin D, fluorine, sugar

Management of bone and dental disease.

LO3 **Discuss the effects of eating disorders on the physical and psychological health of the sufferer**

Eating Disorders and related conditions:

To include anorexia nervosa, bulimia, orthorexia, obsessive-compulsive disorders.

Causative factors:

Poor family relationships, peer pressure, previous eating disorder history, impact and influence of social media, other external factors.

Physiological effects:

Weight loss, bone density loss, dry skin, brittle hair, lanugo hair development, cold extremities, cardiac arrhythmias, constipation, amenorrhea, death due to exhaustion, vomiting, binge eating, purging, lack of feelings of satiety, metabolic dysfunction due to vomiting, tooth enamel decay due to vomiting, death by suicide.

Psychological effects:

Body dysmorphia, effects of late onset as opposed to early onset, abnormal attitude to food, 'morbid fear of fatness' (Boskind-Lodahl), self-destructiveness, depression.

LO4 **Explore preventative strategies in the management of nutritional disease**

Prevention of deficiency diseases:

Current government guidelines on RDA

Role of health visitors in infant nutrition

Public education and information

Management strategies.

Prevention of diseases of excess:

Current government guidelines on RDA

Role of health visitors in infant nutrition.

Public education and information

Management strategies.

Prevention of eating disorders:

Guidelines on prompt recognition of symptoms

Management strategies.

Learning Outcomes and Assessment Criteria

<table>
<tr><th>Pass</th><th>Merit</th><th>Distinction</th></tr>
<tr><td colspan="2">LO1 Discuss the causes, symptoms, treatment and local impact of a range of nutrient related diseases</td><td rowspan="8">LO1, LO2, LO3 and LO4

D1 Critically evaluate the role of the government and other agencies, in the prevention and management of these nutritional diseases and disorders</td></tr>
<tr><td>P1 Discuss the causes, symptoms and treatment of a range of deficiency diseases

P2 Discuss the causes, symptoms and treatment of a range of diseases of nutritional excess</td><td>M1 Analyse the local impact of nutrient related diseases</td></tr>
<tr><td colspan="2">LO2 Explore the relationships between diet and related diseases of the human body</td></tr>
<tr><td>P3 Discuss in detail, the causes and symptoms of obesity, diabetes and coronary heart disease

P4 Provide an analysis of the causes, symptoms and interrelationship between bone and dental disease, and diet</td><td>M2 Evaluate the interrelationships between obesity, diabetes, coronary heart disease, and diet</td></tr>
<tr><td colspan="2">LO3 Discuss the effects of eating disorders on the physical and psychological health of the sufferer</td></tr>
<tr><td>P5 Discuss the causes of anorexia nervosa and bulimia

P6 Analyse the physiological effects of anorexia nervosa and bulimia</td><td>M3 Evaluate the impact of the psychological effects of anorexia nervosa and bulimia on the long-term outcome of the disorder</td></tr>
<tr><td colspan="2">LO4 Explore preventative strategies in the management of nutritional disease</td></tr>
<tr><td>P7 Discuss the government policies currently in place to prevent nutritional diseases</td><td>M4 Critically analyse the strategies in place to manage eating disorders</td></tr>
</table>

Recommended resources

Textbooks

GARROW, J.S., JAMES, W.P.T., RALPH, A. (1999) *Human Nutrition and Dietetics*. 10th ed. London: Churchill Livingstone.

Journals

Journal of Human Nutrition and Dietetics. Wiley Online Library.

MOZAFFARIAN, D., ANGELL, S.Y., LANG, T., RIVERA, J.A. (2018) 'Role of government policy in nutrition – barriers to and opportunities for healthier eating', British Medical Journal, 361, k2426.

Web

healthline.com	Healthline Causes of malnutrition (General reference)
health.gov	Health.gov Office of Disease Preventing and Health Promotion Current guidelines on diet (General reference)
nice.org.uk	NICE Cardiovascular disease prevention (General reference)
rcpsych.ac.uk	Royal College of Psychiatrists Anorexia and bulimia (General reference)

Links

This unit links to the following related units:

Unit 6: Anatomy and Human Physiology

Unit 13: Human Health and Nutrition

Unit 44: Advanced Health and Nutrition

Unit 46: Polymer Processing and Manufacture

Unit code	**A/617/5408**
Unit level	**5**
Credit value	**15**

Introduction

Polymers play an important role in today's world. They have become an essential material in many areas of our life, being utilised in diverse sectors from automotive to packaging and electronics to construction. There are many factors behind this widespread use and not least of these is the relative ease of processing for these materials. Polymers, that is to say plastics and rubbers, possess an ability to be shaped economically, even when complex shapes are required.

The range of processes available to the manufacturer also allows a greater freedom of design, and gives a choice to the producer. A knowledge of these processes and an ability to select the best fit for a particular end product is an essential skill for those employed within the polymer industry.

This unit sets out to detail the steps involved in transforming the raw material into the required shaped by considering a number of factors in the processing journey. The two primary processes used in the polymer manufacturing industry (injection moulding and extrusion) will be explored. Additionally, an exploration will be made of other processes available, including those utilised in the production of rubber and composite goods.

On completion of this unit, students will be cognisant of the range of processes available and issues that may arise during production. They will also be aware of the manner by which products are formed and shaped through the use of moulds and dies. Further, they will be introduced to newer techniques and associated health and safety considerations.

Learning Outcomes

By the end of this unit, students will be able to:

1. Investigate a range of extrusion processing techniques
2. Investigate the injection moulding process and the importance of the mould within the system
3. Illustrate how the processing of reinforced polymers differs from non-reinforced polymers
4. Evaluate the additional polymer processing techniques available to the manufacturer.

Essential Content

LO1 **Investigate a range of extrusion processing techniques.**

Overview of the stages within the process, including:

Storage of material at production site

Transport of material to extruder including manual; automatic

Feeding of raw material into extruder including; hopper design, function and dosage

Extruder composition

Services and maintenance.

Flow behaviour of melt:

Including: drag flow; pressure flow; leak flow

Considering the: velocity; shear; turning memory.

Die considerations, including function and forms of output:

Rod dies

Profile dies

Sheet die, including use of manifold (T-manifold die and coathanger die) and its effects on flow rate; shear; varying diameter; adjustability

Pipe dies including use and position of torpedo and associated elements including, e.g., spider arms (and design); importance of pressure; effect on melt

Wire coating dies, including considerations of position of join of melt to conductor (internal, external); clearance; diameter of conductor; cooling.

Overview of potential problems – causes and solutions:

Die swell, including; effects of land; die cross section; draw-down rate

Hollow shapes

Hydroscopic materials; mica marks and other surface marks

Melt viscosity

Extrudate finish: matt; glossy; lumpy; irregular

Warping

Melt fracture

Molecular relaxation

Surface defects; sharkskin; orange peel; bambooing

Orientation effects.

Co-extrusion including co-axial dies:

Twin screw operation and characteristics, such as: co-rotating; counter rotating.

Extrusion blow moulding:

Additional elements to consider include: crosshead; blow pin; mould; clamp assembly; parison; tail flash; cut-off; stripper ring.

Extrusion blown film line:

Consider downstream components, function and terminology including: annular die; collapsing rolls; wind-up; air-supply; bubble inflation; freeze line.

LO2 **Investigate the injection moulding process and the importance of the mould within the system.**

Injection moulding process:

Consider the function of elements within the processes including: Hopper (including heating, dosing and bridging); cylinder/barrel (venting, material of manufacture, melt behaviour); reciprocating screw; heating system; drive motor.

Injection moulds:

Mould types: two plate mould; three plate mould

Consider the feed system; daylights; runner system; number of cavities; venting; mould pitting; projected area; screw cushion; shot capacity; residence time

Within the feed system consider function, siting and appearance of the: cavity; sprue; runner; gate

Gating types used in specific applications, including but not limited to: sprue gate; pin-point gate; side gate; submarine gate; fan gate; tab gate; ring gate

Significance of gate number and location; separation of moulding from runner; position on moulding; clamping pressure

Stress points; aesthetical considerations; weldline (also known as meldline) location, extent and strength

Ejection systems including the purpose and conditions of use; systems including but not limited to: pin ejection; use of stepped pins; sleeve ejection; ejector blades; stripper plates

Consideration of inherent characteristics of material including: internal stresses; mould shrinkage; rate of cooling and its effect on properties.

Mould design and polymer material characteristics:

Consideration of inherent characteristics of polymer including: material types; internal stresses; mould shrinkage; rate of cooling and its effect on properties

Overcoming moulding problems and troubleshooting; use of fillers; anisotropy; flow to thick/thin sections; cavitation; dimensional stability; absorption of liquids (by material or filler); post-mould shrinkage; voids

Considerations of: ribs; draft angles; corners; sinking; bosses; flow around pins or inserts.

LO3 **Illustrate how the processing of reinforced polymers differs from non-reinforced polymers.**

Reinforcement overview and mechanisms:

Ratios of reinforcement to matrix

Terminology and function of: resin/matrix; compound; composite; dispersion; fibres; mineral fillers.

Fibre reinforced moulding:

Overview of the equipment, processes, raw materials and restrictions associated with fibre moulding techniques.

Consider the monitoring involved in ascertaining the gelation point achieving a network state within the molecules.

Consider use of autoclaves.

Importance of fibre orientation and wetting when moulding via:

Hand lay-up

Spray-up

Infusion Process

Vacuum bagging

Filament winding

SMC/DMC Moulding.

Pultrusion:

Processing machinery configuration

Reasons for use; advantages/disadvantages

Health and safety:

Consider the health and safety implications when processing reinforced polymers, including Control of Substances Hazardous to Health Regulations (COSHH).

LO4 **Evaluate the additional polymer processing techniques available to the manufacturer.**

Injection-related processes:

Basic introduction to the equipment, processes, raw materials and restrictions associated with:

Gas assist

Resin transfer

Ram injection

Structural foam.

Vacuum forming / thermoforming:

Typical materials utilised

Process steps; clamping; heating; forming; pressure; vacuum; removal; trimming; finishing

Applicable moulds with consideration of: mould material and associated output; vents; draft angles; sheet thinning; draw ratios; webbing; bridging; surface finish; surface treatment

Moulding variations including: plug assist; pressure forming; press/ matched-mould; pressure-bubble snapback

Sheet orientation effects.

Compression moulding:

Common raw materials including, rubbers; production rates; cure; moulding quality; flash; trimming

Configuration including: up-stroke; down-stroke; horizontal platens (fixed, moving); daylight (single, multiple); moulds (flash mould); ejection pins; heating; pressure; moulding cycle; cooling.

Rotational moulding:

Raw material form

Machine configuration including: mould chambers; heaters; loading/unloading bay; drive motor.

Calendaring:

Typical materials and applications

Roll configurations including: Vertical; Inverted L; Z; Inclined I; Pick off roll; Barrel contour; Roll bending; Cross axis metering; Casting.

3D printing:

Typical materials used and limitations of the materials

Techniques used

Design and cycle time considerations.

Learning Outcomes and Assessment Criteria

Pass	Merit	Distinction
LO1 Investigate a range of extrusion processing techniques		**D1** Critically analyse the passage of a given material through the extrusion process for a given application, and show how the material behaves across the system from entering the hopper to forming as an extrudate
P1 Assess the importance of stipulating the position of elements (e.g. torpedo, spider) within a die giving the reasons in terms of advantages and disadvantages for the decision **P2** Discuss the flow rate across a given set of dies and show how this can be made to vary	**M1** Design a troubleshooting chart showing how melt/extrudate defects can be rectified	
LO2 Investigate the injection moulding process and the importance of the mould within the system		**D2** Critically evaluate the gating systems available to the injection moulder, giving applications where they may be used
P3 Determine the causes of shear thinning **P4** Assess the stages in the processing of a given polymer material and the considerations that need to be taken when moulding such a material	**M2** Analyse the function of the given components of a mould	

Pass	Merit	Distinction
LO3 Illustrate how the processing of reinforced polymers differs from non-reinforced polymers		**D3** Explore the health and safety considerations, including disposal issues, necessary when processing reinforced materials
P5 Differentiate between the various forms of reinforcing materials available and suggest where they may be utilised **P6** Explore the reasons why some forms of composite fabrication are relatively labour intensive and suggest reasons why this may be the case	**M3** Investigate the features of pultrusion, showing its comparability and variances with the extrusion process, and indicate where the process may be utilised	
LO4 Evaluate the additional polymer processing techniques available to the manufacturer.		**D4** Critically evaluate the steps taken by a manufacturer of a given product when deciding which process to utilise for manufacture, and suggest why one process may be chosen over another when a number may offer similar advantages and disadvantages
P7 Examine the possibilities and limitations associated with manufacturing through 3D printing **P8** Assess the use of the calendering technique for producing sheet materials, and suggest reasons why this method of processing may be selected over sheet extrusion	**M4** Investigate the importance of vacuum forming in the mass production of polymer goods and show why there are restrictions in the materials that can be utilised in this process	

Recommended resources

Textbooks

BAIRD, D.G., COLLIAS, D.I. (2014) *Polymer Processing: Principles and Design*. 2nd ed. Oxford: Wiley-Blackwell.

MORTON-JONES, D.H. (2013) *Polymer Processing*. Dordrecht, Netherlands: Springer.

OSSWALD, T.A. (2017) *Understanding Polymer Processing: Processes and Governing Equations*. 2nd ed. Munich: Hanser.

STRONG, B. (2005) *Plastics: Materials and Processing*. 3rd ed. London: Pearson Education Ltd.

Web

bpf.co.uk	The British Plastics Federation (General reference)
hardiepolymers.com	Hardie Polymers – Polymer Knowledge Base Polymer manufacturing processes (General reference)
hse.gov.uk	The Health and Safety Executive (General reference)
iom3.org	Institute of Materials, Minerals and Mining (General reference)

Links

This unit links to the following related unit:

Unit 47: Polymer Materials and Properties

Unit 47: Polymer Materials and Properties

Unit code	**F/617/5409**
Unit level	**5**
Credit value	**15**

Introduction

There are many materials utilised in the modern manufacturing industry. These can usually be broken down into the three main categories of metal, ceramic and polymers, with composites straddling the categories in various combinations. Of these, polymers in their varied forms are the focus of this unit.

Polymers, that is to say plastics and rubbers (also known as elastomers), have facilitated, and indeed in some instances been the driving force behind, advances in many fields as diverse as sport and leisure, medical, safety, food packaging and transport, to name but a few. This has been achieved through the judicious matching of the right material to a given application.

To understand how this pairing can be made and subsequently how polymers became embedded in so many diverse applications, it is important to be conversant with the wide range of materials classified as a polymer. Moreover, it is necessary to recognise the properties of these materials and how they can be enhanced and tailored through the use of co-polymerisation, blending and additives.

This unit therefore sets out to categorise thermoplastics, thermosets and elastomeric materials. The properties distinguishing these materials will be explored as will the additives that can in turn influence these properties. The function of fillers and reinforcement will be examined, not least in the compounding of rubber, and the possible path polymer materials will, and maybe need to, take in the future will also be considered.

On successful completion of this unit the student will be cognisant of the behaviour of a polymer material under varying conditions. They will also be conversant on the properties a polymer exhibits and how this influences material selection. The student will also be aware of varying means used to modify a polymer's properties as well as how polymers are required to adapt to fit into the future environmentally friendly landscape.

Learning Outcomes

By the end of this unit, students will be able to:

1 Explore the behaviour of polymers in relation to environmental factors

2 Determine the importance of a polymer's properties in material selection

3 Determine the reasons and mechanisms by which a polymer can be modified through the addition of reinforcements, fillers and other additives

4 Explore the challenges facing the polymer industry in the present climate, and what measures need to be taken in adapting polymers to fit future demands.

Essential Content

LO1 **Explore the behaviour of polymers in relation to environmental factors**

Molecular level forces considering:

Bonding

Intermolecular activity

Thermal expansion

Swelling (elastomers)

Deformation behaviour in relation to load, rate and temperature.

Time-dependant behaviour considering:

Viscoelasticity

Maxwell and Voigt models

Creep (primary, secondary and tertiary)

Isochronous stress-strain relationships

Stress relaxation and recovery.

Temperature effects, including:

Temperature transitions including: Tg; Tm; Tc

Temperature dependent stress-strain behaviour.

LO2 **Determine the importance of a polymer's properties in material selection**

Physical properties:

Density; deformation (elasticity, plasticity, ductility); rigidity; toughness; brittleness; opacity; water absorption; shrinkage; isotropy/anisotropy.

Mechanical properties:

Tensile/flexural/compression in terms of: stress; strain; modulus; hysteresis; fatigue; poisson's ratio; shear; Impact in terms of notched and unnotched strengths.

Thermal properties:

Coefficient of linear expansion; conductivity; aging; limiting oxygen index; flammability.

Chemical properties:

Compatibility; reactions; solvents; Environmental Stress Cracking (ESC).

Electrical properties:

Conductivity; resistivity (surface/volume); dielectric properties; arc resistance general properties.

Weathering in terms of:

Oxidation; other radiation resistance, e.g. electromagnetic; ionizing; magnetic properties; wear; corrosion; cost; recyclability/reprocessability.

Use of polymer selection charts:

To find the best fit between properties and materials, e.g.: Ashby charts, etc.

LO3 **Determine the reasons and mechanisms by which a polymer can be modified through the addition of reinforcements, fillers and other additives**

Incorporation of additives considering levels of incorporations and its effects on properties:

Considering; evaporation; migration; dispersion; thermal degradation; waste disposal (potential damage to the environment)

Including but not limited to; stabilisers; anti-oxidants; uv stabilisers; heat stabilisers; shrinkage control; extenders; colourants; impact modifiers; lubricants; blowing agents; fire retardant; plasticisers.

Particulate filler:

in the form of, e.g.: chalk; clay; talc; other mineral powders

Carbon black

Wood flour

Nanotubes.

Reinforcing agents such as beads and fibres including:

Glass

Carbon

Aramid

Nylon

Polyester

Nanoparticles

Consider also: aspect ratios; interface adhesion/bonding mechanisms; attrition.

Rubber compounding, including the need for adding other ingredients to rubber, including but not limited to:

Vulcanisers – agents and accelerators

Extenders

Fillers

Activators

Processing aids

Softeners

Pigments.

Steps taken for compounding rubber including:

Recipe/formulation development

Sequential addition

Internal mixers

Two-roll mill

Mastication

Dispersion.

LO4 **Explore the challenges facing the polymer industry in the present climate and what measures need to be taken in adapting polymers to fit future demands.**

Consider the impact environmental concerns, public perception and government and international policies have on material selection and uses. Includes consideration, e.g.

Recycling

Disassembly

Repurposing/reuse

Compostability

Incineration.

Consideration of viable alternatives, such as:

Starch based materials including polylactic acid (PLA)

Biopolymers

Cellulose

Paper-based materials

Other potentially viable materials undergoing research such as algae

Keeping abreast of legislation and government policies, both national and international, in order to maintain product compliance.

Learning Outcomes and Assessment Criteria

Pass	Merit	Distinction
LO1 Explore the behaviour of polymers in relation to environmental factors		**LO1 and LO2**
P1 Compare the intermolecular forces a polymer may be subject to, and assess how these can influence properties **P2** Differentiate between the various stages a polymer material undergoes while subjected to creep	**M1** Discuss how load, rate and temperature can influence the deformation of a polymer	**D1** Critically evaluate the importance of an awareness of a polymer's underlying structure and its related properties for a given application
LO2 Determine the importance of a polymer's properties in material selection		
P3 Explain how selection charts can aid in choosing the polymer best suited to an application **P4** Assess the properties of primary importance to a particular application	**M2** Differentiate between the properties that can be determined within a particular grouping	

Pass	Merit	Distinction
LO3 Determine the reasons and mechanisms by which a polymer can be modified through the addition of reinforcements, fillers and other additives		
P5 Determine a range of benefits additives bring to a polymer **P6** Discuss the importance of incorporating additives to a rubber material	**M3** Explore the mechanisms by which an additive or reinforcing agent can degrade or undergo attrition	**D2** Analyse the ways in which reinforcing agents operate on a material
LO4 Explore the challenges facing the polymer industry in the present climate and what measures need to be taken in adapting polymers to fit future demands.		
P7 Investigate the causes behind the criticism polymers are currently undergoing **P8** Identify and review the materials emerging as a result of demand	**M4** Analyse the legislation and policies arising from this disapproval of polymers, and identify their potential impact on polymer manufacture	**D3** Evaluate the positives and negatives of the materials being put forward as alternatives and suggest whether they could prove beneficial to the environment

Recommended resources

Textbooks

BRAZEL, C.S., ROSEN, S.L. (2012) *Fundamental Principles of Polymeric Materials*. 3rd ed. Oxford: Wiley-Blackwell.

BRYDSON, J. (2016) *Brydson's Plastics Materials*. 8th ed. Oxford: Butterworth-Heinemann.

HALARY, J.L., LAUPRETRE, F., MONNERIE, L. (2011) *Polymer Materials: Macroscopic Properties and Molecular Interpretations*. Oxford: Wiley.

YOUNG, R.J., LOVELL, P.A. (2011) *Introduction to Polymers*. 3rd ed. Abingdon: Routledge.

Web

bpf.co.uk	The British Plastics Federation (General reference)
hse.gov.uk	The Health and Safety Executive (General reference)
plastics.americanchemistry.com	The American Chemistry Council Plastics – the basics (General reference)
pslc.ws	The Macrogalleria Information about polymer science (General reference)
warwick.ac.uk	The University of Warwick Materials, properties and selection – an overview (General reference)

Links

This unit links to the following related units:

Unit 42: Materials Life Cycle and the Circular Economy

Unit 46: Polymer Processing and Manufacture

Unit 48: Polymer Testing

Unit 48: Polymer Testing

Unit code	**Y/617/5416**
Unit level	**5**
Credit value	**15**

Introduction

Testing is an important part of any manufacturing process, particularly when confidence is required in the finished product. Indeed, given the wide area of application of polymer goods, whether in the medical field, sport and leisure, packaging or the vast array of applications between, it could be said to be essential.

Testing can come in a variety of forms and can be static, dynamic, long or short term, cover physical, chemical or indeed a host of other elements. The ability to apply the correct test for a given application, and to apply the appropriate standard for a given test method, are important skills for those employed in the polymer industry. Once the purpose and function of a product is defined and its service environment is identified, a range of polymers can be assessed to pinpoint a suitable material for use. Testing is an integral part of this process as it allows a material to be characterised according to its properties. Testing also aids in allowing the user to predict the future behaviour of a material. This can be vitally important.

This unit will consider testing as characterised through the physical, chemical, environmental, optical and electrical forms of polymer materials. It will cover the testing of polymers, that is both plastic and rubbers, and also with a look at reinforced plastics. It will also demonstrate the need for recognised standards in testing and the importance of correctly applying these standards.

On completion of this unit the student will have the knowledge to determine or verify material properties by testing and those working in manufacturing would be aware of the range of standard tests and test equipment available. They ought also to be able to interpret resultant test data.

Learning Outcomes

By the end of this unit, students will be able to:

1 Investigate methods of testing for mechanical properties in terms of the deformation and fracture of polymer materials

2 Investigate further applicable tests for describing and measuring the physical properties of a polymer material

3 Discuss the chemical, electrical and thermal tests available to describe a polymer material

4 Explore the additional considerations needed in the testing of rubber and fibre reinforced plastics.

Essential Content

LO1 **Investigate methods of testing for mechanical properties in terms of the deformation and fracture of polymer materials**

Consider the importance of equipment and test conditions in determining mechanical properties:

Consideration of the tensometer, in terms of, e.g.: crosshead; load cell; grip method

Importance of test factors including but not limited to; specimen shape and dimensions; rate of strain; temperature; humidity; method of specimen manufacture/preparation

Consideration of confidence and significance of results.

Tests under the conditions of tensile, flexure and compression defining properties including strength, stiffness, fatigue and toughness:

Methods of characterising tensile properties including stress-strain behaviour; Poisson's ratio

Methods of characterising flexural properties including consideration of bending modes (e.g. 3-point, 4-point and cantilever); span; test conditions; material behaviour

Methods of characterising compression properties, including consideration of factors such as viscoelasticity; creep; long- and short-term testing; isochronous and isometric graphs; pseudo-elastic behaviour; lateral strain ratios.

Consider the fracture mechanisms of polymer materials:

Including concepts of stress concentration; fracture mechanisms; crack growth; toughness; critical strain energy; stress intensity factor (K); creep rupture; creep fatigue.

Consider the importance of the correct application of specifications in conducting tests:

Including the range of specifications both national and international.

LO2 **Investigate further applicable tests for describing and measuring the physical properties of a polymer material**

Consider dynamic testing in terms of impact:

Impact testing including pendulum (Izod and Charpy) and drop weight

Consider the test apparatus including fixtures for specimen support/containment

Specimen preparation, including relevance of testing notched and un-notched samples

Specimen type: film; sheet; pipe; plate; bar.

Additional physical/mechanical tests:

Dynamic mechanical analysis (DMA)

Peel

Tear

Hardness; Rockwell

Shear

Abrasion

Coefficient of Friction both static and dynamic

Environmental stress cracking.

LO3 **Discuss the chemical, electrical and thermal tests available to describe a polymer material.**

Tests used in quality control and material analysis of the raw material and end product:

Chemical properties, including: reaction; solvation

Electrical properties, including: electrical conductivity; volume and surface resistivity; dielectric strength and permittivity; dissipation; arc resistance

Thermal properties, including: thermal conductivity; heat deflection temperature; Vicat softening temperature; differential scanning calorimetry (DSC)

Flammability

Limiting oxygen index

Ageing

Chromatography

Rheological property measurement including; melt flow rates; die swell; melt strength

Optical properties; haze; spectroscopy

Magnetic properties

Environmental considerations including: oxidation; weathering; water absorption

Non-destructive tests.

LO4 **Explore the additional considerations needed in the testing of rubber and fibre reinforced plastics.**

Rubber:

Hardness tests and relevance of test scales

Viscoelastic tests, e.g. Mooney viscometer

Cure test, e.g. oscillating disc rheometer

Vibration damping test

Tear tests, considering, e.g. tear mechanisms; stick-slip; knotty; test piece type e.g. trouser, crescent, angle

Dynamic fatigue

Compression set

Volume swell

Environmental stress cracking

Resilience

Heat ageing

Gas permeability.

Fibre reinforced plastics:

Consider the effects of reinforcement on mechanical testing such as yield, strength and failure, and the effects of various constituents of a reinforced system on tests. Influences can include choices made in terms of, e.g., matrix; fibre; other reinforcement types; reinforcement orientation; reinforcement lengths

Considerations of: stress transfer; interface interactions; fibre pull-out; failure mechanisms, e.g. delamination; splitting; shear; crushing.

Learning Outcomes and Assessment Criteria

Pass	Merit	Distinction
LO1 Investigate methods of testing for mechanical properties in terms of the deformation and fracture of polymer materials		**D1** Investigate the importance of testing to identify the fracture behaviour of a material in a given application, including the factors likely to initiate fracture
P1 Explore how test factors can influence test results **P2** Discuss the importance of applying the correct testing specification to a given test	**M1** Compare the expected mechanical behaviour for given materials, spanning the range from ductile to brittle	

Pass	Merit	Distinction
LO2 Investigate further applicable tests for describing and measuring the physical properties of a polymer material		**D2** Demonstrate where knowledge of environmental stress cracking is an important consideration and show how it can influence the behaviour of a polymer
P3 Review the various impact test methods available, and suggest where they may be used **P4** Investigate the methods of sample preparation, and explain the purpose of notched and un-notched specimens	**M2** Analyse the reasons for testing under static and dynamic conditions	
LO3 Discuss the chemical, electrical and thermal tests available to characterise a polymer material		
P5 Discuss the various rheological tests available and show how they can be utilised in the quality control of a raw material **P6** Assess the importance of testing the thermal properties of a polymer for a given application	**M3** Analyse how knowledge of the rheological properties of a polymer is important in terms of quality control and the processing of a polymer	

Pass	Merit	Distinction
LO4 Explore the additional considerations needed in the testing of rubber and fibre reinforced plastics		**D3** Critically evaluate the considerations needed when tensile testing across a range of disparate polymer materials, e.g. selecting from a range of rubber and reinforced plastics
P7 Explore the hardness tests applicable in describing rubber materials, and show how appropriate test methods are selected **P8** Investigate the expected failure mechanisms in long and short-fibre composites	**M4** Investigate the flexural deformation behaviour of a given reinforced plastic	

Recommended resources

Textbooks

BROWN, R. (1999) *Handbook of Polymer Testing*, Boca Raton, FL: CRC Press.

SHAH, V. (2006) *Handbook of Plastics Testing and Failure* Analysis. 3rd ed. Hoboken, NJ: John Wiley & Sons, Inc.

STRONG, B. (2005) *Plastics: Materials and Processing*. 3rd ed. London: Pearson Education Ltd.

Web

bpf.co.uk	The British Plastics Federation (General reference)
sciencedirect.com	Science Direct Polymer Testing Journal (Research)

Links

This unit links to the following related units:

Unit 46: Polymer Processing and Manufacture

Unit 47: Polymer Materials and Properties

Unit 51: Specialist Scientific Techniques and Experimentation

Unit 49: Principles of Pharmacology

Unit code	**F/617/5426**
Unit level	**5**
Credit value	**15**

Introduction

This unit is concerned with the area of medicine and science that studies the mechanisms of action, therapeutic uses and development of drugs. Study of this unit will allow students to develop in-depth knowledge of the way in which drugs act within the human body, as well as an overview of how modern drugs are discovered and brought to the market.

Students will develop their knowledge and understanding of the basic principles of pharmacology by the study of pharmacokinetics and pharmacodynamics and the molecular sites of drug action. This foundation knowledge will be further developed through learning about regulations that surround the pharmaceutical industry. Finally, students will develop detailed knowledge about specific compounds that treat the body systems, including the cardiovascular, respiratory and nervous systems.

In this unit, students will develop research skills and a knowledge of how new drugs are discovered through introduction to traditional in vitro assays and hands-on experience of model biochemical assay systems.

Learning Outcomes

By the end of this unit students will be able to:

1 Investigate the regulatory requirements that must be satisfied to bring a drug to market

2 Discuss the range of molecular targets for drugs in the human body

3 Compare the therapeutic use of compounds used to treat disorders of the respiratory and cardiovascular systems in humans

4 Account for the effects of pharmacological agents on the human nervous system.

Essential content

LO1 **Investigate the regulatory requirements that must be satisfied to bring a drug to market**

Research and development of new drugs:

British Pharmacopoeia standards for drug substance and drug products

Patent issues in drug development

Role of Medicines and Healthcare products Regulatory Agency (MHRA) or Food and Drug Administration (FDA, USA)

Role of Facilities and Personnel Management

Street drugs (e.g. unregulated, untested, unknown without quality)

In vitro testing, chemical and bioassays for lead compounds, compound libraries

Standard operating procedures

Regulatory requirements for animal testing

Harmonisation of testing

Clinical trials (phases I, II, III & IV, V) to include numbers of test subjects and the nature of each phase.

LO2 **Discuss the range of molecular targets for drugs in the human body**

Interaction of compounds with cell surface and intracellular receptors (DNA), binding of drugs to enzymes, drugs that act on second messengers (G proteins, cAMP)

Effect of drugs on the body (pharmacokinetics, absorption, distribution, metabolism, and excretion (ADME) and determination of pKa), effect of the body on drugs (pharmacodynamics)

Routes of administration, first pass effect.

LO3 **Compare the therapeutic use of compounds used to treat disorders of the respiratory and cardiovascular systems in humans**

Cardiovascular pharmacology:

Pathology of hypertension, with drugs used to treat hypertension such as first line diuretics, calcium channel antagonists and ACE inhibitors

Pathologies associated with coronary heart disease and drugs used to treat these disorders such as anticoagulants, statins, glyceryl trinitrate, digoxin in left heart failure.

Respiratory system pharmacology:

Pathology of asthma and chronic obstructive pulmonary disease including respiratory infections

Commonly used therapeutic agents including B2 agonists, antimuscarinic drugs, inhaled corticosteroids, antimicrobial agents.

LO4 **Account for the effects of pharmacological agents on the human nervous system.**

Structure and function of the human nervous system:

Anatomic and functional divisions of the nervous system (central and peripheral, autonomic and voluntary components)

Names of specific nerves are not needed (though the phrenic and vagus are useful) but the general principles of this functional approach should be taught with links to the anatomical differences in each system.

Drugs which act on the sympathetic nervous system:

Role of noradrenaline and adrenaline

Adrenergic drugs

Receptor-specific agonists

Receptor-specific antagonists

Therapeutic uses of sympathetic drugs.

Drugs which act on the parasympathetic nervous system:

Role of acetylcholine

Muscarinic drugs

Agonists and antagonists, therapeutic uses.

The neuromuscular junction:

Role of acetylcholine which could be usefully contrasted with effect of acetylcholine in the parasympathetic system

Nicotinic drugs

Drugs used as adjuncts to general anaesthesia.

Learning Outcomes and Assessment Criteria

Pass	Merit	Distinction
LO1 Investigate the regulatory requirements that must be satisfied to bring a drug to market		**D1** Discuss using examples, ways in which regulation itself limits research and discovery in the pharmaceutical industry
P1 Investigate regulation in the pharmaceutical industry **P2** Review the impact of regulation in bringing a new medicine to clinical use	**M1** Apply knowledge of regulation in the pharmaceutical industry to different products currently or previously in clinical use	
LO2 Discuss the range of molecular targets for drugs in the human body		**D2** Assess ways in which novel targets are discovered, using emerging knowledge of cellular and molecular processes
P3 Discuss the ways in which therapeutic agents interact with a range of molecular targets in the body **P4** Differentiate the routes of administration of drugs, based on their pharmacokinetics and dynamics	**M2** Apply existing knowledge of molecular structures in cells to account for the discovery of novel targets	

Pass	Merit	Distinction
LO3 Compare the use of therapeutic compounds used to treat disorders of the respiratory and cardiovascular systems in human		**D3** Justify the use of multiple agents to treat a single disorder of the cardiovascular system in humans
P5 Explore the therapeutic use of drugs commonly used to treat respiratory disorders **P6** Explore the therapeutic use of drugs commonly used to treat cardiovascular disorders	**M3** Analyse advantages and disadvantages of the specific actions of therapeutic agents in treating a single disorder in different individuals	
LO4 Explore the effects of pharmacological agents on the human nervous system		**D4** Critically evaluate the role of sympathetic drugs in the modern clinical practice
P7 Compare the functional differences of the sympathetic and parasympathetic nervous system **P8** Investigate the effects of drugs that interact with the sympathetic and parasympathetic nervous systems in humans	**M4** Assess the effects of drugs on the human body, based on their actions on the parasympathetic and sympathetic systems	

Recommended resources

Textbooks

GOLDACRE, B. (2013) *Bad Pharma*. London: Fourth Estate.

NEAL, M.J. (2015) *Medical Pharmacology at a Glance*. 8th ed. Oxford: Wiley-Blackwell.

RITTER, J., FLOWER, R., HENDERSON, G., RANG, H. (2015) *Rang & Dale's Pharmacology*. 8th ed. Amsterdam: Churchill Livingston.

Web

abpi.org.uk	The Association of the British Pharmaceutical Industry (General reference)
drugdiscoverytoday.com	Drug Discovery Today – review journal (Research)

Links

This unit links to the following related units:

Unit 2: Scientific Data Handling Approaches and Techniques

Unit 3: Regulation and Quality in the Applied Sciences

Unit 4: Cell Biology

Unit 5: Fundamentals of Chemistry

Unit 6: Anatomy and Human Physiology

Unit 17: Fundamentals of Biochemistry

Unit 27: Analysis of Scientific Data and Information

Unit 29: Biochemistry of Macromolecules and Metabolic Pathways

Unit 33: Analytical Techniques for Forensic Science

Unit 50: Toxicology

Unit 52: Drug Development for Production

Unit 50: Toxicology

Unit code	**R/617/5429**
Unit level	**5**
Credit value	**15**

Introduction

The science of toxicology has been a part of human existence since ancient times when natural substances were used to induce visions, there is well-documented evidence of the use of poisons in pursuit of power, to the present day, where forensic analysis allows detection of toxic substances in minute quantities.

The aim of this unit is to provide students with a broad background knowledge and understanding of the science of toxicology, the wealth and scope of the discipline and the wider applications of this important and specialist field to other subject areas. Students will study different aspects of toxicology (including the classes of toxic substances and their mechanisms of toxicity), methods used to assess toxicity (exposure, response, analysis) and how toxicology relates to other disciplines (forensics, environmental science, pharmacology).

Students will explore distribution and exposure to common toxic agents and consider how regulation impacts on safety.

The knowledge, understanding and skill sets gained in this unit will prepare students to choose their own preferred areas of specialism in toxicology and its related disciplines and to be aware of the contribution and impact of this science to a wide range of careers in health, the environment, public health and forensic science, amongst others.

Learning Outcomes

By the end of this unit students will be able to:

1 Explore the range of toxic substances that can affect the human body

2 Assess ways in which toxic substances mediate their effects on the body

3 Undertake methods used to assess the toxicity of substances in humans

4 Analyse the contribution of toxicology to other disciplines.

Essential content

LO1 **Explore the range of toxic substances that can affect the human body**

Classes of toxic substances that affect health:

Toxicity due to exposure to heavy metals

Effect of solvents and vapours on inhalation and contact

Exposure to radiation, to include: ultraviolet (UV), X-ray and gamma radiation used medically or otherwise

Toxic effects of radiation: alpha particles and gamma emitters

Toxicity of organic compounds, including pesticides

Nature of toxins produced by plants and animals.

LO2 **Assess ways in which toxic substances mediate their effects on the body**

Routes of entry of toxic substances:

Absorption of substances, including those which are lipid soluble

Ingestion of toxic substances, including inhalation

Factors affecting dose.

Physiological barriers to toxic substances:

Skin

Secretions

Role of the liver, kidney and lungs in clearance.

Mechanisms of action of common groups of toxic substances:

Protein binding

Competitive inhibitors of enzymes

Irreversible chemical reaction.

Reducing exposure to toxic agents:

Personal protective equipment

Coverings, including masks, gloves and eyewear

Nature of materials to protect against toxicity depends on the toxic substance

Use of competing substances to prevent damage on exposure (iodine, substances, which chemically bind the toxic substance).

LO3 **Undertake methods used to assess the toxicity of substances in humans**

NB: Data should be used to deliver this topic

Measuring toxicological effects:

Assessing exposure

Modelling exposure using predictive analysis which may be mathematical or qualitative.

Response to exposure:

Level of response to toxic agents including susceptibility, with emphasis on where response may be greater, such as during development and age-related effects.

Effect of dose on outcome:

Short-term versus long-term

Immediate compared with delayed effects

Effects of cumulative exposure.

LO4 **Analyse the contribution of toxicology to other disciplines**

Food industry:

Contribution of food additives to human health in preventing toxin production due to spoilage or contamination by microbes

Food additives as toxic substances

Toxic effects of materials that are in contact with food.

Forensic toxicology:

Analytical techniques used such as infrared spectroscopy at festivals, to identify substances in blood

Detecting poisons, use of chemical and biological markers.

Occupational health:

Workplace regulations to reduce environmental exposure and enhance workplace safety

Diseases linked with occupational exposure to toxic substances such as mesothelioma.

Learning Outcomes and Assessment Criteria

Pass	Merit	Distinction
LO1 Explore the range of toxic substances that can affect the human body		**D1** Critically evaluate the effects of substances toxic to humans that are produced by plants and animals
P1 Illustrate the nature of toxicity resulting from exposure to organic compounds, using named examples **P2** Compare the toxicity of two classes of toxic substance	**M1** Analyse exposure of a patient to radiation in clinical diagnosis compared with levels used in therapy	
LO2 Assess ways in which toxic substances mediate their effects on the body		**D2** Critically analyse the impact of methods to reduce exposure to toxic substances
P3 Discuss ways in which toxic substances can enter the body **P4** Assess the effectiveness of physiological processes in protecting the body against toxic substances	**M2** Analyse the mechanisms of action by which named substances cause toxicity	

Pass	Merit	Distinction
LO3 Undertake methods used to assess the toxicity of substances		**LO3 and LO4**
P4 Analyse samples to produce data on the content of toxic substances in samples **P5** Explore the ways in which exposure to toxic substances can have cumulative effects	**M3** Analyse data generated from testing for toxic substances in samples to form justified conclusions	**D3** Critically evaluate the methods used to detect long term toxic effects of substances
LO4 Analyse the contribution of toxicology to other disciplines.		
P6 Analyse the contribution of toxicology to the food and forensics industries **P7** Illustrate the ways in which regulations reduce exposure to toxic substances	**M4** Evaluate the conclusion that exposure to asbestos is linked to the later development of mesothelioma	

Recommended resources

Textbooks

Burcham, P.C. (2014) *An Introduction to Toxicology*: New York: Springer.
Timbrell, J. (2002) *Introduction to Toxicology*. 3rd ed. London: Informa Healthcare.

Web

thebts.org	British Toxicology Society UK (General reference)
cot.food.gov.uk	Committee on Toxicity of Chemicals in Food, Consumer Products and the Environment (General reference)
gov.uk	UK Government website – publications Chemical Hazards Compendium (General reference)
gov.uk	UK Government website – organisations Medicines and Healthcare products Regulatory Agency (MHRA) (General reference)
journals.sagepub.com	SAGE Journals International Journal of Toxicology (Research)
hindawi.com	Hindawi – open access Journal of Toxicology (Research)

Links

This unit links to the following related units:

Unit 14: Food Technology

Unit 24: Sampling and Sample Preparation

Unit 33: Analytical Techniques for Forensic Science

Unit 34: Forensic Evidence Collection and Preservation

Unit 35: Analytical Chemistry

Unit 39: Environmental Monitoring and Analysis

Unit 43: Investigating the Properties of Food Molecules

Unit 49: Principles of Pharmacology

Unit 54: Materials in Contact with Food

Unit 51: Specialist Scientific Techniques and Experimentation

Unit code	**L/617/5431**
Unit level	**5**
Credit value	**15**

Introduction

Each sector and industry uses specialist scientific techniques, many of which may be unique to that sector. The techniques could be routine tests, complex sample preparations or activities associated with research or fieldwork. This unit gives the tutor and students the opportunity to identify such specialist scientific techniques associated with the pathway of study, or even with laboratory work in a particular organisation, and research three of these techniques. The application of the three specialist scientific techniques identified will be investigated and the underpinning scientific principles will be discussed. Students will carry out one of the specialist techniques and report on their findings.

Students should plan how they will carry out their research to allow appropriate visits or placements to be arranged, and sources of information to be accessed in a timely way. Students may be able to investigate the use of certain specialist techniques at the centre, if the expertise exists. Students could also gain experience of the techniques from their workplaces or work placements, or by visiting a higher education institution, a research establishment, or carrying out fieldwork. It will be useful for students to have access to a range of scientific papers, based on application of key techniques.

On completion of this unit, students will be able to apply the research methodology and the range of presentation methods adopted to subsequent work contexts, and potentially as part of the planning for the Level 5 project.

Learning Outcomes

By the end of this unit, students will be able to:

1 Investigate how various specialist scientific techniques are used in your sector

2 Discuss the scientific principles underpinning the specialist scientific techniques investigated

3 Undertake routine analysis or an investigation using a specialist scientific technique in an industrial or pathway specific setting

4 Report on the routine analysis or investigation undertaken using the selected specialist scientific technique.

Essential Content

LO1 **Investigate how various specialist scientific techniques are used in your sector**

Examples of investigation methods:

Visits to industrial laboratories or to fieldwork locations

Visits to higher education institutions

Work placements

Experimentation days at advanced facilities

Reviewing journal articles

Talks from visiting speakers

Textbooks

Websites.

Examples (not exhaustive) of specialist practical techniques that may be selected for investigation, and must be used for a specific industrial or specialised scientific purpose:

Soil analysis: e.g. representative sampling of soil from a large area; acid digestion/solvent extraction to extract analytes from the matrix

Microbiology (water or food analysis/infection control): e.g. water filtration and plate inoculation in legionella testing; spiral plating; serial dilution and culturing; sub-culturing

Biological assays: e.g. enzyme-linked immunosorbent assay (ELISA); polymerase chain reaction (PCR); electrophoresis

Food science: e.g. protein determination; calorific value; mycotoxin screening

Chemical laboratories: e.g. X-Ray diffraction; X-Ray fluorescence; inductively coupled plasma atomic emission spectroscopy (ICP-AES); mass spectrometry (MS); gas chromatography (GC) method development and validation; GC-mass spectrometry (GC-MS); ICP-MS; high performance liquid chromatography (HPLC) method development and validation; non-dispersive infrared spectroscopy (NDIR); Raman spectroscopy; surface adsorption; thermal gravimetric analysis (TGA); differential scanning calorimetry (DSC); nuclear magnetic resonance (NMR);

Research chemistry laboratories: e.g. electron microscopy; cyclic voltammetry

Materials testing: e.g. representative sampling of ceramic from bulk containers; mechanical testing; physical testing; environmental testing

Pathology: e.g. use of bulk analysers in haematology, histopathology and biochemical pathology

Ecology: e.g. belt transect; plot sampling; reforestation; honey-bee pollination

Orthopaedic biomechanics: e.g. hip/knee/shoulder/elbow/other replacement; subchondroplasty; spine stabilisation

Medical imaging: e.g. X-ray radiography; magnetic resonance imaging (MRI); medical ultrasonography or ultrasound; endoscopy; elastography; tactile imaging; thermography; medical photography; nuclear medicine; positron emission tomography (PET); single-photon emission computed tomography (SPECT); electroencephalography (EEG); magnetoencephalography (MEG); electrocardiography (ECG)

Health Informatics: e.g. Datafly algorithm; General Data Protection Regulation (GDPR); Omaha System; openEHR; Health Level 7 (HL7); Logical Observation Identifiers Names and Codes (LOINC); Systematized Nomenclature of Medicine (SNOMED); Digital Imaging and Communications in Medicine (DICOM); xDT.

Examples of factors to consider in the use of the technique:

Purpose of the technique

Relationship between the choice of the technique and its purpose

Specific parameters to be considered in relation to the application

Typical experiments/tests using the specialist techniques.

LO2 **Discuss the scientific principles underpinning the specialist scientific techniques investigated**

Discussion formats:

Recorded professional discussion with a tutor

Essay

Presentation

Part of a report

Poster presentation.

Examples of topics to include when explaining scientific principles:

Explanation of how the technique works

Block diagrams and function of components (for instrumentation)

Parameters that may be varied to get more reliable results in a particular context

Reasons for choosing specific methods of data analysis in relation to the validity of results

Limitations of the technique.

LO3 **Undertake routine analysis or an investigation using a specialist scientific technique in an industrial or pathway-specific setting**

Examples of factors to be considered when planning routine analysis or an investigation:

Health, safety and risk assessment

Training in the use of the technique

Availability of standard methods/standard operating procedures

Specific objectives

Methodology and approach to use

Cleaning of the work area required before and after carrying out the analysis or investigation

Preparation of necessary materials and equipment

Waste disposal methods to be used

Use of appropriate documentation for recording information: e.g. worksheet; logbook, diary, portfolio, spreadsheets, databases.

Examples of factors to be considered during routine analysis or an investigation:

Selecting and setting specific parameters of operation for the purpose

Data analysis

Comparison of results with specifications or expected results

Actions necessary to ensure results are valid for an instrumental technique: e.g. calibration check; following a standard operating procedure; running a control sample; control chart; standard required for analyst to be considered competent; comparison of results with results from a competent analysis; repeatability and reproducibility

Modifications needed to ensure reliability of results

Revise the initial plan as and if required: e.g. review activities at the appropriate time to see if they meet requirements; make alterations as needed.

LO4 **Report on the routine analysis or investigation undertaken using the selected specialist scientific technique.**

Report:

Report format suitable for the context: e.g. technical report; scientific report; oral presentation; poster presentation

Analysis of results

Discussion of the validity of results.

Evaluation of learning experience and own performance:

Account of learning during experimentation

Reflect on the quality of the work undertaken

Recommend how the learning experience could have been enhanced.

Learning Outcomes and Assessment Criteria

Pass	Merit	Distinction
LO1 Investigate how various specialist scientific techniques are used in your sector		**LO1 and LO2** **D1** Critically analyse the planning of the investigation into the use of specialist scientific techniques and their underpinning scientific principles and draw conclusions about how such planning activities may be improved in the future
P1 Carry out investigations into at least three specialist scientific techniques and experimentation used in the relevant industry or sector **P2** Report on the ways that the investigated specialist scientific techniques are used	**M1** Illustrate the information in the report is derived from observations of industry/sector practice and literature	
LO2 Discuss the scientific principles underpinning the specialist scientific techniques investigated		
P3 Illustrate the scientific principles that underpin each of the specialist techniques investigated at LO1 **P4** Discuss the parameters of these techniques that may be adapted to suit different, specific applications within the sector	**M2** Analyse the scientific principles using more than one discussion format	

Pass	Merit	Distinction
LO3 Undertake routine analysis or an investigation using a specialist scientific technique in an industrial or pathway specific setting		**LO3 and LO4** **D2** Critically evaluate own performance and learning and recommend how the learning experience could have been enhanced
P5 Carry out appropriate planning activities for the routine analysis or investigation **P6** Carry out routine analysis, or an investigation, using the chosen specialist technique	**M3** Justify adjustments to experimentation made during the routine analysis or investigation	
LO4 Report on the routine analysis or investigation undertaken using the selected specialist technique.		
P7 Analyse the results from carrying out routine analysis or an investigation, using the specialist technique **P8** Report on the routine analysis or investigation undertaken in an appropriate format	**M4** Evaluate the validity of the results obtained from using the specialist technique	

Recommended resources

Textbooks

AHMED, N., GLENCROSS, H., WANG, Q. (Eds.) (2016) *Biomedical Science Practice: Experimental and Professional Skills.* 2nd ed. Oxford: Oxford University Press.

BOYLE. J., RAMSAY, S. (2017) *Writing for Science Students.* London: Palgrave.

CHALMERS, J.M., EDWARDS, H.G.M. (2012) *Infrared and Raman Spectroscopy in Forensic Science.* Chichester: John Wiley & Sons Ltd.

CHRISTIAN, G.D., DASGUPTA, P.K., SCHUG, K.A. (2014) *Analytical Chemistry.* 7th ed. Hoboken, NJ: John Wiley & Sons, Inc.

CRANWELL, P.B., HARWOOD, L.M., MOODY, C.J. (2017) *Experimental Organic Chemistry.* Chichester: John Wiley & Sons Ltd.

CRUZ, R.M.S., KHMELINSKII, I., VIEIRA, M.C. (Eds.) (2016) *Methods in Food Analysis.* Boca Raton, FL: CRC Press.

DEY, P. (2018) *Basic and Advanced Laboratory Techniques in Histopathology and Cytology.* Singapore: Springer Nature.

EVANS, E.H., FOULKES, M.E. (2019) *Analytical Chemistry: A Practical Approach.* Oxford: Oxford University Press.

GAISFORD, S., KETT, V., HAINES, P. (Eds.) (2016) *Principles of Thermal Analysis and Calorimetry*. 2nd ed. Cambridge: The Royal Society of Chemistry.

GOLDMAN, E., GREEN, L.H. (Eds.) (2015) *Practical Handbook of Microbiology.* 3rd ed. Boca Raton, FL: CRC Press

HANLON, G., HODHES, N.A. (2013) *Essential Microbiology for Pharmacy and Pharmaceutical Science.* Chichester: Wiley-Blackwell

HARRIS, D.C., LUCY, C.A. (2016) *Quantitative Chemical Analysis.* 9th ed. New York: Macmillan Education.

HOFFMAN, A., CLOKIE, S., WILSON, K., WALKER, J. (2018) *Wilson and Walker's Principles and Techniques of Biochemistry and Molecular Biology.* 8th ed. Cambridge: Cambridge University Press.

HOSSEINI, S., VASQUEZ-VILLEGAS, P., RITO-PALOMARES, M., MARTINEZ-CHAPA, S.O. (2018) *Enzyme-linked Immunosorbent Assay (ELISA) From A to Z*. Singapore: Springer Nature.

HUGHES, J. (Ed.) (2019) *Freshwater Ecology and Conservation: Approaches and Techniques (Techniques in Ecology & Conservation).* Oxford: Oxford University Press.

JOHNSON, S., SCOTT, J. (2019) *Study and Communication Skills for the Biosciences*. 3rd ed. Oxford: Oxford University Press.

JOHNSON, S., SCOTT, J., OVERTON T. (2019) *Study and Communication Skills for the Chemical Sciences*. 3rd ed. Oxford: Oxford University Press.

LANGFORD, A.M., DEAN, J. *et al.* (2018) *Practical Skills in Forensic Science.* 3rd ed. Harlow: Pearson Education Ltd.

MCPHERSON, P. (2015). *Practical Volumetric Analysis.* Cambridge: The Royal Society of Chemistry.

MILLER J., MILLER J.C., MILLER, R.D. (2018) *Statistics and Chemometrics for Analytical Chemistry*. 7th ed. Harlow: Pearson Education Ltd.

NELSON, S.S. (Ed.) (2017) *Food Analysis (Food Science Text).* 5th ed. Cham: Springer Nature.

NORDBY, J., BELL, S., JAMES, S.H. (Eds.) (2019) *Forensic Science: An Introduction to Scientific and Investigative Techniques.* 5th ed. Boca Raton, FL: CRC Press.

RADOJEVIC, M., BASHKIN, V.N. (2006) *Practical Environmental Analysis.* 2nd ed. Cambridge: The Royal Society of Chemistry.

RASMUSSEN, K.E., PEDERSEN-BEJERGAARD, S., HANSEN, S.H (2012) *Introduction to Pharmaceutical Chemical Analysis.* Hoboken, NJ: John Wiley & Sons, Inc.

REED, R., HOLMES, D. *et al.* (2016) *Practical Skills for the Biomolecular Sciences.* 5th ed. Harlow: Pearson Education Ltd.

SANDLE, T. (2016) *Pharmaceutical Microbiology: Essentials for Quality Assurance and Quality Control*. Cambridge: Woodhead Publishing Ltd.

SASTRY, A.S, BHAT K.S. (2018) *Essentials of Practical Microbiology*. New Delhi: Jaypee Brothers Medical Publishers (P) Ltd.

SKOOG, D.A., WEST, D.M., HOLLER, F.J, CROUCH, S.R. (2014) *Fundamentals of Analytical Chemistry.* 9th ed. Belmont: Brooks/Cole.

SNYDER, L.R, KIRKLAND, J.J., GLAJCH, J.L. (2012) *Practical HPLC Method Development.* 2nd ed. New York: John Wiley & Sons, Inc.

SPARKMAN, D.S. (2011) *Gas Chromatography and Mass Spectroscopy: A Practical Guide.* 2nd ed. Oxford: Academic Press.

STUART, B.H. (2013) *Forensic Analytical Techniques (Analytical Techniques in the Sciences).* Chichester: John Wiley & Sons Ltd.

THOMAS, R. (2013) *Practical Guide to ICP-MS: A Tutorial for Beginners.* 3rd ed. Boca Raton, FL: CRC Press

THOMPSON, M., WALSH, J.N. (2013) *Handbook of Inductively Coupled Plasma Spectroscopy*. 2nd ed. New York: Chapman Hall.

WALLACE, J.S. (2018) *Chemical Analysis of Firearms, Ammunition and Gunshot Residue (International Forensic Science and Investigation).* 2nd ed. Boca Raton, FL: CRC Press.

WHEATER, C.P., BELL, J.R., COOK, P.A. (2011) *Practical Field Ecology: A Project Guide.* Chichester: John Wiley & Sons Ltd.

Web

hse.gov.uk	The Health and Safety Executive
	Information on specific health and safety issues
iom3.org	Institute of Materials, Minerals and Mining The Polymer Society
	(Research)
microbiologysociety.org	Microbiology Society
	(Research)
nature.com	Nature – International Journal of Science
	(Research)
rsb.org.uk	Royal Society of Biology
	(General reference)
rsc.org	Royal Society of Chemistry
	(General reference)

Links

This unit links to the following related units:

Unit 1: Fundamentals of Laboratory Techniques

Unit 2: Scientific Data Handling Approaches and Techniques

Unit 10: Principles of Ecology and their Applications

Unit 18: Microbiological Techniques

Unit 24: Sampling and Sample Preparation

Unit 26: Managing Scientific Projects

Unit 27: Analysis of Scientific Data and Information

Unit 28: Applied Sciences Research Project

Unit 32: Biotechnology Techniques

Unit 33: Analytical Techniques for Forensic Science

Unit 35: Analytical Chemistry

Unit 39: Environmental Monitoring and Analysis

Unit 47: Polymer Materials and Properties

Unit 53: Industrial Microbiology

Unit 55: Nanomaterials and their Technology

Unit 52: Drug Development for Production

Unit code	**D/617/5434**
Unit level	**5**
Credit value	**15**

Introduction

Once substances that potentially have a beneficial therapeutic effect have been identified, they must undergo investigation to establish their safety, toxicity, pharmacokinetics and metabolism with respect to humans. The active pharmaceutical ingredients (APIs) must be processed and blended with other substances to ensure maximum benefit at the lowest cost. The optimum formulations must then be produced safely in a reproducible way, with tightly controlled process parameters and with a minimum of contamination.

Technician scientists are often involved in investigating the properties of various formulations. Once production commences, they may be involved in checking that the APIs or formulated drugs are within specification. Biology technician scientists may be involved in ensuring that microbial contamination is at a minimum. In biopharmaceutical manufacture, they may have to solve production problems. Other roles for biology technician scientists are emerging with the advent of gene therapies and biologics.

Learning Outcomes

By the end of this unit, students will be able to:

1. Discuss the drug development process
2. Discuss drug formulation
3. Explore the uses of assay and testing methods in drug development
4. Discuss production of pharmaceutical and biopharmaceutical formulations, gene therapies and biologics.

Essential content

LO1 **Discuss the drug development process**

Stages of development of a new drug, e.g.:

Target issue that a new drug will address

Possible compounds that may have a beneficial effect

Initial tests to identify compounds for further study

In-vitro and animal testing

Clinical trials: volunteer studies, phase II and phase III clinical studies

Pre-formulation and formulation

Use of sub-contracting organisations

Pilot manufacture

Scale up for launch

Primary and secondary manufacturing

Stability testing

Packaging

Approval by the regulators

Good manufacturing practice (GMP)

Good documentation practice (GDP)

Good laboratory practice (GLP)

Development of batch manufacturing instructions and documentation

Commissioning of manufacturing plant and controls

Development of a quality assurance process, meeting regulatory requirements

Development of reliable quality control checks

Sterility testing

Development of protocols for investigating sterility issues

Cost associated with drug development

Ethical pricing of drugs.

LO2 **Discuss drug formulation**

Types of formulations (small molecules):

Hard and soft capsules

Injectables

Tablets

Suspensions.

Features of APIs to consider when formulating drugs, e.g.:

Ionisation

Solubility

Properties of different salts

Partition coefficient

Crystallinity

Morphology

Oxidative and thermal stability

Interaction with excipients

Powder properties

Particle size and milling.

Bioavailability:

Chemical equivalence; bioequivalence; therapeutic equivalence

Route, by which API reaches the plasma or tissues

Area under the curve plasma concentration versus time

Pharmacokinetics

Formulations releasing API at different rates e.g.: immediate-release; modified-release; delayed-release; targeted-release.

Excipients/additives:

Examples of functions of excipients and additives: stabilisers, tablet binders, disintegrators, viscosity increasing agent, anti-microbial preservative, anti-oxidant, solvent, diluent, sweetening agent, anti-caking agent, glidant, coating agent

Examples of excipients/additives: citric acid, gelatine, alginate, cellulose, calcium phosphate, lactose, mannitol, magnesium oxide.

LO3 **Explore the uses of assay and testing methods in drug development**

Assay methods, e.g:

Ultraviolet spectroscopy

Infrared spectroscopy

High performance liquid chromatography (HPLC)

Thin layer chromatography (TLC)

Gas chromatography (GC)

Differential scanning calorimetry (DSC)

Thermal gravimetric analysis (TGA)

Dynamic vapor sorption

X-Ray diffraction (XRD).

Test methods:

Friability

Dissolution testing

Viscosity

Sterility testing.

Uses:

Stability testing

Measuring rate of dissolution

Assessing rate of release of the API

Analysis of purity

Proof of sterile manufacturing environment

Optimisation of powder properties

Compaction studies to optimise formulation for tableting.

LO4 Discuss production of pharmaceutical and biopharmaceutical formulations, gene therapies and biologics

Production processes in primary manufacture of small molecule modalities:

Recrystallisation

Milling

Dissolution

Spray drying

Biomanufacture of antibiotics

Packing pharmaceuticals.

Control of primary processes:

Key process parameters to be kept within specification

Sterility

Contamination.

Production processes in secondary manufacture, e.g.:

Mixing

Tableting

Coating.

Cell and gene therapies and biologics:

Examples of emerging modalities to consider (not an exhaustive list): targeted delivery; hybrid modalities; antibody drug conjugate; bispecific antibody; antibody construct; chimeric antibody receptors incorporated into cytotoxic T cells; fusion protein; monoclonal antibody; oncolytic immunotherapy virus; peptibody; peptide; RNA interference; therapeutic protein

Process descriptions for commercial production of modalities, other than small molecules

Practical difficulties associated with replication of production of modalities, other than small molecules

Partnerships between organisations to solve drug development problems.

Learning Outcomes and Assessment Criteria

Pass	Merit	Distinction
LO1 Discuss the drug development process		**D1** Justify the cost of drug development by considering aspects such as material sourcing, research, development, testing, production, distribution, retailing and legislation.
P1 Discuss the stages in turning a potentially therapeutic substance into a commercially produced drug **P2** Discuss the quality assurance processes that must be developed for an approved, commercially produced drug	**M1** Explore the drug development process by using well-chosen examples	
LO2 Discuss drug formulation		**D2** Justify the choice of additives in two different drug formulations
P3 Discuss the features of four different methods of drug delivery **P4** Discuss the features of a specific drug formulation that make it fit for purpose	**M2** Compare two different formulations containing the same active pharmaceutical ingredient	

Pass	Merit	Distinction
LO3 Explore the uses of assay and testing methods in drug development		**LO3 and LO4**
P5 Illustrate why specific assay methods are used in the qualitative and quantitative analysis of a specific drug **P6** Investigate the testing methods used during the formulation of a specific drug	**M3** Justify the analysis and tests carried out routinely during manufacture of a specific drug approved for manufacture	**D3** Critically analyse the quality assurance processes required by regulators for a specific therapeutic formulation
LO4 Discuss production of pharmaceutical and biopharmaceutical formulations, gene therapies and biologics.		
P7 Investigate how a specific pharmaceutical or biopharmaceutical drug is manufactured **P8** Discuss the issues involved in the commercial production of a specific gene or cell therapy or biologic	**M4** Analyse the parameters that must be controlled during the production of a pharmaceutical or biopharmaceutical small molecule drug	

Recommended resources

Textbooks

ACKERS, M.J. (2010) *Sterile Drug Products: Formulation, Packaging, Manufacturing and Quality (Drugs and the Pharmaceutical Sciences)*. London: Informa Healthcare.

BLASS, B. (2015) *Basic Principles of Drug Discovery and Development*. London: Academic Press.

GAISFORD, S., SAUNDERS, M. (2013) *Essentials of Pharmaceutical Preformulation.* Chichester: John Wiley & Sons Ltd.

HILL, R.G., RANG, H.P. (Eds.) (2012) *Drug Discovery and Development: Technology in Transition*. 2nd ed. Edinburgh: Churchill Livingstone.

INSPECTION, ENFORCEMENT AND STANDARDS DIVISION, MEDICINES AND HEALTHCARE PRODUCTS REGULATORY AGENCY (MHRA) (2017) *Rules and Guidance for Pharmaceutical Manufacturers and Distributors 2017 (The Orange Guide).* London: Pharmaceutical Press.

NG, R. (2015) *Drugs: From Discovery to Approval.* 3rd ed. Hoboken, NJ: John Wiley & Sons, Inc.

ROSIER, J.A., MARTENS, M.A., THOMAS, J.R. (2014) *Global New Drug Development. An Introduction*. Chichester: John Wiley & Sons Ltd.

SHARGEL, L., YU, A.B.C. (Eds.) (2016) *Applied Biopharmaceutics and Pharmacokinetics*. 7th ed. New York: McGraw-Hill.

TOVEY, G.D. (Ed.) (2018) *Pharmaceutical Formulation: The Science and Technology of Dosage Forms*. London: The Royal Society of Chemistry.

Journals

ALFONSO-CRISTANCHO, R., ARMSTRONG, N., ARJUNJI, R., RIEMSMA, R., WOTHY, G., GANGULY, R., KLEIJNEN, J. (2017). 'Comparative effectiveness of biologics for the management of rheumatoid arthritis: systematic review and network meta-analysis', *Clinical Rheumatology*, 36 (1), pp. 25–34.

JARVIS, L.M. (2018). 'A Year in New Drugs', *Chemical and Engineering News,* 96 (4).

KAJI, E.H., LEIDEN, J.M. (2001) 'Gene and Stem Cell Therapies', *Journal of the American Medical Association*, 285 (5), pp. 545–550.

VALEUR, E., GUĚRET, S.M., ADIHOU, H. et al. (2017). 'New Modalities for Challenging Targets in Drug Discovery', *Angewandte Chemie International Edition in English*, 56 (35), pp. 10294–10323.

Web

amgenscience.com	AMGEN Science The Shape of Drugs to Come (Article)
drugtopics.com	Drug Topics: Voice of the Pharmacist Overview of Pharmaceutical Excipients used in Tablets and Capsules (Article)
edqm.eu	European Directorate for the Quality of Medicines & Healthcare European Pharmacopoeia (9th edition) (General reference)
fda.gov	U.S. Food and Drugs Administration (General reference)
gov.uk	UK Government website – organisations Medicines and Healthcare products Regulatory Agency (MHRA) (General reference)
pharmacopoeia.com	British Pharmacopoeia (General reference)
pharmafocusasia.com	Pharma Focus Asia Reviving Pharma Focus R&D Productivity with New Modalities (VALEUR, E.) (Report)

Links

This unit links to the following related units:

Unit 1: Fundamentals of Laboratory Techniques

Unit 3: Regulation and Quality in the Applied Sciences

Unit 4: Cell Biology

Unit 5: Fundamentals of Chemistry

Unit 6: Anatomy and Human Physiology

Unit 8: Organic Chemistry

Unit 17: Fundamentals of Biochemistry

Unit 29: Biochemistry of Macromolecules and Metabolic Pathways

Unit 30: Molecular Biology and Genetics

Unit 31: Immunology

Unit 32: Biotechnology Techniques

Unit 35: Analytical Chemistry

Unit 49: Principles of Pharmacology

Unit 51: Specialist Scientific Techniques and Experimentation

Unit 53: Industrial Microbiology

Unit 53: Industrial Microbiology

Unit code	**H/617/5435**
Unit level	**5**
Credit value	**15**

Introduction

In industrial microbiology, microorganisms are used in industrial processes to yield large quantities of specific products, such as the production of some antibiotics, vitamins, enzymes, amino acids, solvents, alcohol, biopesticides, inoculants and dairy. This unit provides the opportunity to investigate diverse applications of microbiology in industry.

In food production, fermentation reactions are used to make bread, beer, yogurt and cheese. Certain primary or secondary metabolites of microorganisms are products of industrial importance thus understanding microbiology is essential in order to manipulate the conditions of production of the metabolites to ensure maximum yield. In the process of wastewater treatment, microorganisms are used to metabolise impurities in wastewater. The deterioration caused by the growth of microorganisms, and understanding microbial growth, is very important to a range of other industries, as it may allow effective presentation methods to be developed. Knowledge of the principles of microbiology are also important to the personal care industry and in ensuring sterility during production processes, including control of legionella in cooling towers and other stagnant water through legionella testing and chemical dosing, as necessary.

Learning Outcomes

By the end of this unit students will be able to:

1 Review microbiology relevant to the food industry

2 Assess the commercial production of a substance derived from the metabolism of a microorganism

3 Investigate how biodeterioration of products may be prevented

4 Investigate microbial treatment in an environmental context and in the control of legionella.

Essential Content

LO1 **Review microbiology relevant to the food industry**

Fermentation processes, e.g. in production of:

Bread

Beer

Wine

Yogurt

Cheese.

Examples of pathogenic organisms:

Campylobacter

Salmonella

E.coli

Listeria

Clostridia

Clostridium botulinium

Clostridium perfringens

Norovirus

Hepatitis A

Prion causative agents

Mycotoxins

Protozoa, e.g. cryptosporidium.

Modes of transmission of pathogenic organisms

Methods for prevention of contamination by pathogens, e.g.:

Heat treatment

Pasteurisation

Optimum storage temperatures

Irradiation.

Environmental monitoring:

Sampling frequency

Sampling methods

Sample points

Spot tests

Growth and positive identification of organisms.

Examples of actions taken as part of good manufacturing practice (GMP):

Use of standard methods

Maintenance of production parameters within strict limits

Testing raw materials

Use of raw materials, with a suitable level of sterility

Expiry dates for equipment and flexible hoses

Sterilisation of fermenters

Documenting that processes are being followed.

LO2 **Assess the commercial production of a substance derived from the metabolism of a microorganism**

Examples of substances produced from metabolism of microorganisms:

Antibiotics and other drugs

Enzymes

Biofuels

Industrial alcohol

Citric acid

Lactic acid

Vinegar

Amino acids

Vitamins

Bioinsecticides

Ergot alkaloids

Vaccines.

Development of the method, e.g.:

Design and material of reactors

Temperature control

Foam production and control

Inoculum preparation

Continuous and batch processes

Isolation and purification methods (e.g. filtration, centrifugation, coagulation and flocculation, foam fractionation, cell disruption, liquid extraction, dissociation extraction, ion-exchange adsorption, precipitation, crystallisation, chromatography, decolourisation, drying).

LO3 **Investigate how biodeterioration of products may be prevented**

Examples of products susceptible to biodeterioration:

Meats

Dairy products

Fats and oils

Nuts

Wood.

Preservation:

Optimising conditions for minimal growth (e.g. temperature, moisture, pH, presence of oxygen)

Methods of preservation (e.g. low temperature, storage in dry conditions, excluding air, replacing air by another gas, irradiation, heat treatment to kill organisms, use of biocides)

Regulation of biocides, e.g. by Health and Safety Executive

Registration, Evaluation, Authorisation and restriction of CHemicals (REACH) (or current equivalent regulation of chemicals).

LO4 **Investigate microbial treatment in an environmental context, and in the control of legionella**

Examples of environmental contexts involving microbial treatment:

Municipal wastewater treatment

Commercial waste water treatment

In-house waste water treatment

Sludge digestion

Explanation of processes

Specific examples of processes.

Control of legionella:

Legionnaires' disease

Natural incidence of legionella

Factors affecting growth of legionella

Incidences of public infection by legionella

Cooling towers

Air-conditioning systems

Sampling water for legionella

Microbiological test method for legionella

Chemical dosing to control legionella

Health and Safety Executive Code of Practice (L8).

Regulation:

Environment Agency (in relation to wastewater and sludge treatment)

Permit to discharge waste water

Conditions of permit (e.g. suspended solids, pH, temperature, COD)

Consequences of breaching permit

Public register

Health and Safety Executive (in relation to Legionella).

Learning Outcomes and Assessment Criteria

Pass	Merit	Distinction
LO1 Review microbiology relevant to the food industry		**D1** Evaluate the benefits of good manufacturing practice and environmental microbiological monitoring in a production environment
P1 Review the production of a food industry product involving a fermentation process **P2** Explore the sources and possible consequences of pathogenic organisms in the food industry	**M1** Analyse the methods used to control pathogenic organisms in the food industry.	
LO2 Assess the commercial production of a substance derived from the metabolism of a microorganism		
P3 Assess the commercial importance of a product derived from a microorganism **P4** Report on the development of a commercially viable production method for the product	**M2** Analyse the factors that affect production of the product	
LO3 Investigate how biodeterioration of products may be prevented		**D2** Critically analyse the impact of regulation on the use of biocides
P5 Investigate how products may deteriorate as a result of microbial action **P6** Review a range of methods used to prevent deterioration as a result of microbial action	**M3** Evaluate the effectiveness of the methods used to prevent deterioration as a result of microbial action	

Pass	Merit	Distinction
LO4 Investigate microbial treatment in an environmental context and in the control of legionella.		**D3** Critically analyse regulation in relation to the environmental process involving microbial treatment, and in the control of legionella
P7 Review the role of microorganisms in an environmentally important process **P8** Investigate the role of water sampling, testing and dosing in controlling legionella	**M4** Evaluate the impact of controlling legionella	

Recommended resources

Textbooks

BAIRD, R., BLOOMFIELD, S.F. (Eds.) (2017) *Microbial Quality Assurance in Pharmaceuticals, Cosmetics and Toiletries.* 2nd ed. Boca Raton, FL: CRC Press.

BAKI, G., ALEXANDER, K.S. (2015) *Introduction to Cosmetic Formulation and Technology*. Hoboken, NJ: John Wiley & Sons, Inc.

BALTZ, R.H., DAVIES, J.E., DEMAIN, A.L. (Eds.) (2010) *Manual of Industrial Microbiology and Biotechnology.* 3rd ed. Washington, DC: ASM Press.

CRAMER, M.M. (2016) *Food Plant Sanitation: Design, Maintenance and Good Manufacturing Practices.* 2nd ed. Boca Raton, FL: CRC Press.

DENYER, S.P., HODGES, N., GORMAN, S.P., GILMORE, B. (Eds.) (2011) *Hugo and Russell's Pharmaceutical Microbiology.* 8th ed. Chichester: Blackwell Publishing Ltd.

EDWARDS-JONES, V. (Ed.) (2016) *Essential Microbiology for Wound Care.* Oxford: Oxford University Press.

GEIS, P.A. (2006) *Cosmetic Microbiology.* 2nd ed. Abingdon: CRC Press.

HANLON, G., HODGES, N.A. (2013) *Essential Microbiology for Pharmacy and Pharmaceutical Science.* Chichester: John Wiley & Sons Ltd.

HEALTH AND SAFETY EXECUTIVE (2013) *Legionnaires' Disease: The control of legionella bacteria in water systems: Approved Code of Practice and guidance on regulations (Legislation series).* 4th ed. Norwich: The Stationery Office.

HOGG, S. (2013) *Essential Microbiology.* 2nd ed. Chichester: John Wiley & Sons Ltd.

HUI, Y.H. (2014) *Plant Sanitation for Food Processing and Food Service.* 2nd ed. Boca Raton, FL: CRC Press.

MARRIOTT, N.G., SCHILLING, M.W., GRAVANI, R.B. (2018) *Principles of Food Sanitation.* 6th ed. Cham: Springer.

McCOY, W.F. (2005) *Preventing Legionellosis.* London: IWA Publishing.

OKAFOR, N., OKEKE, B.C. (2017). *Modern Industrial Microbiology and Biotechnology*. Boca Raton, FL: CRC Press.

PRIEST, F.G., CAMPBELL, I. (Eds.) (2013) *Brewing Microbiology.* 2nd ed. London: Chapman and Hall.

ROLLER, S. (2012) *Essential Microbiology and Hygiene for Food Professionals.* Boca Raton, FL: CRC Press.

ROSSMOORE, H.W. (Ed.) (2012) *Handbook of Biocide and Preservative Use*. Dordrecht: Springer Science & Business Media B.V.

SANDLE, T. (Ed.) (2012) *The CDC Handbook – A Guide to Cleaning and Disinfecting Cleanrooms.* 2nd ed. Guildford: Grosvenor House Publishing Ltd.

STANGA, M. (2010) *Sanitation: Cleaning and Disinfection in the Food Industry.* Weinheim: Wiley-VCH Verlag GmbH & Co KGaA.

TROLLER, J.A. (2012) *Sanitation in Food Processing*. 2nd ed. New York: Academic Press.

WAITES, M.J., MORGAN, N.L., ROCKEY, R.S., HIGTON, G. (2001) *Industrial Microbiology.* Oxford: Blackwell Science Ltd.

Web

hse.gov.uk	Health and Safety Executive (HSE) (General reference)
microbiologysociety.org	Microbiology Society [Publishes journals such as Microbiology Access Microbiology Microbial Genomics] (Research)

Links

This unit links to the following related units:

Unit 3: Regulation and Quality in the Applied Sciences

Unit 18: Microbiological Techniques

Unit 19: Managing Food Preparation and Production Systems

Unit 32: Biotechnology Techniques

Unit 40: Water and Wastewater Management

Unit 52: Drug Development for Production

Unit 54: Materials in Contact with Food

Unit code	**M/617/5437**
Unit level	**5**
Credit value	**15**

Introduction

From the earliest times, humankind has sought to utilise materials to store, transport and present food. However, the materials used in the processing, packaging, conveyance and storage of food have undergone major changes in recent years. Increasingly the packaging associated with foodstuffs are polymer based, with plastics prevalent across the industry. Processing plants are also increasingly reliant on polymers, although metals can probably be said to have retained their dominance in this sector of the food industry.

The reasons for adopting polymers in such a wholesale manner are many and varied. This material has played a significant role in making our foods more hygienic, longer lasting and safer, indeed, to an extent it can be said that they have benefited the environment. Their demand on resources, and the energy consumed to manufacture and transport goods packaged in plastic, can in many cases be significantly lower than their more traditional counterparts.

There is still a place for more traditional materials, although it is usual now to see them utilised in tandem with other materials. Plastics used in conjunction with other materials, be it paper, metal or fabric, have allowed a greater versatility in handling food.

This unit will consider the contact made by foodstuff on its journey from its source, through factory processing and onto the consumer. It will consider all potential packaging materials, including the development of newer and increasingly sophisticated materials. The unit will also consider the legislation seeking to control and proscribe certain materials, as their effects on food and the environment become evident.

Learning Outcomes

By the end of this unit students will be able to:

1 Explore the contact made by foodstuffs during its progress from source to consumer

2 Investigate the use of traditional/conventional packaging

3 Investigate the use of new or novel materials in packaging

4 Review the legislation surrounding the materials used in conjunction with food.

Essential content

LO1 **Explore the contact made by foodstuffs during its progress from source to consumer**

Journey to processing plant or factory:

Storage facilities and containment including but not limited to those manufactured from: metal; wood; natural fibres; paper; board

Scale of containers, e.g.: silos, tankers, crates, pouches

Hygiene including issues of contamination, chemical migration, leeching and cleaning, if multi-use containers.

Conveyance through processing plant:

Contact with plant equipment, including but not limited to: vats; hose; conveyor systems; hoppers; ovens; freezers; chill cabinets

Consider the materials from which equipment, or the components of the equipment in food contact, is manufactured, e.g. nitrile rubber, PVC, stainless steel, polyethylene, nylon, POM and aluminium

Behaviour of the above, and other identified materials, under varying conditions, and in contact with differing categories of foodstuff

Consider:

Varying temperature profile

Embrittlement potential

Migration

Monomer release

Volatiles

Reactive foodstuff, such as those containing; oils; grease; tomato based compounds; highly acidic or alkaline; tannins; brine

Behaviour of differing materials working in tandem, e.g. differing juxtaposed materials displaying differing thermal expansions on the application of heat

Integrity of the materials utilised, including:

Identifying potential attrition or breakages

Maintaining hygienic conditions across differing materials in a single production line

Use of seals.

Use of materials in the final stages of a processing plant:

Shrink wrap

Pallets

Tote boxes.

LO2 **Investigate the use of traditional/conventional packaging.**

Usage and typical application of natural materials including but not limited to:

Natural fibres; jute; hemp; cotton; linen

Pulp derived materials; paper; board

Wood

Leather.

Usage and typical application of traditional materials including but not limited to:

Glass

Pottery

Metal, such as: Steel; Aluminium.

Usage and typical application of plastics including but not limited to:

Polyolefin; High-density polyethylene (HDPE); Low-density polyethylene (LDPE); Polypropylene (PP)

Polyethylene terephthalate

Polystyrene

Polyvinyl chloride

Ethylene vinyl alcohol copolymers

Polycarbonate.

Usage and reasons for adopting multi-layered materials including but not limited to:

Films of multi-layered plastics

Foils consisting of metal backed plastic

Solid metal containers (cans) lined with plastic film

'Waxed' papers including those of silicone coated paper

Board or paper lined with plastic or foil.

Comparative cost to process – economically and environmentally:

Energy consumption to manufacture and transport

Water consumption to manufacture

Carbon footprint – greenhouse gas (GHG) emissions

Other life cycle considerations

Recyclability.

LO3 **Investigate the use of new or novel materials in packaging.**

Usage of nanomaterials and nanotechnology in packaging:

Improvement of function of packaging

Nanoclays including their use as barriers to: gas permeability; humidity; temperature

Metal nanoparticles offering, e.g. biocidal properties including but not limited to: nanosilver; nanocopper; nanozinc-oxide.

Active packaging:

Interaction between packaging and food, including optimal placement of active layer

Characteristics of chemically and physically active packaging

Use of scavengers, e.g. against ethylene (induces fruit ripening) or oxygen (accelerated deterioration).

Intelligent or smart packaging:

Monitoring and informing on condition of food

Packaging performing a function, e.g. warming contents

Novelty packaging, e.g. lighting up in response to a stimulus

Interactive with IT, e.g. can communicate with smartphones; smart fridges; smart shelves

Provide monitoring of food conditions and give feedback, e.g. smart inks; time/temperature indicators; bioindicators; gas sensors.

Biodegradable packaging:

Derived from plant-based materials, i.e. biomass or bio-based

Synthesised from plant of biomass sources and/or a mix of biomass and petroleum-based materials (partially biomass)

Produced from microbes or bacteria

Fibre-based packaging derived from sources other than wood pulp, e.g. utilising straw; plant stalks; bagasse.

LO4 **Review the legislation surrounding the materials used in conjunction with food.**

Legislation relating to polymer (plastic and rubber):

Permissible additives, including but not limited to: monomers; processing aids; property modifying additives; fillers

Migration of substances under varying conditions including: across a temperature profile; subjected to microwaves; in conjunction with other materials

Recycling and the use of recyclate, including post-consumer recyclate and recycled post production material (e.g. sprues and runners).

Legislation relating to other substances used in the manufacture of food contact materials:

Purity standards, limits on migration (e.g. cadmium and lead in ceramics)

Special conditions for the use of specific materials (e.g. placement of additives in relation to foodstuff)

Other relevant provisions

Materials and substances including: adhesives; ceramics; cork; glass; metals and alloys; paper and board; printing inks; textiles; varnishes and coatings; waxes; wood.

Legislation relating to materials utilised in conjunction with infant foodstuff:

Restrictions concerning polycarbonate and the use of bisphenol A

Restrictions on the use of other materials and additives in the manufacture of, e.g. bottle teats and dummies.

Legislation and advice concerning 'active' and 'intelligent materials':

Including absorption of substances from food packaging interior, such as liquid and oxygen

Release of substances into the food

Release of active materials

Thermochromic labelling.

Learning Outcomes and Assessment Criteria

Pass	Merit	Distinction
LO1 Explore the contact made by foodstuffs during its progress from source to consumer		**D1** Critically analyse the considerations a material selector must make when suggesting suitable materials for the construction of a food processing system
P1 Explore the progress of food items through a factory in terms of the contact they make with conveyance, mixing/portioning and storage equipment **P2** Investigate the hygiene issues connected with a food processing line	**M1** Analyse the potential problems arising from prolonged contact of certain foodstuffs with susceptible materials	
LO2 Investigate the use of traditional/conventional packaging		**D2** Critically evaluate the use of a given material in a packaging application in terms of its environmental impact, i.e. energy to manufacture/transport, water use, carbon footprint
P3 Analyse a given typical item of packaging and ascertain the material(s) from which it has been formed, giving reasons for its/their utilisation **P4**. Explore the reasons for the use of multi-layered plastic film for a given packaging application	**M2** Assess the use of plastics packaging in the food industry, giving reasons for its dominance in the market	

Pass	Merit	Distinction
LO3 Investigate the use of new or novel materials in packaging		**LO3 and LO4**
P5 Investigate the use of metal nanoparticles in food packaging giving the perceived benefits of utilising such a material **P6** Explore the range of intelligent packagings available and detail how they function	**M3** Differentiate between the forms of biodegradable packaging available while delineating the various materials that can be so described	**D3** Investigate the potential issues arising in utilising a given grouping of novel material in packaging, including issues concerning legislation
LO4 Review the legislation surrounding the materials used in conjunction with food		
P7 Investigate the legislation dictating the permissable use of a given material in a food contact context **P8** Explore the legislative limitations in utilising recycled materials in food contact packaging	**M4** Analyse the legislation dictating the permissible contact of a given range of materials with foods	

Recommended resources

Textbooks

COLES, R., KIRWAN, M. (2011) *Food and Beverage Packaging Technology.* 2nd ed. Chichester: Blackwell Publishing Ltd.

KIRWAN, M. (2013) *Handbook of Paper and Paperboard Packaging Technology*. 2nd ed. Chichester: Wiley-Blackwell.

ROBERTSON, G.L. (2013) *Food Packaging: Principles and Practice*. 3rd ed. Boca Raton, FL: CRC Press.

STRONG, B. (2005) *Plastics: Materials and Processing*. 3rd ed. London: Pearson Education Ltd.

Journals

BIJI, K.B., RAVISHANKAR, C.N., MOHAN, C.O., SRINIVASA GOPAL, T.K. (2015) 'Smart packaging systems for food applications: a review', *Journal of Food Science Technology*, Oct 52 (10), pp. 6125–6135.

Food and Chemical Toxicology. Elsevier.

Journal of Food Science and Technology. Springer.

YILDIRIM, S., Röcker, B., PETTERSEN, M.K., *et al.* (2017) 'Active Packaging Applications for Food', *Comprehensive Reviews in Food Science and Food Safety*, 17 (1).

Web

bpf.co.uk	The British Plastics Federation
	(General reference)
fao.org	Food and Agricultural Organization of the United Nations
	UN document on Bio-based food packaging in Sustainable Development
	(Report)
foodmanufacture.co.uk	Food manufacture
	(General reference)

foodpackagingforum.org	Food packaging Forum Food packaging and health – Nanomaterials (Article)
hse.gov.uk	Health and Safety Executive Nanotechnology (General reference)
plasticseurope.org	Plastics Europe The impact of plastic packaging on life cycle energy consumption and greenhouse gas emissions in Europe (Report)
sciencedirect.com	Science Direct (General reference)

Links

This unit links to the following related units:

Unit 42: Materials Life Cycle and the Circular Economy

Unit 46: Polymer Processing and Manufacture

Unit 47: Polymer Materials and Properties

Unit 55: Nanomaterials and their Technology

Unit code	**T/617/5438**
Unit level	**5**
Credit value	**15**

Introduction

Nanomaterials can occur naturally and, as such, are not a new phenomenon. However, it is the artificially constructed nanomaterials, particularly nanocomposites that are of interest in this unit. Here the focus will be on the varying forms of available nanomaterials, that is, both the materials utilised as a matrix and that utilised as the additive, nanoparticulate.

On establishing the varying forms the nano-particulate phase can take, as well as ascertaining the materials, properties and development of this phase, attention will then focus on the composite itself. Nanocomposites can come in a variety of combinations and these will be examined, as will be their methods of production.

The potential nanomaterials have on a diverse range of applications and their current usage will also be investigated. Materials of all aspects are associated with health and safety legislation and advice. Nanomaterials are no different in this respect, and these guidelines will also be assessed.

On successful completion of the unit, the student will be able to identify the terminology associated with nanomaterials. They will also have a grounding in the materials utilised both in the particulate and in the matrix phases and have a grounding in the concepts behind their manufacture. Furthermore, students will be cognisant of the many and varied areas of application of these materials, and the potential for their continued future use.

Learning Outcomes

By the end of this unit, students will be able to:

1 Discuss the basic concepts of a nanomaterial (nanocomposite)

2 Investigate nano-particulate phase materials

3 Investigate the variety of nanomaterial combinations and their production capabilities

4 Explore the current areas of application of a nanomaterial and their future potential.

Essential content

LO1 **Discuss the basic concepts of a nanomaterial (nanocomposite).**

Expected influences of a nano-reinforced composite on engineering properties:

Mechanical properties in terms of: modulus; strength; toughness; impact

Barrier properties in terms of: moisture absorption; chemical resistance; gaseous diffusion

Fire retardance in terms of: burn through; fire, smoke and toxicity (FST); charring

Electrical properties, in terms of: conductivity; anti-static discharge; EMI shielding

Thermal properties, in terms of: heat distortion temperature; stability; conductivity

Tribological properties, in terms of: surface hardness; wear rate; scratch/scuff resistance.

Terminology and basic concepts:

Definition of terms associated with nanomaterials including: resin or matrix; reinforcing phase; compound; composite; concentration; dispersion; nanoscale; nanoparticle; nano-fibre; nanotube; nano-plate; aerogels; adhesion factor; agglomeration; microstructure; surface area; nanomaterial; nanocomposite

Consider the significance of dimensions in the reinforcing plane; 0D; 1D; 2D; 3D.

LO2 **Investigate nano-particulate phase materials.**

Summary of the range of materials utilised within the nano-phase:

Consider the mechanisms and properties (including their influences on end use) imparted by the nano-particulate materials set out below

Clays, e.g.: montmorillonite:

Transformation mechanisms of layered silicates: phase separated; intercalated; exfoliated.

Carbon-based nano-particulate phase:

Carbon black

Graphite, including consideration of: interlayer bonding; inter-planar cleavage; material properties such as thermal, chemical stability and electrical conductivity

Graphene, including consideration of: planar arrangements and dimensions; bond strength; lattice structure; manufacturing challenges; material properties such as conductivity; opacity

Diamond, including consideration of: chemical bonding; material properties such as thermal conductivity and opacity.

Metal-based nanoparticulate phase:

Use of metals, such as: titanium; iron; gold; silver; platinum; palladium; also nano-crystalline metals, such as; aluminium; magnesium; copper; boron

Semiconductor materials, including quantum dots

Consider the: particle size, shape, composition; inter particle spacing; reactive properties; crystallinity; magnetic properties.

Ceramics based nano-particulate phase:

Particulate materials such as: titanium dioxide (TiO_2); boron carbide (B_4C); titanium nitride (TiN); magnesium oxide (MgO)

Issues such as: molecular synthesis; mechanical attrition; crystallisation; phase separation; isostatic pressing

Consider compounds, such as: molybdenum disulphide; tungsten disulphide.

Nanoparticulate morphological features:

Include: platelet; ellipsoid; hollow spheres (bucky balls); tubes, including fullerenes (single and multi-walled); rods; wires; whiskers.

LO3 **Investigate the variety of nanomaterial combinations and their production capabilities**

Polymer matrix nanocomposite:

Commonly utilised matrix polymers, including those classed as: thermoplastics; thermosets

Commonly utilised nano-reinforcement phase

Methods of embedding and dispersing, including via: melt processing; solution; in-situ polymerisation.

Metal matrix nanocomposite:

Commonly utilised matrix metals

Commonly utilised nano-reinforcement phase

Methods of embedding and dispersing including via: powder metallurgy with ball milling and compaction; solidification processing; vapour phase processing; sinter forging

Mechanical dispersion.

Ceramic matrix nanocomposite:

Commonly utilised matrix ceramics

Commonly utilised nano-reinforcement phase

Processing methods including, e.g. chemical vapour deposition

Consider high performance ceramics, including: structural ceramics; functional ceramics.

Nano-coatings:

Consider potential of coatings that are: reactive; tribological; photocatalytic; functional.

LO4 **Explore the current areas of application of a nanomaterial and their future potential**

Usage of nanomaterials in textiles:

Treatments of fabrics to be, e.g.: stain resistant; hydrophobic; wrinkle resistant; personal body armour; antibacterial properties; durability

Consider, e.g.: ‘smart fabrics’ embedded with sensors and electronics; wearable technology.

Usage of nanomaterials in improving function of packaging:

Nanoclays, including their use as barriers to: gas permeability; humidity; temperature

Metal nanoparticles offering, e.g. biocidal properties.

Usage of nanomaterials in domestic applications:

Applications, such as: environmental sensors; air purifiers; filters; antibacterial cleaners; specialised paints such as paint resistant to dirt

Coatings on glass that imparts, for example: water repellency; anti-reflective; self-cleaning; resistance to ultraviolet; antimicrobial; scratch-resistant; electrically conductive.

Usage of nanomaterials in transport applications:

Importance of weight reduction in transport vehicles from automotive to aeronautic

Consider, e.g.: rechargeable battery systems; fuel additives; lubricants; engine oils; petroleum refining; catalytic converters.

Usage of nanomaterials in electronic and electrical applications:

Consider, e.g.: flexible batteries; sensors; smart solar panels; ultra-high definition displays; antimicrobial/antibacterial coatings; dense computer memory

Advances in electronic products that can be, e.g.: flexible, bendable, foldable, rollable, and stretchable.

Usage of nanomaterials in energy applications:

Efficiency of fuel production: ‘scrubbers’ in power plant chimneys; nanostructured solar cells; efficiency of high-tension wires

Consider, e.g.: battery capacitor development; wind turbine blades; energy harvesting and heat converting.

Usage of nanomaterials in additional applications:

Utilisation of nanomaterials in applications such as: cosmetics; sun screen; glasses (self-cleaning)

Environmental benefits; de-salinisation; environmental contaminant clean-up.

Legislation:

Health and safety advice pertaining to nanomaterials and nano-particles.

Learning Outcomes and Assessment Criteria

Pass	Merit	Distinction
LO1 Discuss the basic concepts of a nanomaterial (nanocomposite)		
P1 Discuss the importance of surface area in a nano-particle **P2** Investigate the dimensional aspect of nanomaterials and how reinforcement operates within differing planes	**M1** Explore the importance of dispersion of the reinforcing phase in a nanomaterial, noting the results of a poorly dispersed material	**D1** Evaluate the expected effect nanoparticulate reinforcement has on the engineering properties of a nanocomposite
LO2 Investigate nano-particulate phase materials		**LO2 and LO3**
P3 Assess the types of nanofibre available and consider potential areas of use **P4** Explore the varying forms of carbon-based nanoparticles, making note of how they differ from one another	**M2** Analyse a given range of materials capable of use as nanoparticulate phase reinforcement	**D2** Critically analyse the difficulties that arise when producing and processing nanoparticulates within a matrix for given matrix-particulate nanomaterials
LO3 Investigate the variety of nanomaterial combinations and their production capabilities		
P5 Investigate the typical combination of a given nanocomposite and its matrix-reinforcement phase **P6** Review the field of structural ceramics and consider their properties	**M3** Assess the challenges facing the development of nano-reinforced composites	

Pass	Merit	Distinction
LO4 Explore the current areas of application of a nanomaterial, and their future potential		**D3** Critically evaluate the use of nanocomposite materials in place of the traditional material in a given application
P7 Explore the application of nanomaterials in a given field of application **P8** Discuss the potential for future nanomaterial usage in a given field	**M4** Evaluate the precautions needed when considering nanocomposites for a given application	

Recommended resources

Textbooks

BALASUBRAMANIAN, G. (2018) *Advances in Nanomaterials*. New York, NC: Springer Nature.

BANERJEE, R., MANNA, I. (2013) *Ceramic Nanocomposites*. Amsterdam: Woodhead Publishing.

KOO, J. (2017) *Fundamentals, Properties, and Applications of Polymer Nanocomposites*. Cambridge: Cambridge University Press.

ZHU, S. (2006) *Fundamentals of Nanocomposites.* New York: Springer.

Journals

SRIVASTAVA, A. (2017) 'Metal Matrix Nanocomposites (MMCs): A review of their Physical and Mechanical properties', *International Journal of Nanomedicine*, 2 (8), pp. 152–154.

CAMARGO, P.H.C., SATYANARAYANA, K.G., WYPYCH, F. (2009) 'Nanocomposites: synthesis, structure, properties and new application opportunities', *Materials Research*, 12 (1).

HUSSAIN, F., HOJJATI, M., OKAMOTO, M., *et al.* (2006) 'Polymer-matrix Nanocomposites, Processing, Manufacturing, and Application: An Overview', *Journal of Composite Materials*, 40 (17), pp.1511–1575.

LIU, P., COTTRILL, A.L., KOZAWA, D., *et al.* (2018) 'Emerging trends in 2D nanotechnology that are redefining our understanding of "Nanocomposites"', *nanotoday*, 21 (8), pp.18–40.

Web

biocoreopen.org	BioCore Open access to journal articles (Research)
compositesmanufacturingmagazine.com	Composites Manufacturing Magazine Nanocomposites: What Are They, and Where Are They Headed? (General reference)
hse.gov.uk	Health and Safety Executive Nanotechnology (General reference)
nano.gov	National Nanotechnology Initiative (General reference)
scielo.br	Scielo (Scientific Electronic Library Online) (Research)
sciencedirect.com	Science Direct Journal articles (Research)

Links

This unit links to the following related units:

Unit 46: Polymer Processing and Manufacture

Unit 47: Polymer Materials and Properties

Unit 56: Stem Cell Biology

Unit code	**A/617/5439**
Unit level	**5**
Credit value	**15**

Introduction

Cellular differentiation is the process by which a cell becomes specialised to perform a specific function. All cells are derived from the inner cell mass cells of the blastocyst. These cells are termed pluripotent stem cells. They undergo a stepwise differentiation process to become specialised. The process is directed by gene expression which involves the turning on and off of specific combinations of genes. This differential gene expression and repression is regulated by a combination of factors both extrinsic and intrinsic to the cell. This unit enables students to understand the process of cellular differentiation and the mechanisms that control it.

Somatic, or adult, stem cells typically generate the cell types of the tissue in which they reside. In many tissues, stem cells serve as an internal repair system, dividing essentially without limit to replenish other cells. The study of human stem cells enables scientists to learn about the cells' essential properties. These studies are used to develop a more complex understanding of the genetic and molecular controls of the differentiation process. Somatic stem cells have been used for transplant therapy for many years. The unit will give students an opportunity to explore the role of somatic stem cells in maintaining the human body, and their current and potential use to treat injury and disease.

Human embryonic stem cells are inner cell mass cells that have been removed from the blastocyst prior to differentiation and grown in a Petri dish. Human embryonic stem cell studies may yield information about how diseases arise and suggest new strategies for therapy. Stem cells, directed to differentiate into specific cell types, offer the possibility of a renewable source of replacement cells and tissues both treat diseases and for the development of new, cell-based therapies. The unit will enable students to develop an understanding of embryonic stem cells and how they can be grown, maintained and manipulated in the laboratory. The unit will also enable students to develop an appreciation of the different regulatory positions that exist for the use of human embryonic stem cells for research.

Learning Outcomes

By the end of this unit students will be able to:

1 Discuss the process by which a cell undergoes a change to a specialised cell type

2 Analyse somatic stem cells and their roles

3 Analyse the potential of embryonic stem cells as a tool to treat degenerative disease

4 Discuss the different regulatory positions on using human embryonic stem cells for research.

Essential content

LO1 **Discuss the process by which a cell undergoes a change to a specialised cell type**

Stages involved in the formation of the nervous system, digestive system, respiratory system and circulatory system in the early embryo:

Nervous system: development of the notochord, neural plate, neural groove, neural folds, neural tube, differentiation of neural tube, neural crest, development of motor and sensory neurons

Digestive system: development of the three segments of the primitive gut, derivatives of the foregut, midgut and hindgut

Respiratory system: pseudoglandular period and lung buds derived from outpockets of the developing gut, the canalicular period, saccular period

Circulatory system: primordial heart tube, looping of the heart tube, atrial and ventricular septation, development of the outflow tract, vascular development.

The role of biochemical markers and genetic components in tissue formation:

Positional values

Tissue movements and changes in chemical composition (cytoskeleton components, adhesion molecules, cadherins)

Cytoplasmic factors

Cell–cell interaction

Growth factors

Memory (cytoplasmic, autocrine, nuclear).

LO2 **Analyse somatic stem cells and their roles**

Somatic stem cells and their role in maintaining the human body:

Hematopoietic stem cells

Mesenchymal stem cells

Neural stem cells

Epithelial stem cells of the digestive tract

Skin stem cells

Differentiation pathways of somatic stem cells.

Current and potential use of somatic stem cells to treat injury or disease:

Bone marrow transplant

Engineering skin grafts from skin stem cells in hair follicles

Regenerating bone using cells derived from bone marrow stroma; developing insulin-producing cells for type 1 diabetes

Repairing damaged heart muscle with cardiac muscle cells.

LO3 **Analyse the potential of embryonic stem cells as a tool to treat degenerative disease**

Embryonic stem cells grown in the laboratory:

Removal of the inner cell mass

Feeder layer (mouse embryonic fibroblasts, human placental cells, human bone marrow stromal cells, human foreskin fibroblasts)

Methods of growing embryonic stem cells without a feeder layer (laminin, E-cadherin, vitronectin)

Process of self-renewal

Laboratory tests to verify embryonic stem cells (transcription factors, nanog and Oct4; presence of cell surface markers of undifferentiated cells; teratoma)

Methods to differentiate embryonic stem cells (embryoid bodies, growth factors).

Potential utilisation of embryonic stem cells as an aid to treat degenerative diseases:

Embryonic stem cell lines

Model systems to study early events in human development, research on the differentiation and function of human tissues

Material for testing that may improve the safety and efficacy of human drugs

Potential to provide an unlimited amount of tissue for transplantation; therapies to treat a wide range of degenerative diseases

Vehicles for gene therapy

Creating *in vitro* models of human genetic disorders.

LO4 **Discuss the different regulatory positions on using human embryonic stem cells for research.**

Regulations and legislation that govern the use of embryonic stem cells, e.g.:

United Kingdom (Human Embryology and Fertilisation Act 2008)

European Union

United States of America (Restrictions on Federal Funding)

Asia

Africa

Canada.

Ethical considerations

Learning Outcomes and Assessment Criteria

Pass	Merit	Distinction
LO1 Discuss the process by which a cell undergoes a change to a specialised cell type		
P1 Discuss the stages involved in the formation of the nervous system, digestive system, respiratory system and circulatory system in the early embryo **P2** Review the role of biochemical markers and genetic components in tissue formation	**M1** Analyse the process an inner mass cell must undergo to differentiate into a specialised cell, such as a pancreatic beta cell	**D1** Critically analyse how the development of the fully differentiated multicellular animal is a multi-step process governed by gene expression, which is regulated by factors both extrinsic and intrinsic to the cell

<table>
<tr><th>Pass</th><th>Merit</th><th>Distinction</th></tr>
<tr><td colspan="2">LO2 Analyse somatic stem cells and their roles</td><td rowspan="6">LO2, LO3 and LO4

D2 Critically evaluate if induced pluripotent cell lines (IPS cells) are a suitable, and more ethically acceptable alternative to embryonic stem cells for researching, and potentially treating, degenerative diseases</td></tr>
<tr><td>P3 Review somatic stem cells and their role in tissue maintenance and repair

P4 Analyse the current and potential use of somatic stem cells to treat injury or disease</td><td>M2 Evaluate the risks and prospective benefits associated with the transplantation of cells derived from pluripotent stem cells</td></tr>
<tr><td colspan="2">LO3 Analyse the potential of embryonic stem cells as a tool to treat degenerative disease</td></tr>
<tr><td>P5 Discuss how embryonic stem cells are grown in the laboratory

P6 Analyse the potential utilisation of embryonic stem cells as an aid to understand and treat degenerative diseases</td><td>M3 Evaluate the ethical issues associated with the use of embryonic stem cells</td></tr>
<tr><td colspan="2">LO4 Discuss the different regulatory and ethical positions on using human embryonic stem cells for research.</td></tr>
<tr><td>P7 Discuss the regulations and legislation that govern the use of embryonic stem cells

P8 Discuss ethical considerations that surround the use of stem cells</td><td>M4 Evaluate how the regulations governing the use of embryonic stem cells differ from the regulations governing induced pluripotent cell lines (IPS cells) and somatic cell nuclear transfer (SCNT)</td></tr>
</table>

Recommended resources

Textbooks

ALBERTS, B., HOPKIN, K., JOHNSON, A.D., MORGAN, D., RAFF, M., ROBERTS, K., WALTER, P. (2014) *Molecular Biology of the Cell.* 6th ed. Oxford: Garland Science.

GIBBERT, S.F., BARRESI, M.J. (2016). *Developmental Biology.* 11th ed. Sunderland, MA: Sinauer.

HUANG, F.N., L'HEUREUX, N., LI, S. (2018). *Engineering Stem Cells for Tissue Regeneration.* Hackensack, NJ: World Scientific Publishing.

KNOEPFLER, P. (2015). *Stem Cells: An Insider's Guide.* Hackensack, NJ: World Scientific Publishing.

LANZA, R., ATALA, A. (2014) *Essentials of Stem Cell Biology.* 3rd ed. San Diego, CA: Academic Press.

LODISH, H.F., BERK, A., KAISER, C.A., KRIEGER, M., BRETSCHER, A., PLOEGH, H., AMON, A., MARTIN, K., SCOTT, M.P. (2016). *Molecular Cell Biology.* 8th ed. New York: W.H. Freeman (Macmillan Publishers).

Web

cirm.ca.gov	California's Stem Cell Agency (General reference)
embryology.med.unsw.edu.au	UNSW Embryology Differentiation Process (General reference)
stemcells.nih.gov	National Institutes of Health (NIH) Information on stem cells (General reference)
eurostemcell.org	EuroStemCell Medicine and Stem Cells (General reference)
hhmi.org	Howard Hughes Medical Institute Biointeractive – lectures on embryonic and adult stem cells and the ethical issues associated with using stem cells (General reference)

stemcellsjournals.onlinelibrary.wiley.com	Stem Cells Journals (Research)
stemcellsportal.com	Stem Cells Portal The Stem Cells and Regenerative Medicine Online Community (General reference)

Links

This unit links to the following related units:

Unit 30: Molecular Biology and Genetics

Unit 31: Immunology

Unit 32: Biotechnology Techniques

Unit 49: Principles of Pharmacology

Unit 52: Drug Development for Production

Unit 59: Genetic Analysis

Unit 57: Infectious Diseases and Diagnosis

Unit code	**M/617/5440**
Unit level	**5**
Credit value	**15**

Introduction

One-third of deaths worldwide is attributed to infectious diseases. Intensive research has led to the development of antiviral drugs that treat human immunodeficiency virus (HIV) and hepatitis C virus, as well as vaccines that prevent many infections. However, pathogens such as Ebola virus and Zika virus are constantly emerging. This unit aims to provide students with a broad understanding of the infectious diseases in regard to public health and epidemiology, with a focus on biology and control of infectious diseases.

Students will learn about the scientific basis of health and disease including the causes and public health impacts of infectious diseases; introducing the main types of microorganisms involved in disease and key disease types, host responses and diagnosis, together with developing strategies for their control and treatment.

Students will also study methods for the control of infectious diseases, surveillance methods, and the design of control programmes, with the aim that students will be able to follow essential arguments in reports and articles written about issues in these topical areas.

Furthermore, this unit will allow students to acquire working knowledge of bacterial and virological techniques applied to clinical samples and be able to use diagnostic techniques to identify pathogens. This includes organism isolation, amplification, quantitation and identification.

Learning Outcomes

By the end of this unit, students will be able to:

1 Discuss the host–microbial relationship and the role of host defences in preventing infection

2 Explore the survival strategies of pathogens in the host and their physiological adaptation that contributes to infection in selected key infectious diseases

3 Investigate the prevention and treatment strategies of infectious diseases

4 Explore the techniques and procedures used to identify, isolate and diagnose infectious pathogens.

Essential content

LO1 **Discuss the host–microbial relationship and the role of host defences in preventing infection**

Microorganisms background:

Viruses, bacteria, fungi, protozoa and their life cycles, and the consequences of infection.

Colonisation, invasion and relationships with the host:

Routes of entry and exit

Host surface defences

Microbial mechanisms of colonisation and invasion

The normal microbiota and opportunist infections

Commensals: mutualistic, pathogenic, symbiotic.

Host immunity:

Innate immunity

Adaptive immunity

Phagocytic effector cells and complement

Mechanisms of microbial killing

Predisposing factors for disease

The compromised host in its place

Immunosuppressant drugs, e.g. for cancer treatments

Genetics predisposition to disease.

LO2 **Explore the survival strategies of pathogens in the host and their physiological adaptation that contributes to infection in selected key infectious diseases**

Pathogen adaptation to growth in the host

Avoidance the first line of defence:

Adherence to host cells: adherence; colonisation; invasions; contribution of capsules and surface components; adherence of cell walls to pathogenicity.

Evasion of the immune response:

Phagocytosis; complement; adaptive immune response.

Damage to host cell and tissue:

The production of enzymes (e.g. siderophores); direct damage; toxin types and production (e.g. endotoxins, exotoxins); septic shock, cytopathic effects of viral infections

Toxins in specific diseases (e.g. diphtheria, botulism, tetanus, cholera and whooping cough).

Evolution of pathogens and virulence over time

LO3 **Investigate the prevention and treatment strategies of infectious diseases**

Modes of transmission:

Direct contact (human-to-human, body fluids, animal to human, animal waste)

Indirect contact (vectors, surfaces, water, food, e.g. salmonella, typhoid).

Prevention:

Prophylaxis, personal protective equipment (PPE), behaviours (e.g. safe sex), environmental (water sources, chemical spray)

Vaccination to prevent the spread of disease

Work of national and global organisations: World Health Organization (WHO), NHS, WaterAid, etc.

Treatment available:

Aspects of epidemiology and practice in public health microbiology relating to these microorganisms

Targets and mode of action of key antibiotics, antivirals, antifungals, antiprotozoals

Chemotherapeutic agents

Problems of antimicrobial drug resistance

Access to and acceptance of treatment.

LO4 **Explore the techniques and procedures used to identify, isolate and diagnose infectious pathogens with research methodology into them.**

Sampling procedures:

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.

Isolation, identification, amplification and quantitation techniques:

Undertake a number of techniques from the following suggested list: acid fast, silver stain, the use of selective agar and broth, 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 isothermal techniques, nucleic acid hybridisation techniques, nucleic acid probes, diagnostic virology, microarray, genotyping.

Data and report:

Written, graphical, charts, comparison with the norm, machine error, accuracy of diagnostic techniques, appropriate presentation of results (e.g. graph, chart, written); reliability and limitations of tests used; inclusion of relevant factors, if appropriate (e.g. contamination), significance of pathogen levels, deterioration of specimen, levels of false negative/false positive results, sensitivity of tests used.

Learning Outcomes and Assessment Criteria

Pass	Merit	Distinction
LO1 Discuss the host-microbial relationship and the role of host defences in preventing infection		**LO1 and LO2**
P1 Explore the major groups of pathogens and the range of infectious diseases **P2** Discuss how the immune system prevents infection	**M1** Compare the pathogens responsible for the most important infectious diseases, considering the pathology and immunopathology of infectious diseases	**D1** Evaluate the survival strategies of the major infectious pathogens, their survival strategies in the host, their pathology and immunopathology, and the strategies used by the host to counteract the effects of the pathogens
LO2 Explore the survival strategies of pathogens in the host and their physiological adaptation that contributes to infection in selected key infectious diseases		
P3 Investigate the strategies of pathogens to adapt and survive in the host **P4** Discuss the evolution of pathogens and their virulence effects over time	**M2** Analyse the virulence properties of pathogens over time, considering a selected range of infectious diseases	

Pass	Merit	Distinction
LO3 Investigate the prevention and treatment strategies of infectious diseases		**D2** Evaluate the prevention and treatment strategies of infectious diseases, considering the current progress and challenges
P5 Investigate the modes of transmission of different infectious agents **P6** Examine how infectious diseases can be prevented	**M3** Analyse how the modes of transmission of infectious diseases can be prevented with the available treatment strategies	
LO4 Explore the techniques and procedures used to identify, isolate and diagnose infectious pathogens with research methodology into them.		**D3** Compare and contrast the techniques and procedures used to identify, isolate and diagnose infectious pathogens, considering the recent prognosis, obstacles, ethical and financial aspects of such techniques (use data to compare the norm, machine, error and accuracy of diagnostic techniques)
P7 Undertake three diagnostic techniques **P8** Discuss the techniques used to identify, isolate and diagnose infectious pathogens	**M4** Analyse the techniques and procedures used to identify, isolate and diagnose infectious pathogens, using secondary data to support your review on the norm, machine error and accuracy of diagnostic techniques	

Recommended resources

Textbooks

GOERING, R., DOCKRELL, H., ZUCKERMAN, M., CHIODINI, P. (2018) *Mims' Medical Microbiology*, 6th ed. Amsterdam: Elsevier.

HEYMANN, D.L. (2008) *Control of Communicable Diseases Manual*. 20th ed. Washington, DC: American Public Health Association.

MURPHY, K. (2016) *Janeway's Immunobiology.* 9th ed, New York: Garland Science.

NASH, A., DALZIEL, R., FITZGERALD, J. (2015) *Mims' Pathogenesis of Infectious Disease*. 6th ed. Amsterdam: Elsevier.

WILSON, B.A., SALYERS, A.A., WHITT, D.D., WINKLER, M.E. (2010) *Bacterial Pathogenesis: A Molecular Approach*. 3rd ed. Washington, DC: ASM Press.

Journal

World Health Organization. (2012). ‘Research priorities for Chagas disease, human African trypanosomiasis and leishmaniasis’, *World Health Organization Technical Report Series*, 975, p. v.

Web

antibioticresistance.org.uk	Bugs & Drugs on the Web – NeLI Antimicrobial Resistance website (General reference)
cdc.gov	Centers for Disease Control and Prevention (General reference)

Links

This unit links to the following related units:

Unit 13: Human Health and Nutrition

Unit 45: Nutritional Diseases and Disorders

Unit 58: Epidemiology of Communicable Diseases

Unit code	**T/617/5441**
Unit level	**5**
Credit value	**15**

Introduction

Epidemiology is defined as the study of the distribution and determinants of health-related states or events in specific populations and the application of this study to the control of health problems. Epidemiology is concerned with all public health problems that may occur within a population. It is used to search for the causes and other factors that influence the occurrence of disease and other health-related events. Communicable diseases are a global concern and one that particularly impacts on developing nations. They are a leading cause of death worldwide. They are caused by pathogenic microorganisms, such as bacteria, viruses, parasites or fungi. The epidemiological study of communicable diseases focuses on the interactions between infectious agents, their hosts and the environment, which may lead to disease in human populations.

This unit aims to develop the students, understanding of communicable diseases, and how epidemiologists can control and predict their emergence and transmission. Students develop an understanding of the relationship between the host and the disease-causing organism. Most diseases follow a typical infection cycle. The unit will enable students to examine this cycle of infection and the steps a microbe must take in order to cause a disease in its host. Students will develop an awareness of how understanding the infection cycle of a disease enables epidemiologists to control disease outbreaks. Understanding the incidence, prevalence and possible outcomes of communicable diseases also aids epidemiologists and medical practitioners to determine their potential for further spread within the community, and to develop possible interventions to prevent additional cases and recurrences. This unit will also enable students to review the incidence, prevalence and the possible outcomes of the major microbial diseases and to develop an understanding of their potential impact on populations.

A number of factors contribute to the emergence and spread of a disease. Understanding this chain of infection, and the factors that contribute to their emergence and spread within and between populations, can help with both the prevention and treatment of infectious diseases. The unit will enable students to develop an awareness and understanding of these factors. The importance of global movement, urbanisation and socio-economic factors in the development of pandemics will be emphasised.

The unit will introduce students to the techniques used to diagnose pathogens and diseases. Students will learn the correct methods for collecting and handling specimens. Students will get the opportunity to carry out one of a number of diagnostic techniques to track the spread of a microbe in a population.

Learning Outcomes

By the end of this unit, students will be able to:

1 Discuss the infection cycle

2 Review the prevalence, incidence and possible outcomes of the major microbial diseases

3 Investigate the factors that contribute to the emergence of a disease

4 Undertake a diagnostic technique to track the spread of a microbe.

Essential content

LO1 **Discuss the infection cycle**

Discuss how infectious diseases result from the interaction of the agent, the host and the environment:

Reservoir of disease (human, animal, soil, water)

Mode of transmission (contact, vehicle, vector)

The pathway a microbe must follow to cause disease in a host (Portals of entry number of invading microorganisms; adherence to host tissues; penetrate host defences to [capsules, components of the cell wall, enzymes]; viral mechanisms for evading host defences, damage host tissues [direct damage, hypersensitivity, exotoxins, endotoxins]; cytopathic effects of viruses).

Discuss the predisposing factors for disease:

The compromised host

Gender

Genetic predisposition

Climate

Nutrition

Age

Environment

Lifestyle.

LO2 **Review the prevalence, incidence and possible outcomes of the major microbial diseases**

Investigate the prevalence and incidence of the major microbial diseases of the:

Nervous system (bacterial, viral, fungal, protozoan, prion)

Cardiovascular and lymphatic systems (bacterial, viral, protozoan, helminithic)

Respiratory system (bacterial, viral, fungal)

Digestive system (bacterial, viral, protozoan, helminithic)

Urogenital system (bacterial, viral, fungal, protozoan).

Discuss the possible outcomes of the major microbial diseases of the:

Nervous system (bacterial, viral, fungal, protozoan, prion)

Cardiovascular and lymphatic systems (bacterial, viral, protozoan, helminithic)

Respiratory system (bacterial, viral, fungal)

Digestive system (bacterial, viral, protozoan, helminithic)

Urogenital system (bacterial, viral, fungal, protozoan).

LO3 **Investigate the factors that contribute to the emergence of a disease**

Discuss the factors that precipitate the emergence of disease:

Ecological changes: agriculture; dams, changes in water ecosystems; deforestation/reforestation; flood/drought; famine; climate changes

Human demographics and behaviour: population growth and migration; war or civil conflict; urban decay; religious beliefs; sexual behaviour; intravenous drug use; use of high-density facilities

International travel and commerce: worldwide movement of goods and people

Microbial adaptation and change: antibiotic-resistant bacteria; 'antigenic drift' in influenza virus; response to selection in environment

Technology and industry: globalization of food supplies; changes in food processing and packaging; organ or tissue transplantation; drugs causing immunosuppression; widespread use of antibiotics

Breakdown in public health measures: curtailment or reduction in prevention programs; inadequate sanitation and vector control measures.

LO4 **Undertake a diagnostic technique to track the spread of a microbe**

Review the diagnostic techniques used to identify pathogens and microbial diseases:

Specimen collection

Correct procedures for handling specimens

Histological techniques: acid-fast stain; the silver stain)

Serological techniques: enzyme-linked immunosorbent assay (ELISA); agglutination reactions

Biological testing systems: coagulase test; catalase test; voges proskauer; camp test; urease test; oxidase test)

Selective and differential media and broth: mannitol salt agar; blood agar; emb agar; spirit blue agar; nitrate broth; glucose broth

Molecular techniques: polymerase chain reaction (PCR); real time PCR; hybridization.

Undertake a diagnostic technique to track the spread of a microbe:

Carry out an experiment to track a disease outbreak in a class group by mixing samples within the group. The techniques used to identify the positive samples may include an ELISA, a range of biochemical tests, selective and differential media and broth.

Learning Outcomes and Assessment Criteria

Pass	Merit	Distinction
LO1 Discuss the infection cycle		**LO1 and LO2**
P1 Discuss how infectious diseases result from the interaction of the agent, the host and the environment **P2** Discuss the predisposing factors for disease	**M1** Analyse how the major nosocomial (hospital-acquired) infections result from the interaction of microorganisms in the hospital environment, the compromised host and the chain of transmission	**D1** Critically analyse how understanding the infection cycle, prevalence, incidence and possible outcomes of communicable diseases is critical, in order to identify accessible targets for control strategies
LO2 Review the prevalence, incidence and possible outcomes of the major microbial diseases		
P3 Investigate the prevalence and incidence of the major microbial diseases **P4** Discuss the possible outcomes of the major microbial diseases	**M2** Analyse how the major classes of microbial diseases can be prevented and controlled	
LO3 Investigate the factors that contribute to the emergence of a disease		
P5 Investigate the factors that participate in the emergence of diseases	**M3** Analyse the factors that contribute to a disease becoming pandemic	**D2** Critically evaluate the possibility of the emergence of a highly virulent strain of influenza, and its potential effects on the human population

Pass	Merit	Distinction
LO4 Undertake a diagnostic technique to track the spread of a microbe		**D3** Critically evaluate the results obtained to form conclusions about the transmissibility of a pathogen within a population, and the difficulty in tracking its source to one individual
P6 Review the diagnostic techniques used to identify pathogens and microbial diseases **P7** Undertake a diagnostic technique to track the spread of a microbe	**M4** Analyse the results obtained from the diagnostic technique undertaken to correctly identify the source(s) of the microbe	

Recommended resources

Textbooks

BENNETT, J.E., DOLIN, R., BLAZER, M.J. (2015) *Mandell, Douglas, and Bennett's Principles and Practice of Infectious Diseases.* 8th ed. Philadelphia, PA: Elsevier.

CAPPUCCINO, J.G., WELSH, C.T. (2019) *Microbiology: A Laboratory Manual.* 12th ed. New York: Pearson Education Ltd.

COHEN, J., POWDERLY, W.G., OPAL, M.S. (2017) *Infectious Diseases.* 4th ed. Amsterdam: Elsevier.

KASPER, L.D., FAUCI, A.S. (2017) *Harrison's Infectious Diseases.* 3rd e. New York: McGraw-Hill Education.

MURRAY, P.R. (2017) *Basic Medical Microbiology.* Philadelphia, PA: Elsevier.

TORTORA, G.J., FUNKE, B.R., CASE, C.L., WEBER, D., BAIR, W. (2018) *Microbiology*: *An Introduction.* 13th ed. Hoboken, NJ: Pearson Education.

Web

cdc.gov	Centers for Disease Control and Prevention Emerging infectious disease (General reference)
wwwnc.cdc.gov	Centers for Disease Control and Prevention Emerging Infectious Disease (journal) (Research)
ecdc.europa.eu	European Centre for Disease Prevention and Control (General reference)
health24.com	Health 24 (General reference)
ncbi.nlm.nih.gov	National Centre for Biotechnology Information (General reference)
nccid.ca	National Collaborating Centre for Infectious Diseases (General reference)
who.int	World Health Organization (General reference)

Links

This unit links to the following related units:

Unit 27: Analysis of Scientific Data and Information

Unit 29: Biochemistry of Macromolecules and Metabolic Pathways

Unit 30: Molecular Biology and Genetics

Unit 31: Immunology

Unit 57: Infectious Diseases and Diagnosis

Unit 59: Genetic Analysis

Unit code	**F/617/5443**
Unit level	**5**
Credit value	**15**

Introduction

Genetic analysis is an area that relates to the study and research of genes and molecular biology. Genetic analysis informs the process of diagnosis of disease and the understanding of the inheritance patterns of disease transmission. This understanding is the basis of much scientific research, including into the development and progression of cancers, the effects of mutagens (substances that cause changes in DNA/genes) and the clinical application of theory to predict the magnitude of risk of a child being born with an inherited disorder.

As DNA and genes are constantly being generated within the organism, key understanding of the way in which mutations can be detected is offered, as well as the concepts fundamental to modern laboratory practice where genes are deliberately and precisely manipulated to test outcomes, such as in the process of reverse genetics.

There is a particular focus on the human applications of genetic analysis; however, the subject knowledge is broad as the laboratory skills and techniques requires understanding of bacterial systems, as well as those found in humans.

The aim of this unit is to provide students with the knowledge of both the processes and practical applications of genetics when applied to identify the underlying basis of traits. The unit also explores how advances in this field are changing both medicine and society, offering learning close to the cutting edge of the topic area.

Students will explore the process of principles and practice of a range of techniques (reverse genetics, CRISPR and the role of mitochondrial DNA). Students will apply the understanding gained to the use of these technologies, and the impact this has on developing therapies for diseases and disorders in humans. Strategies for discovery and diagnosis are included, such as karyotyping, fluorescence in situ hybridization (FISH) and cytogenetics, which are easily applied to clinical medicine.

Completing the unit will equip students with knowledge, understanding and skill sets that are applicable to those entering careers in medical science, healthcare and professions allied to medicine. Students will gain the informed ability to consider the ethical issues that accompany the discoveries and technology underpinning genetic analysis, and its role in society.

Learning Outcomes

By the end of this unit, students will be able to:

1 Review the principles of genetic analysis

2 Compare genetic techniques applied to humans

3 Discuss the ethics of genetic intervention in human medicine

4 Explore the applications of genetic analysis.

Essential content

LO1 **Review the principles of genetic analysis**

Structural organisation of DNA:

Chromosomes, loci and gene maps

One gene, one protein theory of gene expression

Regulation of gene expression

Features of mitochondrial DNA.

Basic techniques for the analysis of DNA:

DNA sequencing

DNA footprinting

Polymerase chain reaction (PCR).

Mendelian inheritance and forward genetics:

Laws of inheritance

Allelic variation: single and multi-trait

Application of Mendelian laws to predict outcomes

Segregation of alleles, linkage of genes and epistatic processes.

LO2 **Compare genetic techniques applied to humans**

Cytogenomics:

Karyotyping of cells

Fluorescence *in-situ* hybridization (FISH)

Comparative genomics hybridization.

Genome-wide screening:

Mapping the human genome

Concepts of genomes and metagenomic studies

Association studies

Microarrays as a technique.

Reverse genetics:

Use of site directed mutagenesis to study the role of genes

Knock downs and knockouts

Transgenes

Principles of the CRISPR technique, and its applications

Use of reverse genetics to develop vaccines.

LO3 Discuss the ethics of genetic intervention in human medicine

Ethics and forward genetics:

Pre-implantation diagnosis (relating to Down's syndrome and deafness)

IVF and three-parent babies

Use of stem cells in therapy and research

Concepts of germline and somatic cells.

Risks and benefits of gene therapy:

Role of CRISPR in research and therapy

Defining what is a normal human

Developing treatment of rare diseases through sharing information

Development of novel therapies for serious diseases, such as specific cancers, motor neurone disease.

LO4 Explore the applications of genetic analysis

Using genetic analysis in society:

Genotyping for paternity (or ancestry) testing

Investigation of crimes using DNA analysis (footprinting)

The genetics of community – metagenomics.

Using genetic analysis to deliver personalised medicine:

Concept of informatics (big data) to predictive diagnosis and prognosis

Using knowledge of the genome to predict responses to drug therapy

Use of genetic screening of cancers to select effective therapies.

Role of epigenomics in human disease:

Epigenomics – histone proteins and DNA methylation as regulators of gene function

Diseases that result from epigenomic changes in DNA, such as Prader-Willi syndrome.

Learning Outcomes and Assessment Criteria

Pass	Merit	Distinction
LO1 Review the principles of genetic analysis		**D1** Compare the inheritance patterns of mitochondrial DNA with that of chromosomal DNA in the context of inherited diseases
P1 Review the structural organisation of DNA and the basic techniques used to analyse it **P2** Apply the theories of Mendelian genetics to complex inheritance	**M1** Analyse the value of genetic techniques in the diagnosis of human disorders	
LO2 Compare genetic techniques applied to humans		**D2** Critically evaluate the contribution of genomics to human health
P3 Compare the methods used in genome analysis in humans **P4** Illustrate the use of reverse genetics techniques, using key examples	**M2** Assess the use of the CRISPR technique in research and therapy	
LO3 Discuss the ethics of genetic intervention in human medicine		**D3** Evaluate the way in which the knowledge of rare human disorders is advanced by genetic analysis
P5 Discuss the use of human stem cells in research and therapy **P6** Review the ethical guidelines relating to gene therapy	**M3** Analyse the risks and benefits of gene therapy in humans	

Pass	Merit	Distinction
LO4 Explore the applications of genetic analysis		**D4** Critically evaluate the contribution of epigenomics to human disorders
P7 Review the specific applications of genetic testing in Western society **P8** Assess the potential of metagenomics to affect human health	**M4** Evaluate the ways in which genome analysis, collaboration and 'big data' could influence treatment of serious disease	

Recommended resources

Textbooks

APPASANI, K., SURANI, A. (2014) *Epigenomics: from chromatin biology to therapeutics*. Cambridge: Cambridge University Press.

FARRELLY, C. (2018) *Genetic Ethics: An Introduction*. Cambridge: Polity Press.

MENEELY P. (2014) *Genetic Analysis: Genes, Genomes and Networks in Eukaryotes*. 2nd ed. Oxford: Oxford University Press.

MENEELY, P., DAVIES-HOANG, R., OKELE, I.N., HESTON, K. (2017) *Genetics, Genes, Genomes, and Evolution*. Oxford: Oxford University Press.

Journals

Journal of Medical Genetics, BMJ Group.

VENTER, J.C. (2001) 'The Sequence of the Human Genome', *Science*, 291, pp. 1304–1351.

Links

This unit links to the following related units:

Unit 2: Scientific Data Handling Approaches and Techniques

Unit 3: Regulation and Quality in the Applied Sciences

Unit 4: Cell Biology

Unit 13: Human Health and Nutrition

Unit 17: Fundamentals of Biochemistry

Unit 27: Analysis of Scientific Data and Information

Unit 29: Biochemistry of Macromolecules and Metabolic Pathways

Unit 30: Molecular Biology and Genetics

Unit 31: Immunology

Unit 32: Biotechnology Techniques

Unit 34: Forensic Evidence Collection and Preservation

Unit 41: Conservation and Biodiversity

Unit 45: Nutritional Diseases and Disorders

Unit 49: Principles of Pharmacology

Unit 50: Toxicology

Unit 56: Stem Cell Biology

Unit 60: Renewable Energy Resources and Technology

Unit code	**J/617/5444**
Unit level	**5**
Credit value	**15**

Introduction

Energy that is replenished and overcomes depletion is called renewable energy. Such energy includes sunlight, wind, rain, tides, waves, and geothermal heat. Renewable energy often provides energy for electricity generation, air and water heating and cooling, transportation, and off-grid energy services.

Different sources of renewable energy exist over wide geographical areas and, as such, allow for quick deployment. Renewable sources (photovoltaics, wind power and hydroelectricity) also have the advantage of being able to reduce CO_2 emissions, conserve water and lower pollution. Renewable technologies are becoming energy efficient, resulting in significant energy security, climate change mitigation, and economic benefits.

With the increasing concerns regarding climate change arising from increasing carbon dioxide levels, and other adverse environmental impacts of industrial processes, there are widespread economic, ethical, legislative and social pressures to develop and implement technologies and processes that have reduced carbon and environmental impacts.

The aim of this unit is to introduce students to renewable energy resources and technologies, including current storage and generation technologies, and explore their capabilities and limitations. The students will also learn about the factors that inform the selection of renewable sources and technologies based on specific requirements, and will consider the application of a hybrid renewable energy system for a given context. Finally, the students will evaluate the effect that socio-economic, legislative, environmental and sustainability factors have on the consideration and selection of a particular renewable energy resource and technology.

On successful completion of this unit, students will be able to determine the optimum combination of renewable energy technologies, evaluate their efficiencies, conduct a cost–benefit analysis to determine the most viable option between renewable and conventional energy sources, and consider the relevant political, socio-economic and legal factors that influence the selection of appropriate energy technologies.

Learning Outcomes

By the end of this unit, students will be able to:

1 Review non-renewable and renewable sources of energy and their impact on the environment

2 Evaluate the factors that inform the selection of a renewable energy system for a given context

3 Explore the selection of a hybrid renewable energy system for a given context

4 Examine how socio-economic, legislative, environmental and sustainability factors affect the consideration and selection of a particular renewable energy resource and technology.

Essential Content

LO1 Review non-renewable and renewable sources of energy and their impact on the environment

Non-renewable energy sources:

Fossil fuels: coal, oil and natural gas

Nuclear

Extracting fossil fuels: coal mining, underground mining, surface mining, oil and gas drilling, water impact, land use

Environmental impact from: drilling for oil, fracking for natural gas

Environmental disasters: oil spills, coal mining disasters, air pollution, fatalities, explosions, nuclear radiation leakage

Transporting fossil fuels

Burning fossil fuels: global warming emissions, air pollution

Fossil fuel waste: coal waste, oil and gas wastewater, waste as energy.

Renewable energy sources:

Existing technologies: solar power, wind energy, hydro-electrical systems, ocean and tidal energy, combined heat and power, heat pumps, solar water heating, biomass, biofuels, geothermal energy, water reuse.

Benefits from using alternative energy

Merits and drawbacks of alternative energy.

Technological advances in renewable energy:

Robotics, used for installation, maintenance and optimisation

Optical furnaces, printable solar panels

Liquid metal batteries

Advances in wave power

Sun-tracking solar cells, solar energy harvesting from space

Hydrogen cell technology.

Hybrid renewable energy systems

LO2 **Evaluate the factors that inform the selection of a renewable energy system for a given context**

Energy systems and consumption:

Energy systems available for a given location

Tariffs and tariff calculations

Average energy consumption (domestic, industrial, transport, services sectors)

Energy consumption changes, intensity and trends

Factors affecting changes in energy consumption and demand

Future demand planning based on trends and needs analyses.

Security of supply:

Risk analysis for energy supplies for regional and local areas

Energy capacity margins analysis related to changes in demand

Alternatives for locally used energy sources.

External factors:

Effects of weather, light availability and quality

Presence of natural resources needed to drive the system

Political and aesthetic factors, local feeling, planning permissions, regulatory issues.

Energy reduction and efficiency approaches:

Energy legislation and standards

Energy saving and reduction schemes

Energy saving technologies available

Alternative energy installation costs vs cumulative savings

Energy efficiency approaches for domestic energy use

Grants and government schemes, and the effects of such schemes on supply and demand.

LO3 **Explore the selection of a hybrid renewable energy system for a given context**

NB: This LO must be based on a scenario that considers varying seasonal conditions

Existing (non-renewable) energy supply system:

Evaluation of condition and status

Establishing environmental and financial implications.

Considerations:

Energy demand (industrial or residential)

Energy demands and consumption

Establishing seasonal conditions.

Proposing appropriate renewable energy systems:

Identifying appropriate renewable energy systems

Energy storage devices

Considering installation and maintenance demands

Performing a cost-benefit analysis

Performing a return-on-investment analysis

Reporting on the proposed system.

LO4 Examine how socio-economic, legislative, environmental and sustainability factors affect the consideration and selection of a particular renewable energy resource and technology

Socio-economic factors:

Value added through the use of renewable energy

Effects on health and standard of living

Switching to renewable energy: incentives vs penalties.

Legislative factors:

National and international climate change legislation

The Kyoto Protocol

The Paris Climate Agreement

Local, regional and global targets

Carbon taxes and carbon emissions trading.

Environmental factors:

Effects of CO_2 emissions, greenhouse effect, waste products and management, health issues

Setting-up and operating renewable technologies.

Sustainability factors:

Projections for availability of non-renewable resources

Hidden sustainability and environmental cost of renewables: manufacture, transportation, installation, maintenance.

Evaluation planning tools:

PESTLE and SWOT analyses.

Learning Outcomes and Assessment Criteria

Pass	Merit	Distinction
LO1 Review non-renewable and renewable sources of energy and their impact on the environment		**D1** Critically evaluate the impact on the environment from disasters relating to non-renewable sources of energy
P1 Review non-renewable sources of energy, their operating principles, and their impact on the environment **P2** Review renewable sources of energy, their operating principles, and their impact on the environment	**M1** Discuss the impact that drilling for oil and fracking for natural gas have on the environment	
LO2 Evaluate the factors that inform the selection of a renewable energy system for a given context		**D2** Analyse the efficiencies of a variety of combinations of renewable energy technologies for a chosen location
P3 Evaluate the factors affecting the selection of a renewable energy system **P4** Analyse advances in renewable energy technology and how they meet the needs of a given context	**M2** Justify the selection of a renewable energy system by considering energy systems and consumption, supply security, external selection factors and energy efficiencies	
LO3 Explore the selection of a hybrid renewable energy system for a given context		**D3** Critically evaluate the impact on the environment from an energy project that is based on a hybrid instead of a fully renewable energy solution
P5 Review the principle of operation behind hybrid renewable energy systems **P6** Explore the potential need for hybrid renewable energy systems	**M3** Discuss the impact that seasonal conditions have on the choice of a renewable energy solution, and how these may be overcome	

Pass	Merit	Distinction
LO4 Examine how socio-economic, legislative, environmental and sustainability factors affect the consideration and selection of a particular renewable energy resource and technology.		**D4** Analyse how specific renewable technologies meet the requirements of environmental initiatives, such as the Kyoto Protocol, carbon trading and global and local government targets
P7 Examine how socio-economic and legislative factors affect the selection, set-up and operation of renewable energy sources **P8** Examine how environmental and sustainability factors affect the selection, set-up and operation of renewable energy sources	**M4** Investigate, through the use of PESTLE analysis, possible sources of conflict of interest that may affect the consideration and selection of a particular renewable energy resource and technology	

Recommended resources

Textbooks

ANDREWS, J., JELLEY, N. (2017) *Energy Science: Principles, Technologies and Impacts*. 3rd ed. Oxford: Oxford University Press.

BOTKIN, D., PEREZ, D. (2010) *Powering the Future*. Upper Saddle River, NJ: FT Press.

BOYLE, G., OPEN UNIVERSITY (2011) *Renewable Energy*. 3rd ed. New York: Oxford University Press.

DUFFY, A., ROGERS, M., AYOMPE, L. (2015) *Renewable Energy and Energy Efficiency: Assessment of Projects and Policies*. Chichester: Wiley-Blackwell.

EVERETT, B., BOYLE, G., RAMAGE, J., PEAKE, S. (2012) *Energy systems and sustainability: Power for a Sustainable Future*. 2nd ed. Oxford: Oxford University Press.

GRINNELL, S. (2016) *Renewable Energy & Sustainable Design*. Boston, MA: Cengage.

TESTER, J. (2012) *Sustainable Energy: Choosing Among Options*. 2nd ed. Cambridge, MA: MIT Press.

TWIDELL, J., WEIR, T. (2015) *Renewable Energy Resources*. 3rd ed. London: Routledge.

Web

altenergy.org	Alternative Energy (General reference)
energysavingtrust.org.uk	Energy Saving Trust Renewable energy (General reference)
theguardian.com	The Guardian Renewable energy (Articles)
gov.uk	UK Government website Department of Energy and Climate Change (General reference)
therenewableenergycentre.co.uk	The Renewable Energy Centre (General reference)

Links

This unit links to the following related units:

Unit 2: Scientific Data Handling Approaches and Techniques

Unit 12: Managing Environmental Resources

Unit 27: Analysis of Scientific Data and Information

Unit 42: Materials Life Cycle and the Circular Economy

Unit 61: Science Laboratory Management

Unit code	**R/617/5446**
Unit level	**5**
Credit value	**15**

Introduction

This unit focuses on the organisation of different types of science laboratories and the processes associated with their management, and examines the typical responsibilities of laboratory managers. The types of science laboratories considered include contract analytical laboratories; project laboratories supporting innovation 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.

Many learners studying at this level may move into a laboratory management role in the future, or may already have supervisory duties. All laboratory managers need to ensure that their staff are trained appropriately and are competent in 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. These skills are covered in this unit.

Learning Outcomes

By the end of this unit, students will be able to:

1 Review work undertaken within the typical duties of laboratory managers in different types of science laboratories

2 Explore organisational aspects of a science laboratory

3 Discuss how laboratories comply with health and safety legislation

4 Discuss features of managing a quality control science laboratory.

Essential content

LO1 Explore work undertaken within the typical duties of laboratory managers in different types of science laboratories

Functions of a contract analytical laboratory:

Science laboratories as part of an accreditation scheme

Working for a client: contractual responsibilities, costing, ability to respond to customer needs

Production of data: quality, accuracy, reproducibility, traceability, legally defensible data, assessing the quality of data, reporting and discussing results

Working with samples: standard procedures, booking in samples, barcoding, preservation techniques

Types of analysis performed by contract laboratories, e.g.: oil, food, forensic samples, medical samples, soil, water

Typical duties of a laboratory manager in the context of a contract analytical laboratory.

Role of an industrial project laboratory:

Product innovation, prototyping, producing materials on a pilot scale

Investigating aspects of operation of manufacturing plants

Project management, importance of timescales, deadlines depending on the project, record keeping and reporting in a number of formats

Typical duties of a laboratory manager in the context of an industrial project laboratory.

Role of a quality control laboratory:

Sampling techniques and storage of samples

Testing raw materials, other relevant products, products during production and after production

Results within given tolerances for different grades of product; format of reporting results to production staff

Typical 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

Support: research; students' learning, fewer routine activities

Typical duties of a laboratory manager in an educational laboratory in comparison to those of other laboratory managers.

LO2 **Explore organisational aspects of a science laboratory**

Sources of reference:

Equipment manuals; staff training records; standards; company policies; staff intranet; CLEAPSS material for school/college technicians.

Purchasing:

Lists of approved suppliers; budget; internal order forms; ordering procedures; approving/signatures on orders; need to obtain quotes.

Stock control systems:

Inventories of chemicals and other consumables

Equipment lists

Stock: receiving, checking, storing, rotation, taking/recording, maintaining records, control of stationery

Special storage, e.g.: refrigeration, vented, heated, air conditioned.

Laboratory design:

Purpose of laboratory and special features relating to purpose

Utilities, e.g.: lighting, water, gas, electricity, sinks, waste

Safety features, e.g.: extraction, safety shower, solvent sink

Sample entry/records

Space allocation: work surfaces, space occupied by equipment, space needed by individuals, areas for writing/use of computer

Storage for: glassware, chemicals, stationery, labels, waste, samples.

LO3 **Discuss how laboratories comply with health and safety legislation**

Legislation:

Health and Safety at Work Act (1974)

Duties of employers; duties of employees.

Regulations:

Management of Health and Safety at Work Regulations (1999)

Control of Substances Hazardous to Health (COSHH) (2002)

Workplace Regulations (Health, Safety and Welfare) (1992)

Waste management

Approved codes of practice, best practice and guidance.

Responsibilities of laboratory managers:

Management of health and safety, e.g.: 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.

LO4 **Discuss features of managing a quality control science laboratory**

Company policies:

Functions, e.g. health and safety, data management, reporting, customer service, training.

Standard operating procedures:

Procedures, e.g. 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 and sample entry procedures

Recording systems: paper-based, computer-based, laboratory information management system (LIMS), back up, worksheets, hardback notebooks, signatures, initialling of errors

Records: results, reports, traceability, training, standard procedures, calibration

Inventories of equipment and materials

Internal quality checks

External quality checks, e.g.: details of inter-laboratory testing, accreditation information and records.

Learning Outcomes and Assessment Criteria

Pass	Merit	Distinction
LO1 Explore work undertaken within the typical duties of laboratory managers in different types of science laboratories		
P1 Explore the different types of science laboratories **P2** Explore the typical duties of science laboratory managers **P3** Discuss how the role of an educational laboratory manager may differ from that of an industrial laboratory manager	**M1** Analyse the process and importance of conforming to standards when booking in, handling and analysing samples, as well as the process of assessing, reporting and discussing the resulting data	**D1** Critically evaluate the work undertaken by laboratory managers to scrutinise laboratory results and the decision process

Pass	Merit	Distinction
LO2 Explore organisational aspects of a science laboratory		**D2** Critically analyse how the laboratory design may impact on the organisation in terms of cost, ongoing maintenance and housekeeping, management of equipment and consumables, minimisation of potential contaminants and safety
P4 Review the operation of a stock control system **P5** Investigate key areas for consideration when purchasing equipment and consumables **P6** Discuss the features of laboratory design	**M2** Design a laboratory for your chosen pathway so that costs are minimised, stocks are available, and the laboratory is functioning with optimal dependability (availability, reliability and maintainability)	
LO3 Discuss how laboratories comply with health and safety legislation		**D3** Critically analyse the effectiveness of systems used to manage health and safety risks in the laboratory
P7 Explore health and safety regulations that apply to working in laboratories **P8** Discuss the importance of complying with health and safety legislation **P9** Analyse the duties of employers and employees under the Health and Safety at Work Act (1974)	**M3** Review the responsibilities of a science laboratory manager in terms of managing health and safety	

Pass	Merit	Distinction
LO4 Discuss features of managing a quality control science laboratory.		**D4** Critically analyse, in the event of a high level of errors in the results, the required steps a manager takes to identify the root cause, take corrective action and improve upon overall laboratory quality control
P10 Discuss the function of company policies and standard procedures **P11** Justify the need for science laboratory staff training **P12** Review the process and importance of data management in a science laboratory	**M4** Evaluate the impact of statistical sampling on quality control and the effects on reducing errors in results	

Recommended resources

Textbooks

GARCIA, L.S., BACHNER, P. (2014) *Clinical Laboratory Management*. 2nd ed, Washington, DC: ASM Press.

HARMENING, D. (2013) *Laboratory Management: Principles and Processes*. 3rd ed, St Petersburg, FL: D.H. Pub. & Consulting.

Web

clma.org	Clinical Laboratory Management Association Membership Association (General reference)
hse.gov.uk	Health and Safety Executive Information and advice about work-related health, safety and illness (General reference)
hse.gov.uk	Health and Safety Executive Workplace (Health, Safety and Welfare) Regulations 1992 (General reference)
hse.gov.uk	Health and Safety Executive Control of Substances Hazardous to Health (COSHH) (General reference)

Links

This unit links to the following related units:

Unit 1: Fundamentals of Laboratory Techniques

Unit 3: Regulation and Quality in the Applied Sciences

Unit 51: Specialist Scientific Techniques and Experimentation

Unit 62: Organisations and Change Management

Unit code	**Y/617/5447**
Unit level	**5**
Credit value	**15**

Introduction

Organisations vary in type, size, scope, structure and function. Each organisation is influenced by its culture, politics, power and behaviour of its staff. All these can have a positive or negative effect on managing change within the organisation, and will influence and determine the way with which leadership would approach change.

The aim of this unit is to introduce students to the various forms of organisation, as well as the various types of behaviour that influence the way they operate. It will prepare students to anticipate, plan and deliver organisational change. Learning will be supported by appropriate case studies, to provide examples on change management within organisations and the issues surrounding the process. Students will be able to predetermine the appropriate and timely interventions required to maximise the benefits and minimise the risk of organisational change.

On successful completion of this unit, students will have an understanding and awareness of the various forms of organisation, and the key influences which affect the behaviour of individuals, teams and organisations as a whole. They will have developed sufficient knowledge and understanding of leadership in the context of organisational change, to make an effective and immediate contribution to the way in which an organisation determines and responds to change drivers. Students will also be in a strong position to contribute to change initiatives, as well as to consider the strategies required to change resistors.

Learning Outcomes

By the end of this unit, students will be able to:

1 Explore the various types, structures and functions of organisations

2 Analyse how culture, politics and power influence behaviours within an organisation

3 Explore change and how it impacts on an organisation's strategy, operations and behaviour

4 Analyse how barriers to change influence leadership decision-making and approaches.

Essential Content

LO1 **Explore the various types, structures and functions of organisations**

Different types of organisations:

Differences between for-profit and not-for-profit and non-government organisations (NGOs)

Micro, small, and medium-sized enterprises (SMEs); different business purposes, objectives and supply of goods and services

The range of legal structures associated with different forms of business: sole traders, partnerships and private limited companies.

Size and scope of organisations:

Differences between large, medium-sized and small organisations, including objectives and goals, market share, profit share, growth and sustainability

Global growth and developments of transnational, international and global organisations

Differences between franchising, joint ventures and licensing

Industrial structures and competitive analysis

Market forces and economic operations, e.g.: scarcity and choice, supply and demand, income elasticity

Stakeholders and responsibilities of organisations to meet different stakeholder interests and expectations.

The various functions within an organisation:

The role of marketing, finance, human resource management and operations within an organisational context, and their interrelationships

How functions relate to overall organisation mission and objectives.

Organisational structure:

Different structures depending on the size and scope of the organisation, including bureaucratic and post-bureaucratic, parent, strategic business units (SBUs), matrix and functional levels

Organisation structures and complexities of transnational, international and global organisations.

LO2 **Analyse how culture, politics, power and motivation influence behaviours within an organisation**

Influence of culture:

Classifications of culture: power, role, task and person

The importance of cultural-difference awareness

Hofstede's dimensions of culture theory, and application

The rise of globalisation and digital technology, and how they have influenced and shaped organisational culture in the 21st century

Principles of network theory and systems theory as frameworks to understand organisations

Organisational psychology.

Influence of politics:

Organisational politics and differentiation between personal, decisional, structural and organisational change.

Influence of power:

Power as a property viewpoint: individual, relationships and embedded in structures

Bases and types of power, power controls and power sources.

Motivational theories:

Extrinsic and intrinsic motivation

Motivational content theories: Maslow, Herzberg and Alderfer

Motivational process theories: Vroom, Adams, Latham and Locke

The implications of motivational theory on management and leadership within organisations.

Behavioural psychology:

Definition of emotional intelligence and the importance of soft skills for managers and teams

Task vs relationship leadership and psychodynamic approach to behaviour.

LO3 **Explore change and how it impacts on an organisation's strategy, operations and behaviour**

Change as a constant requirement:

What is change in an organisational context?

How does position and perception influence a view of change as negative or positive?

Types of organisational change:

To include structural and strategic, and people and processes.

Drivers of change:

Consideration of internal and external drivers, which could be based on a PEST and/or SWOT analysis.

Dealing with change:

To include planned and emergent change, strategies for change and the Bohner and Arnold Change Impact Analysis.

Change and the impact on organisational behaviour:

Considering the psychological impact of change on people

How change impacts on team dynamics, and how people are led and managed.

Recognising drivers of change:

Using analytical tools, such as PEST and SWOT

Selecting the most significant drivers in a given context.

Responding to drivers of change:

Using systems theory and continuous improvement models to predict and proactively plan for change

Using the Burke-Litwen model to make the change process efficient and effective.

LO4 **Analyse how barriers to change influence leadership decision-making and approaches**

Initiated or imposed change:

Deciding to be preemptive and proactive, or responsive and reactive, will be based on the situation and the nature/scope of the change

Adaptive and constructive change.

Barriers and resistance to change:

Using a force field analysis to understand likely opposition and support for change in a contemporary context

Schein's organisational culture model, self-efficacy perceptions and situational resistance when determining barriers.

Leadership and decision-making:

Doing the right thing is important when dealing with change as change mostly affects people, decisions should be considered with this in mind.

Situational leadership:

The context of a task/activity/challenge determines the appropriate leadership style/approach.

Initiating change:

Where change is initiated then leaders have more control, more time and, therefore, more opportunity to select the best approach to apply

When change is imposed then these opportunities are reduced or even negated.

Change theories, concepts and models:

The key theories, concepts and models, including Kotter's 8-step change model, Lewin's change management model, change through strategic communication, change and movement through leadership, the principles of change leadership.

Learning Outcomes and Assessment Criteria

Pass	Merit	Distinction
LO1 Explore the various types, structures and functions of organisations		**D1** Critically analyse the complexities of different types of business structures, and the interrelationships of the different organisational functions
P1 Explain the different types and purposes of organisations in the public, private and voluntary sectors, and their legal structures **P2** Review the relationship between different organisational functions, and how they link to organisational objectives and structure	**M1** Analyse how the structure, size and scope of different organisations link to the business objectives and product and services offered by the organisation	
LO2 Analyse how culture, politics and power influence behaviours within an organisation		**D2** Critically evaluate the relationship between culture, politics, power and motivation that enables teams and organisations to succeed providing justified recommendations
P3 Analyse how the culture, politics and power of an organisation can influence individual and team behaviour and performance **P4** Analyse how content and process theories of motivation and motivational techniques enable effective achievement of goals in an organisational context	**M2** Evaluate how the behaviour of employees could be influenced through the effective application of behavioural motivational theories, concepts and models	

Pass	Merit	Distinction
LO3 Explore change and how it impacts on an organisation's strategy, operations and behaviour		**D3** Justify the importance of planning effectively for change and applying change impact analysis
P5 Compare different organisational examples where change had an impact on an organisation's strategy and operations **P6** Explore ways in which internal and external drivers of change affect leadership, team and individual behaviours within an organisation	**M3** Assess the different drivers for change in each of the given examples and the resultant organisational response to change	
LO4 Analyse how barriers to change influence leadership decision-making and approaches.		**D4** Analyse the conditions under which organisational leaders can select the most appropriate approach to apply to organisational change
P7 Explain different barriers to change and determine how they influence leadership decision-making in a given organisational context **P8** Review different leadership approaches to dealing with change in a range of organisational contexts	**M4** Use force field analysis to analyse the driving and resisting forces and show how they influence decision-making	

Recommended resources

Textbooks

ARCHER, D., CAMERON, A. (2013) *Collaborative Leadership; Building Relationships, Handling Conflict and Sharing Control*. 2nd ed. Abingdon: Routledge.

BARON, P. (2012) *Business and its Environment*. 7th ed. London: Prentice Hall.

BY, R.T., BURNES, B. (Eds) (2012) *Organizational Change, Leadership and Ethics: Leading Organisations Towards Sustainability.* London: Routledge.

CHEUNG-JUDGE, M-Y., HOLBECHE, L. (2015) *Organizational Development: a Practitioner's Guide for OD and HR*. 2nd ed. London: Kogan Page.

HUCZYNSKI, A., BUCHANAN, D. (2013) *Organisational Behaviour*. 8th ed. Harlow: Pearson Education Ltd.

LEVI, D. (2014) *Group Dynamics for Teams.* 4th ed. Thousand Oaks, CA: SAGE Publications.

LEWIS, L. (2019) *Organizational Change: Creating Change Through Strategic Communication.* 2nd ed. Hoboken, NJ: Wiley-Blackwell.

NORTHOUSE, P.G. (2018) *Leadership Theory and Practice*. 8th ed. Thousand Oaks, CA: SAGE Publications.

PALMER, A., HARTLEY, B. (2011) *The Business Environment*. 7th ed. Maidenhead: McGraw-Hill.

PENDLETON, D., FURNHAM, A. (2016) *Leadership: All You Need to Know*. 2nd ed. London: Palgrave Macmillan.

ROLLINSON, D. (2008) *Organisational Behaviour and Analysis: An Integrated Approach*. 4th ed. Harlow: Pearson Education Ltd.

STANFORD, N. (2014) *Organization Design: Engaging with Change*. 2nd ed. Abingdon: Routledge.

WETHERLY, P., OTTER, D. (Eds.) (2014) *The Business Environment: Themes and Issues in a Globalizing World*. 3rd ed. New York: Oxford University Press.

WORTHINGTON, I., BRITTON. C., THOMPSON, E. (2018) *The Business Environment: A Global Perspective*. 8th ed. Harlow: Pearson Education Ltd.

Links

This unit links to the following related units:

Unit 2: Scientific Data Handling Approaches and Techniques

Unit 3: Regulation and Quality in the Applied Sciences

Unit 12: Managing Environmental Resources

Unit 25: Personal and Professional Development for Scientists

Unit 26: Managing Scientific Projects

Unit 28: Applied Sciences Research Project

Unit 51: Specialist Scientific Techniques and Experimentation

Unit 61: Science Laboratory Management

Unit 63: Entrepreneurship and New Business Development

Unit 63: Entrepreneurship and New Business Development

Unit code	**D/617/5448**
Unit level	**5**
Credit value	**15**

Introduction

Entrepreneurs can identify and weigh up opportunities, threats and personal capacity in order to translate that opportunity into a business idea. The idea is then evaluated and, based on its potential, the entrepreneur may design, launch and run a new business. Entrepreneurs have a particular mindset and are driven by personal characteristics and situational factors, including education and background.

This unit discusses entrepreneurship, provides students with an understanding of where new venture ideas come from, and gives them the opportunity to investigate and evaluate a new venture idea. The balance between risk and reward in starting a new venture based on their idea will be discussed. Following this the launching of the new venture will be planned, ways to attract customers will be considered, and competitive advantage will be pursued. Students will prepare a budget for launch and a cash flow forecast for the first 12–18 months of operation for the chosen venture. Students will learn about the need for resourcefulness when starting a new venture, and will be able to identify and tap into personal networks that can offer a valuable source of knowledge, resources, advice and opportunities.

Learning Outcomes

By the end of this unit, students will be able to:

1 Explore entrepreneurship venture types and entrepreneurial mindsets

2 Discuss entrepreneurial ideas and opportunities

3 Assess the range of skills and resources required to launch a new venture

4 Produce a cash flow forecast, budget and break-even analysis, and interpret key financial statements.

Essential Content

LO1 **Explore entrepreneurship venture types and entrepreneurial mindsets**

Scoping and defining entrepreneurship:

What is entrepreneurship? Defining entrepreneurship, entrepreneurial activity and enterprise

The differences between serial entrepreneurs, intrapreneurs and owner-managers.

The typology of entrepreneurship:

Lifestyle and growth firms, entrepreneurship in a corporate or public sector context

Roles and characteristics of micro, small and medium-sized organisations.

Social enterprise:

Understanding social enterprise, social entrepreneurs and the growth of the social economy.

Entrepreneurial characteristics and mindset:

Research on personal characteristics of entrepreneurs and small business owners

Different lines of argument relating to characteristics of entrepreneurs, such as, Are entrepreneurs born or made? Or can characteristics be learnt and adopted by anyone?

Skills set of the entrepreneur:

The types of skills that typify entrepreneurs and how these skills differentiate from other organisation managers.

Personal entrepreneurial tendency:

Entrepreneurial characteristics and situational factors in a personal context, including family upbringing, lifestyle, cultural differences and personal motivation and drivers.

LO2 **Discuss entrepreneurial ideas and opportunities**

Sources of business ideas:

External/macro-environmental sources of change that create opportunities (Drucker's 7 sources of innovation, STEEP factors)

The role of the 'entrepreneur' in weighing up opportunities, threats and personal capacity to translate the opportunity into a business idea

Personal situational factors and knowledge.

Types of innovation:

The scope of innovation, particularly in relation to small firms

The different types of innovation: product and process innovation; incremental vs big bang; Schumpeter's sources of innovation

The difference between invention and innovation and the role of creativity

Exploring the difference between a product or service idea and a business idea

Innovation and location and the role of 'clusters' in fostering innovation amongst small firms.

Exploring creativity:

Understand, and practice using, creativity techniques to generate ideas.

Identifying customers:

Understand the need to identify specific customer types for targeting new ideas

Behavioural, demographic and geographic segmentation

Tangible and intangible features and benefits of a product or service.

Understanding the industry environment:

How the industry environment affects the likely success of a new entrant

Explore Porter's Five Forces model to analyse the attractiveness of an industry from the perspective of a new entrant

Approaches to competitor analysis relevant to entrepreneurs and small firms.

Industry life−cycle.

LO3 **Assess the range of skills and resources required to launch a new venture**

Defining the idea and the target customer:

The venture idea and how it represents a business/social enterprise opportunity

Analysis of the small business environment to support the venture idea

The characteristics of the target or ‘typical’ customer applying geographic, demographic and behavioural segmentation

Use of competitor and industry analysis techniques, such as Porter’s Five Forces analysis

Identification of tangible and intangible features and benefits

Achieving competitive advantage.

Understanding and planning resources:

The different types of resources that are needed to start a new venture: tangible, intangible and human

The three categories of ‘capital’: human, social and financial

Identifying and planning resources for a new venture, including tangible (premises, equipment, IT facilities) and intangible (skills and capabilities).

Understanding and acquiring skills and capabilities:

Identifying the necessary skills and capabilities required

The importance of building credibility in a start-up venture, addressing risk factors and responding to change

The concept of ‘bootstrapping’: making use of free or low-cost sources of resources and skills, leasing and renting

Low cost/free marketing and promotion

The principles of the ‘Lean Start-up’ method.

The importance of networks:

The importance of networks to new ventures as a source of ‘social capital’ that can bring access to knowledge, resources, advice and opportunities

Consideration of both formal and informal networks

Assessing and developing personal networks and ‘the strength of weak ties’.

LO4 Produce a cash flow forecast, budget and break-even analysis and interpret key financial statements

Sources of finance for start-up and small businesses:

The main sources of finance for start-up and small businesses, including own savings, equity finance or loans from family and friends, bank loans and overdrafts, leasing and hire purchase, invoice factoring.

Forecasting and budgeting:

Techniques for forecasting and budgeting: using time series data, calculating a moving average, finding a trend, dealing with seasonality

Developing budgets, including 'what-if' sensitivity analysis

Using budgets for performance monitoring and control

Variance analysis

Break-even analysis.

Financial statements for a small business:

The key financial statements that are required for a small business, and how to interpret them

The difference between profit and cash, and the vital importance of cash flow for a small business/social enterprise

The elements of working capital, and how to manage cash flow effectively.

Learning Outcomes and Assessment Criteria

Pass	Merit	Distinction
LO1 Explore entrepreneurship venture types and entrepreneurial mindsets		**D1** Analyse the characteristic traits, skills and motivational drivers of successful entrepreneurs, supported by specific examples
P1 Examine different types of entrepreneurial ventures, and explain how they relate to the typology of entrepreneurship **P2** Explore the characteristic traits and skills of successful entrepreneurs that differentiate them from other business managers	**M1** Investigate a diverse range of entrepreneurial ventures, to demonstrate an understanding of entrepreneurship in both the public and corporate sector	
LO2 Discuss entrepreneurial ideas and opportunities		**D2** Critically evaluate a specific entrepreneurial idea, based on appropriate interpretation and investigation of the competitive market place
P3 Explore different sources of entrepreneurial ideas and innovation **P4** Discuss the rationale and market gap for a specific entrepreneurial opportunity, using relevant tools and techniques to support your choice	**M2** Provide justification of how a specific entrepreneurial idea fills a market gap, using different techniques for gap and competitive analysis	

Pass	Merit	Distinction
LO3 Assess the range of skills and resources required to launch a new venture		**D3** Develop a detailed proposal that demonstrates critical analysis and reflection of the competitive environment, with supporting contingency planning to minimise risk
P5 Review specific tangible and intangible resources that would be required for the launch of a new venture **P6** Assess the skills and capabilities required to launch a new venture, and how they are acquired or developed	**M3** Apply a range of methods and techniques for competitive analysis to justify how to achieve competitive advantage	
LO4 Produce a cash flow forecast, budget and break-even analysis, and interpret key financial statements.		**D4** Produce an accurate cash flow forecast and break-even analysis, with a critical evaluation of how key financial statements contribute to the successful management of the business
P7 Produce an annual itemised monthly cash flow forecast, showing fixed and variable costs set against income for a specific organisation **P8** Carry out break-even analysis that could be applied to an organisational situation **P9** Communicate key financial statements for an organisation in relation to how they contribute to the successful management of the organisation	**M4** Apply appropriate quantitative and analytical techniques, to provide an appropriately detailed cash flow forecast and break-even analysis	

Recommended resources

Textbooks

BLANCHARD, K., ONCKEN, W., BURROWS, H. (2011) *The One Minute Manager Meets the Monkey*. London: Harper Collins.

BURNS, P. (2016) *Entrepreneurship and Small Business: Start-up, Growth and Maturity*. 4th ed. Basingstoke: Red Globe Press (Palgrave MacMillan).

BURNS, P. (2018) *New Venture Creation: A Framework for Entrepreneurial Startups*. London: Palgrave MacMillan.

CARTER, S., JONES-EVANS, D. (2012) *Enterprise and Small Business: Principles, Practice and Policy*. 3rd ed. Harlow: Pearson Education Ltd.

DOWN, S. (2010) *Enterprise, Entrepreneurship and Small Business*. London: SAGE Publications.

GRIFFITHS, A., WALL, S. (2011) *Economics for Business and Management*. 3rd ed. Harlow: Pearson Education Ltd.

RIES, E. (2011) *The Lean Start-up*. London: Penguin Books.

WALL, S., CODAY, C., MITCHELL, C. (2014) *Quantitative Methods for Business and Management: An Entrepreneurial Perspective*. Harlow: Pearson Education Ltd.

WILLIAMS, S. (2014) *Financial Times Guides: Business Start-up 2015*. 28th ed. Harlow: Pearson Education Ltd.

Journals

Journal of Small Business Management. Oxford: Wiley-Blackwell.

Web

isbe.org.uk	The Institute for Small Business and Entrepreneurship (ISBE) (General reference)

Links

This unit links to the following related units:

Unit 2: Scientific Data Handling Approaches and Techniques

Unit 3: Regulation and Quality in the Applied Sciences

Unit 12: Managing Environmental Resources

Unit 25: Personal and Professional Development for Scientists

Unit 26: Managing Scientific Projects

Unit 28: Applied Sciences Research Project

Unit 51: Specialist Scientific Techniques and Experimentation

Unit 61: Science Laboratory Management

Unit 62: Organisations and Change Management

Unit 64: Work-based Investigation

Unit code	**J/617/8862**
Unit level	**4**
Credit value	**15**

Introduction

This unit gives students the opportunity to plan, undertake, monitor progress of and communicate the outcomes of a work-related investigative project. Students who are employed or have a significant placement in the Applied Sciences sector should carry out a relevant practical investigation at work. Those on programmes who are not working or do not have access to a significant placement in the sector should undertake the investigation on a work-related topic in their Centre's laboratory. It may be appropriate to for the project to be based on fieldwork, depending on the sector. The project should mirror current workplace practice in the Applied Sciences sector as closely as possible.

Appropriate topics for investigation may include validation of a new analytical or testing method, validation of a new analytical/testing instrument for a particular technique, variation of the conditions used in a process, an ecological survey, microbiological environmental monitoring etc.

By undertaking this project, students will develop skills valued by employers in the Applied Sciences sector e.g. planning, working independently, managing time effectively, solving problems, negotiating resources, recording, reporting etc. This work-based investigation unit will prepare students for undertaking the Level 5 Applied Sciences Research Project.

Learning Outcomes

By the end of this unit, students will be able to:

1 Plan a work-based project

2 Undertake a work-based project

3 Show how to maintain a detailed experimental logbook for a work-based project

4 Report on a work-based project

Essential Content

LO1 Plan a work-based project

Supervisor(s): Academic supervisor at the Centre; industrial supervisor (if appropriate)

Work-based topic: Topic selected in conjunction with an industrial supervisor or topic typical of those carried out at this level in industry, e.g. validation of an analytical method, exploration of variables in a process, ecological survey, environmental microbiological monitoring, comparing how nutrients in food similar products vary etc.

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

Health and safety: Risk assessment for work carried out

Amend schedule: following discussions with supervisor(s) e.g. agreed amendments to specification, timescales

LO2 Undertake a work-based project

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 error; use of appropriate statistical and other data analysis techniques

Safe practice: safety manuals; safety equipment; COSHH assessment; risk assessment

Autonomy: Amendments to schedule; practical work; contributions to group work; discussions with supervisor(s); proposals for additional work

Agreed plans: documented arrangements for group work; agreed deadlines

LO3 Show how to maintain a detailed experimental logbook for a work-based project

Document work: format of logbook appropriate to the situation e.g. hard-backed notebook, electronic logbook etc.; dated entries; details of methods used; instruments 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(s)

LO4 **Report on a work-based project**

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

Report: Slide-share presentation and a formal scientific report

Presentation: appropriate use of media; style appropriate to audience; balance of visual material, text and explanation; clear explanations of scope and results; justified conclusions; appropriate responses to questions

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

Scientific report format: in-text referencing and bibliography according to accepted scientific methodology; past passive tense; tabulated results; graphs; diagrams; appropriate headings and sub-headings and numbering of tables, graphs and diagrams

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

Learning Outcomes and Assessment Criteria

Pass	Merit	Distinction
LO1 Plan a work-based project		**D1** Evaluate the factors that determine project topic choices
P1 Suggest a work-related topic and an outline specification for the project **P2** Develop the schedule as appropriate following consultations with supervisor(s) **P3** Identify the required resources and support for the project	**M1** Justify the choice of project topic and techniques to be used in terms of literature and sector practice	
LO2 Undertake a work-based project		**D2** Evaluate the constraints that affect how the project is carried out
P4 Carry out the identified practical procedures safely **P5** Demonstrate an appropriate degree of autonomy	**M2** Justify the nature and number of repeat measurements	

Pass	Merit	Distinction
LO3 Show how to maintain a detailed experimental logbook for a work-based project		**D3** Discuss the factors that determine how the work is recorded
P6 Record the work undertaken in a systematic manner **P7** Review and amend the schedule, taking account of the outcomes of work undertaken	**M3** Justify the need for (or the lack of) amendments to the schedule	
LO4 Report on a work-based project		**D4** Critically evaluate the results of the project and the scope for further work
P8 Communicate how the investigation was undertaken by delivering a presentation **P9** Report the work undertaken in an accepted formal written style	**M4** Design a presentation that uses an effective balance of visual material, text and verbal explanation and respond to questions appropriately	

Recommended resources

Textbooks

AHMED, N., Glencross H., Wang, Q. (Eds.) (2016) *Biomedical Science Practice: Experimental and Professional Skills.* 2nd Ed. Oxford: Oxford University Press.

BOYLE. J., RAMSAY, S. (2017) *Writing for Science Students.* London: Palgrave.

CHRISTIAN, G.D., DASGUPTA, P.K., SCHUG, K.A. (2013) *Analytical Chemistry.* 7th Ed. Hoboken: John Wiley & Sons Inc.

CRANWELL, P.B., HARWOOD, L.M., MOODY, C.J. (2017) *Experimental Organic Chemistry.* Chichester: John Wiley & Sons Ltd.

CRUZ, R.M.S., KHMELINSKII, I., VIEIRA, M.C. (Eds.) (2016) *Methods in Food Analysis.* Boca Ratan: CRC Press

DEAN J.R, JONES A.M. et al. (2017) *Practical Skills in Chemistry.* 3rd Ed. Harlow: Pearson Education.

DEY, P. (2018) *Basic and Advanced Techniques in Histopathology and Cytology.* Singapore: Springer Nature.

EVANS, E.H., FOULKES M.E. (2018) *Analytical Chemistry: A Practical Approach.* Oxford: Oxford University Press.

GAISFORD, S., KETT, V., HAINES, P. (Eds.) (2016) *Principles of Thermal Analysis and Calorimetry*. 2nd Ed. Cambridge: The Royal Society of Chemistry.

GOLDMAN, E., GREEN, L.H. (Eds.) (2015) *Practical Handbook of Microbiology.* 3rd Ed. Boca Raton: CRC Press.

GRELLMANN, W., SEIDLER, S. (2013) *Polymer Testing.* 2nd Ed. Munich: Hanser.

HANLON, G., HODHES, N.A. (2013) *Essential Microbiology for Pharmacy and Pharmaceutical Science.* Chichester: Wiley-Blackwell.

HANSEN, S.H., PEDERSEN-BEJERGAARD, S., RASMUSSEN, K.E. (2012) *Introduction to Pharmaceutical Chemical Analysis.* Chichester: John Wiley & Sons Ltd.

HARRIS, D.C., CHUCK, L. (2015) *Quantitative Chemical Analysis.*9th Ed. New York: W H Freeman.

HOFFMAN, A., CLOKIE, S. (2018) *Wilson and Walker's Principles and Techniques of Biochemistry and Molecular Biology.* 8th Ed. Cambridge: Cambridge University Press.

HOSSEINI, S., VASQUEZ-VILLEGAS, P., RITO-PALOMARES, M., MARTINEZ-CHAPA, S.O. (2018) *Enzyme-linked Immunosorbent Assay (ELISA) From A to Z*. Singapore: Springer Nature.

HUGHES, J. (Ed.) (2018) *Freshwater Ecology and Conservation: Approaches and Techniques (Techniques in Ecology & Conservation.* Oxford: Oxford University Press.

JAMES, S.H., NORDBY, J., BELL, S. (Eds.) (2015) *Forensic Science: An Introduction to Scientific and Investigative Techniques.* 4th Ed. Boca Raton: CRC Press.

JOHNSON, S., SCOTT, J. (2019) *Study and Communication Skills for the Biosciences.* 3rd. Ed. Oxford: Oxford University Press.

JONES, A., REED, R., WYERS, J. (2016) *Practical Skills in Biology.* 6th Ed. Harlow: Pearson Education Ltd.

LANGFORD, A.M., DEAN, J. et al (2018) *Practical Skills in Forensic Science. 3rd* Ed. Harlow: Pearson Education Ltd.

MCPHERSON, P. (2015). *Practical Volumetric Analysis.* Cambridge: The Royal Society of Chemistry.

MILLER J., MILLER J.C., MILLER, R.D. (2018) *Statistics and Chemometrics for Analytical Chemistry.*7th Ed. Cambridge: Pearson.

NELSON, S.S. (Ed.) (2017) *Food Analysis (Food Science Text).* 5th Ed. Cham: Springer Nature.

OVERTON T., JOHNSON, S., SCOTT, J. (2019) *Study and Communication Skills for the Chemical Sciences*. 3rd Ed. Oxford: Oxford University Press.

RADOJEVIC, M., BASHKIN, V.N. (2006) *Practical Environmental Analysis.* 2nd Ed. Cambridge: The Royal Society of Chemistry.

REED, R., HOLMES, D. et al (2016) *Practical Skills for the Biomolecularsciences.* 5th Ed. Harlow: Pearson Education Ltd.

ROBBINS, S. (2009) *Science Study Skills*. Baskingstoke: Palgrave Macmillan.

SASTRY, A.S, BHAT K, S. (2018) *Essentials of Practical Microbiology* New Delhi: Jaypee Brothers Medical Publishers (P) Ltd.

SKOOG, D.A., WEST, D.M., HOLLER, F.J, CROUCH, S.R. (2014) *Fundamentals of Analytical Chemistry.* 9th Ed., Belmont: Brooks/Cole.

SNYDER, L.R, KIRKLAND, J.J., GLAJCH, J.L. (2012) *Practical HPLC Method Development.* 2nd Ed. New York: John Wiley & Sons Inc.

WHEATER, C.P., BELL, J.R., COOK, P.A. (2011) *Practical Field Ecology: A Project Guide.* Chichester: John Wiley & Sons Ltd.

Web

www.rsb.org.uk	The Royal Society of Biology (General reference)
www.rsc.org	The Royal Society of Chemistry (General reference)
https://microbiologysociety.org	Microbiology Society (General reference)
www.iom3.org	Institute of Materials and Minerals The Polymer Society (General reference)
www.britishecologicalsociety.org	British Ecological Society (General reference)

Links

This unit links to the following related units:

Unit 1: Fundamentals of Laboratory Techniques

Unit 2: Scientific Data Handling Approaches and Techniques

Unit 3: Regulation and Quality in the Applied Sciences

Unit 12: Managing Environmental Resources

Unit 25: Personal and Professional Development for Scientists

Unit 26: Managing Scientific Projects

Unit 28: Applied Sciences Research Project

Unit 51: Specialist Scientific Techniques and Experimentation

Unit 61: Science Laboratory Management

Unit 62: Organisations and Change Management

Unit 65: Further Analytical Chemistry

Unit code	**F/618/0058**
Unit level	**5**
Credit value	**15**

Introduction

Analytical chemistry has a wide range of applications, for example: in supporting manufacture of a wide range of products (e.g. food and drink, ceramics, polymers, pharmaceuticals, coatings, explosives, nuclear fuel, petroleum products) as well as in environmental analysis of air, water and soils and in forensic science.

The analytical chemist not only needs to know about how a range of techniques may be applied but needs to understand the process of ensuring that analysis is valid and reliable. This includes understanding how errors may be minimised and quantifies, how methods are selected and validated, sampling, sample preparation and how analysis should be planned. Real samples often contain many substances in addition to the one, for which analysis is being undertaken. It may be necessary to extract the analyte from its matrix.

In this unit, the student will plan, carry out and report the analysis of three matrices which should be chosen to all students to explore a range of sampling and preparative techniques. The analysis should provide students with the opportunity to understand the use of control samples, spikes and standards. Students should explore the quality control and quality assurance procedures used in industry and relate them to the analysis that they have carried out.

By undertaking this unit, students will gain an understanding about quality systems in analysis which will be useful in industrial laboratories or prepare them for further study of analytical chemistry.

Learning Outcomes

By the end of this unit, students will be able to:

1 Plan the steps in analyses

2 Undertake appropriate sampling, sample preparation and analysis

3 Report on the quality of the analysis

4 Investigate quality assurance measures associated with analysis

Essential Content

LO1 **Plan the steps in analysis**

Three different analysis tasks:

Differences could relate to analytical techniques, sampling, sample presentation, method selection

Analytes and matrices:

Analytes and purpose of analysis must be identified.

Recognition that the analyte is often present along with other substances in a matrix e.g. pharmaceutical product, natural mineral water, foodstuff, coating, building products etc. Some substances may interfere with analysis. Analyte may bind to substances in the matrix.

Sampling:

Representative sample; sample size; stratified materials; composite samples; homogenisation; isokinetic sampling of gases; sampling plan; soils; aggregates;

Sample Preparation:

Relevant techniques. For example: Liquid/liquid extraction e.g. use of a separating funnel; Liquid/solid extraction e.g. shaking with a solvent or Soxhlet extraction; Acid digestion; ashing; preconcentration; filtration etc.

Choice of techniques:

Choice of technique in relation to the analyte and matrix. Any relevant techniques e.g.

Mass spectrometry; gas chromatography (GC); high performance liquid chromatography (HPLC); hyphenated chromatographic techniques; ultraviolet/visible spectroscopy; infrared spectroscopy; raman spectroscopy; X-ray fluorescence (XRF) spectroscopy; flame/furnace atomic absorption (AA); atomic emission spectrometry; inductively coupled plasma emission spectrometry (ICP); nuclear magnetic resonance (NMR) spectroscopy; electron microscopy; Energy dispersive X-ray analysis (EDX); ion-selective electrodes; potentiometry; voltammetry; thermogravimetric analysis; differential thermal analysis

Qualitative and quantitative techniques

Selection of a suitable method:

Standard methods (UK or International); in-house methods; validity; reliability; use of instrument instructions and information; methods supplied by instrument manufacturer: availability of specialist equipment

LO2 **Undertake appropriate sampling, sample preparation and analysis**

Sampling, sample preparation and analysis

Use of planned procedures; adapting procedures in response to specific circumstances; justification of the sampling, sample preparation and analytical procedures used; scope for improvements to sampling sample preparation and analysis; limitations of equipment and materials available; calibration of equipment; use of standard substances; spiking; method of standard additions

LO3 **Report on the quality of the analyses**

Features of quality:

Quality as closeness to the true value; accuracy; precision; repeatability; reproducibility

Different types of error:

Random; bias; reasons for error e.g. quality/tolerance of volumetric glassware; lack of competence; calculation transcription errors; unsuitable method used; contamination; extraction/sample preparation techniques chosen; presence of interferences; calibration errors; sampling errors; losses and degradation; consequences of the underlying reasons for error

Minimising types of error:

Elimination of bias; minimisation of spread of random errors; ways of reducing error e.g. training, performing calculations on computer, system of double-checking data entry, method validation, steps to reduce contamination, optimising extraction/sample preparation, selection or modification of method to reduce interference, rigorous calibration procedures, validated sampling procedures, adequate sample storage

Distribution of results:

Population mean and sample mean; distribution of results about mean; normal distribution curve; standard deviation from the mean; percentage of results between $\pm 2\sigma$ and $\pm 3\sigma$; confidence limits

LO4 **Investigate quality assurance measures associated with analysis in industry**

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; benefits of proficiency testing; quantification of performance e.g. z score, E_n number, Q score

Features of quality assurance:

Activities providing confidence that results are correct e.g. staff training and training records, record keeping, data management, provision of an adequate laboratory environment, 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:

Use of control samples; calculation of standard deviation and setting confidence, warning and action limits; Sewhart Chart; Moving Average Chart; CUSUM chart; actions to be taken in response to the appearance of the control charts

Learning Outcomes and Assessment Criteria

Pass	Merit	Distinction
LO1 Plan the steps in analysis		**D1** Critically evaluate the options available for sampling, sample preparation and analysis with respect to the work you have undertaken
P1 Investigate the typical composition of three matrices containing analytes **P2** Plan appropriate sampling procedures, sample preparation and analysis for the analytes from the three matrices **P3** Demonstrate a knowledge of the operation of and the underlying principles for the analytical techniques which will be used for each analysis	**M1** Justify the planned sampling, sample preparation and analysis	
LO2 Undertake appropriate sampling, sample preparation and analysis		
P4 Carry out representative sampling for three matrices **P5** Carry out sample preparation to facilitate the use of suitable analytical techniques **P6** Carry out appropriate analysis involving three matrices	**M2** Justify amendments to the planned sampling, sample preparation and analysis	

Pass	Merit	Distinction
LO3 Report on the quality of the analyses		
P7 Discuss the quality of the analyses undertaken **P8** Report the results of the three analyses to an appropriate tolerance	**M3** Justify the tolerance limits for the quoted results	**D2** Critically evaluate suggestions for improvements to the analyses undertaken, in terms of quality
LO4 Investigate quality assurance measures associated with analysis in industry		
P9 Discuss internal and external quality control measures relevant to the types of analyses undertaken **P10** Discuss how analytical results may be quality assured in industry	**M4** Justify the quality control and quality assurance measures discussed using suitable industrial examples	**D3** Critically evaluate how industrial quality best practice can be used to improve the validity and reliability of analytical outcomes

Recommended resources

Textbooks

CHRISTIAN, G.D, DASGUPTA, P.K., SCHUG, K.A., (2013). *Analytical Chemistry.*

EVANS, E.H., FOULKES, M.E. (2019) *Analytical Chemistry*. Oxford: Oxford University Press.

FUNK, W. and DAMMANN, V. (2007) *Quality Assurance in Analytical Chemistry: Applications in Environmental, Food and Materials Analysis, and Medical Engineering.* 2nd Ed. Weinheim: Wiley-VCH Verlag GmbH & Co KGaA

HIBBARD, D.B. (2007). *Quality Assurance in the Analytical Chemistry Laboratory.* Oxford: Oxford University Press.

MILLER, J.N., MILLER, JC, MILLER, R.D. (2018). *Statistics and Chemometrics for Analytical Chemistry.* 7th Ed. Harlow: Pearson Education Ltd.

PRICHARD, E. and BARWICK, V. (2007) *Quality Assurance in Analytical Chemistry*. Chichester: John Wiley and Sons Ltd.

SKOOG, D.A., WEST, D.M., HOLLER, F.J, CROUCH, S.R. (2014) *Fundamentals of Analytical Chemistry.* 9th Ed., Belmont: Brooks/Cole.

WENCLAWIAK, B.W. and KOCH, M. (2013) *Quality Assurance in Analytical Chemistry: Training and Teaching.* Heidelberg: Springer-Verlag.

WORLD HEALTH ORGANIZATION (2011) *Laboratory Quality Management System: Handbook.* Geneva: World Health Organization.

Journals

Journal of Small Business Management. Oxford: Wiley-Blackwell.

Web

rsc.org.uk	Royal Society of Chemistry

Links

This unit links to the following related units:

Unit 2: Scientific Data Handling Approaches and Techniques

Unit 3: Regulation and Quality in the Applied Sciences

Unit 26: Managing Scientific Projects

Unit 28: Applied Sciences Research Project

Unit 35: Analytical Chemistry

Unit 51: Specialist Scientific Techniques and Experimentation

Unit 61: Science Laboratory Management

Unit 64: Work-based Investigation

Unit 66: Volume Crime Scene Science

Unit code	**A/650/2662**
Unit type	**Specialist**
Unit level	**4**
Credit value	**15**

Introduction

Volume crime scenes make up the bulk of forensic crime scenes. They cover a range of settings and types of evidence generated.

This unit is designed to introduce students to all the processes that occur at volume crime scenes. Students will investigate crime scene procedures, including record keeping at crime scenes, the preservation of evidence and the collection of evidence from volume crime scenes. Techniques covered include the recovery of fingerprints, footwear marks and tool marks, and the collection and correct packaging of items such as hairs, fibres, glass and paint. Students will be introduced to the legal and documentary framework that accompanies the collection and preservation of evidence.

As well as theoretical knowledge, students will experience the practicalities of searching for and recovering evidence from volume crime scenes. Evidence examination will be considered in terms of the amount of information that can be obtained from the analysis. The focus of the unit is on the multidisciplinary nature of forensic investigations and the integration of legal, practical and scientific aspects of crime scene investigations forensic science in identifying offenders and interpreting crime scenes.

Learning Outcomes

By the end of this unit, students will be able to:

1 Investigate the legal aspects of evidence collection, storage and the presentation of evidence in a legal framework

2 Describe different classes of volume crime scenes

3 Apply routine techniques for collection and analysis of evidence from volume crime scenes

4 Report on forensic evidence collection from a volume crime scene.

Essential Content

LO1 Investigate the legal aspects of evidence collection, storage and the presentation of evidence in a legal framework

Legal frameworks and legislation, e.g. in the UK currently

Police and Criminal Evidence Act 1984 (PACE)

Codes of practice for forensic practitioners

ACPO (Association of Chief Police Officers) – digital evidence

Health and Safety at Work etc. Act 1974 and subsequent updates

COSHH (Control of Substances Hazardous to Health) Regulations 2002

The Management of Health and Safety at Work Regulations 1999

LO2 Describe different classes of volume crime scenes

Defining volume crime scene

Non-volume crime scenes, e.g. murder, robbery, serious assaults

Current crime statistics

Classes of volume crime scenes

Indoor

Outdoor

Conveyance

Theft of/from motor vehicles

Burglary

Criminal damage

Personnel present at volume crime scenes

First attending officer (FAO)

CSI (Crime Scene Investigator)

Crime Scene Manager

Police officers

Forensic scientists

Victim

Perpetrator

Witness(es)

LO3 Apply routine techniques for collection and analysis of evidence from volume crime scenes

Techniques for collection of evidence

Evidence collection techniques: recovery of trace evidence (taping, swabbing and hand picking) including for hairs, fingerprints, blood, fibres and paint

Evidence packaging: types and methods, including for tools, weapons, clothes/shoes, glass and bottles

Appropriate documentation: labelling of evidence, continuity of evidence

Storage methods

Transportation of evidence

Search methods

Personal protective equipment (PPE): selecting and justifying

Field presumptive testing

Recovery of footwear marks

Recovery of tool marks

Recovery of trace evidence: taping, swabbing, hand picking

Principles of photographing the crime scene

Other forms of supplementing documentation, i.e. notes, videography, risk assessments, sketching the scene

Analysis of evidence

Fundamentals of fingerprint enhancement

Fundamentals of footwear marks

Knowledge and application of statistical tests

Importance of quality control

LO4 Report on forensic evidence collection from a volume crime scene

Reporting

Reviewing data and evidence

Prioritising the submission of items and forensic samples for analysis in line with forensic strategy

Importance of maintaining communications with relevant people concerning progress of examinations in line with forensic strategy

Forms, e.g. currently in the UK

Streamlined Forensic Reporting

Streamlined Forensic Report (SFR) Initial Forensic Investigation/Examination Report MG 22 A

Streamlined Forensic Report (SFR1) Stage 1 Forensic Result Report/ MG 22 B

Streamlined Forensic Report (SFR2) Stage 2 Report Forensic Issues report/ MG 22 C

Streamlined Forensic Report (SFR) Crime Scene Investigation/Forensic Examination statement/MG 22 D

Full Evaluative Statements

Expert Witness Statement

Learning Outcomes and Assessment Criteria

Pass	Merit	Distinction
LO1 Investigate the legal aspects of evidence collection, storage and the presentation of evidence in a legal framework		
P1 Investigate the current legal framework governing the collection, storage and presentation of evidence in criminal investigations.	**M1** Analyse the current legal framework governing the collection, storage and presentation of evidence in criminal investigations.	**D1** Evaluate the current legal framework governing the collection, storage and presentation of evidence in criminal investigations.
LO2 Describe different classes of volume crime scenes		
P2 Describe the different classes of volume crime scenes.	**M2** Analyse the different classes of volume crime scenes.	**D2** Evaluate the different classes of volume crime scenes, including the personnel present.
LO3 Apply routine techniques for collection and analysis of evidence from volume crime scenes		**LO3 and LO4**
P3 Perform evidence collection from a volume crime scene. **P4** Perform analysis of evidence collected from a volume crime scene.	**M3** Justify the main techniques used for collection and analysis of evidence from volume crime scenes.	**D3** Evaluate the methods of collection, analysis and reporting of evidence from volume crime scenes.
LO4 Report on forensic evidence collection from a volume crime scene		
P5 Describe the form of forensic reports. **P6** Report on evidence collected from a volume crime scene in the form of a relevant forensic report	**M4** Justify the use of forensic reports used for evidence collected from a volume crime scene.	

Recommended Resources

Textbooks

BELL, S. (2019) *Forensic Science: An Introduction to Scientific and Investigative Techniques.* 5th ed. Boca Raton, FL: CRC Press.

FISHER, B. A. J., FISHER, D. R. (2012) *Techniques of Crime Scene Investigation (Forensic and Police Science)*. 8th ed. Boca Raton, FL: CRC Press.

HAMMER, L. (2019) *Footwear and Tire Track Evidence Collection Manual.* Boca Raton, FL: CRC Press.

JACKSON, A. R. W., JACKSON, J. M., MOUNTAIN, H., BREARLEY, D. (2016) *Forensic Science.* 4th ed. Harlow: Pearson Education Ltd.

LANGFORD, A. M., DEAN, J. R., HOLMES, D., REED, R., WEYERS, J., JONES, A. (2019) *Practical Skills in Forensic Science.* 3rd ed. Harlow: Pearson Education Ltd.

MOZAYANI, A., PARISH-FISHER, C. (Eds). (2017) *Forensic Evidence Management: From the Crime Scene to the Courtroom.* Boca Raton, FL: CRC Press.

PFEFFERLI, P. (2015) *Forensic Evidence Field Guide: A Collection of Best Practices.* Amsterdam: Academic Press (Elsevier).

REIBER, L. (2019) *Mobile Forensic Investigations: A Guide to Evidence Collection, Analysis, and Presentation.* 2nd ed. New York: McGraw-Hill Education.

SUTTON, R., TRUEMAN, K., MORAN, C. (Eds). (2016) *Crime Scene Management: Scene Specific Methods*. 2nd ed. Chichester: Wiley-Blackwell.

WHITE, P.C. (Ed). (2016) *Crime Scene to Court: The Essentials of Forensic Science.* 4th ed. Cambridge: The Royal Society of Chemistry.

Journals

WULLENWEBER, S., GILES, S. (2021) 'The Effectiveness of Forensic Evidence in the Investigation of Volume Crime Scenes', *Science and Justice,* 61(5). The Chartered Society of Forensic Sciences.

Web

forensicmag.com – *Forensic* magazine (research)

https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/891370/Manual-of-guidance-MG-forms-v11ext.pdf – manual of guidance and Manual of Guidance (MG) forms

https://www.cps.gov.uk/legal-guidance/streamlined-forensic-reporting-guidance-and-toolkit – streamlined forensic reporting guidance and toolkit

Links

This unit links to the following related units:

Unit 21: Criminal Investigation

Unit 22: Theories and Causes of Crime

Unit 33: Analytical Techniques for Forensic Science

Unit 34: Forensic Evidence Collection and Preservation

Unit 67: Undertake Forensic Examinations at Scenes of Incidents

Unit 68: Forensic Strategies for Serious and Complex Investigations

Unit 69: Manage Forensic Investigations at Scenes.

Essential requirements

Learners must have the opportunity to collect and analyse evidence from a simulated volume crime scene.

Unit 67: Undertake Forensic Examinations at Scenes of Incidents

Unit code	**D/650/2663**
Unit type	**Specialist**
Unit level	**4**
Credit value	**15**

Introduction

This unit is designed to introduce students to all the processes used in the collection and recording of evidence at crime scenes. Students will investigate crime scene procedures, including record keeping at crime scenes, the preservation of evidence, the collection of evidence and the collection of photographic evidence.

Students will gain experience of using cameras and other photographic equipment needed to take high-quality digital photographs of forensic evidence and crime scenes. They will learn how photographs can be enhanced and how photographs can be presented and used in a court of law.

On successful completion of this unit, students will be better prepared to undertake a role as a crime scene investigator.

Learning Outcomes

By the end of this unit, students will be able to:

1 Identify the requirements of crime scene examinations in line with the forensic strategy

2 Develop a strategy to use forensic photography at a crime scene

3 Demonstrate forensic photography techniques to record photographic evidence at a crime scene

4 Outline the use of forensic photography at a crime scene to present photographic evidence in a court of law

Essential Content

LO1 **Identify the requirements of crime scene examinations in line with the forensic strategy.**

Requirements of crime scene

Confirm the circumstances of incidents with relevant people in line with organisational procedures

Types of examinations to undertake

Forensic photography requirements at crime scenes

Implications of current law, policies, operating procedures and guidelines relevant to undertaking forensic examinations at scenes of incidents

Investigative needs for a forensic strategy

How to define and establish access to scenes

Prevention of contamination, cross-contamination, degradation, damage and loss of potential evidence

Location of potential, visible and latent evidence using investigative skills

Recording and recovery of potential evidence in line with forensic procedures

Optimisation and preservation of potential evidence

Identification of risks to safety, linked to collecting potential evidence

LO2 **Develop a strategy to use forensic photography at a crime scene.**

Photographic equipment

Camera types – digital, single-lens reflex (SLR), digital single-lens reflex (DSLR) and phone

Lens types – standard, wide angle, telephoto, macro, fish-eye

Light sources, including white light, flash, ultraviolet (UV) light, laser, infrared, Crime-lite®.

Light meters

Accessories, including tripod, remote release, cable release

Colour filters

Photographic techniques and theories

Theory of exposure

Focusing

Depth of field

Colour images

Resolution

Use of digital software to enhance images

Type of lens

Strategy

Crime scene access and security

Personal protective equipment – scene suit, gloves, mask and overshoes

Conditions of scene

Equipment to take to scene

Order of photographs

Range of evidence in photographs

Log of photographs

Chain of continuity

LO3 **Demonstrate forensic photography techniques to record photographic evidence at a crime scene.**

Photography at a crime scene

Use of personal protective equipment when at a crime scene

Approach of crime scene, identification of relevant evidence, use of markers and scales, avoidance of contamination or destruction of evidence

Notes and measurements – to explain scene orientation and other important details

Selection of equipment used

Use of photographic equipment

Range of photographs of scene

Photographs of evidence with scales or references

Record of crime scene

Notes and diagrams of scene to show positions of objects photographed

Photo log

Image section

Enhancement of images with log of changes

Log of chain of continuity

Reason of image section

LO4 **Outline the use of forensic photography at a crime scene to present photographic evidence in a court of law.**

Photographic evidence in a court of law

Regulation on photographic evidence, e.g. Criminal Justice Act 2003 and the Police and Criminal Evidence Act 1984 or most recent legislation

Purpose of photographic evidence

Chain of continuity

Importance of scales, colour chart and markers

Enhancement of evidence types

Admissible evidence via Crown Prosecution Service (CPS) guidelines

Use of photographic evidence

Technical knowledge used to take the photographs

Photographs of crime scenes, showing all features

Photographs to show evidence, in detail and in situ

Enhancement of photographic evidence

Chain of continuity to preserve integrity

Learning Outcomes and Assessment Criteria

Pass	Merit	Distinction
LO1 Identify the requirements of crime scene examinations in line with the forensic strategy.		
P1 Identify the requirements of crime scene examinations. **P2** Identify the forensic photography needs for examinations in line with the forensic strategy.	**M1** Explain the requirements of crime scene examinations and forensic photography needs for examinations in line with the forensic strategy.	**D1** Analyse the requirements of crime scene examinations and forensic photography needs for examinations in line with the forensic strategy.
LO2 Develop a strategy to use forensic photography at a crime scene.		**LO2 and LO3**
P3 Describe a strategy you have developed to use photographic techniques and equipment to record evidence at a crime scene.	**M2** Explain how photographic techniques and equipment can be used to enhance the photographic evidence at a crime scene.	**D2** Justify how your use of photographic techniques and equipment are used to record photographic evidence at a crime scene.
LO3 Demonstrate forensic photography techniques to record photographic evidence at a crime scene.		
P4 Demonstrate effective use of photographic equipment to record photographic evidence at a crime scene. **P5** Demonstrate effective photographic techniques to record photographic evidence at a crime scene.	**M3** Utilise a range of photographic equipment and techniques to record photographic evidence at a crime scene.	
LO4 Outline the use of forensic photography at a crime scene to present photographic evidence in a court of law.		
P6 Outline the legislation relating to use of forensic photography at a crime scene. **P7** Outline how the recorded forensic photography accurately records the crime scene.	**M4** Explain the legislation relating to use of forensic photography at a crime scene and how the recorded forensic photography accurately records the crime scene.	**D3** Evaluate the use of forensic photography at a crime scene to present photographic evidence in a court of law.

Recommended Resources

Textbooks

BELL, S. (2019) *Forensic Science: An Introduction to Scientific and Investigative Techniques.* 5th Ed. Boca Raton, FL: CRC Press.

DALRYMPLE, B. (2018) *Forensic Digital Image Processing: Optimization of Impression Evidence*. Boca Raton, FL: CRC Press.

FISHER, B. A. J., FISHER, D. R. (2012) *Techniques of Crime Scene Investigation (Forensic and Police Science Series).* 8th Ed. Boca Raton, FL: CRC Press.

FISHER, B. A. J., FISHER, D. R. (2022) *Techniques of Crime Scene Investigation (Forensic and Police Science Series)*. 9th Ed. Boca Raton, FL: CRC Press.

HAMMER, L. (2019) *Footwear and Tire Track Evidence Collection Manual.* Boca Raton, FL: CRC Press.

JACKSON, A. R. W., JACKSON, J. M., MOUNTAIN, H., BREARLEY, D. (2016) *Forensic Science.* 4th Ed. Harlow: Pearson Education Ltd.

JAMIESON, A., MOENSSENS, A. A. (2016) *Wiley Encyclopedia of Forensic Science.* John Wiley & Sons.

LANGFORD, A. M., DEAN, J. R., HOLMES, D., REED, R., WEYERS, J., JONES, A. (2019). *Practical Skills in Forensic Science.* 3rd ed. Harlow: Pearson Education Ltd.

MANCINI, K. (2018) *Fundamentals of Forensic Photography: Practical Techniques for Evidence Documentation on Location and in the Laboratory.* 1st Ed. London: Taylor and Francis.

MARSH, N. (2014) *Forensic Photography: a Practitioner's Guide*. 1st Ed. Chichester, England: Wiley Blackwell.

MOZAYANI, A., PARISH-FISHER, C. (Eds). (2017) *Forensic Evidence Management: From the Crime Scene to the Courtroom.* Boca Raton, FL: CRC Press.

PFEFFERLI, P. (2015) *Forensic Evidence Field Guide: A Collection of Best Practices.* Amsterdam: Academic Press (Elsevier).

REIBER, L. (2019) *Mobile Forensic Investigations: A Guide to Evidence Collection, Analysis, and Presentation*. 2nd Ed. New York: McGraw-Hill Education.

SAFERSTEIN, R., HALL, A. B. (2020) *Forensic Science Handbook*. Volume 1. 3rd Ed. Boca Raton, CRC Press.

SUTTON, R., TRUEMAN, K., MORAN, C. (Eds). (2016) *Crime Scene Management: Scene Specific Methods*. 2nd Ed. Chichester: Wiley-Blackwell.

WHITE, P. C. (Ed). (2016) *Crime Scene to Court: The Essentials of Forensic Science.* 4th Ed. Cambridge: The Royal Society of Chemistry.

Web

forensicmag.com - *Forensic* magazine
(research)

Links

This unit links to the following related units:

Unit 21: Criminal Investigation

Unit 22: Theories and Causes of Crime

Unit 33: Analytical Techniques for Forensic Science

Unit 34: Forensic Evidence Collection and Preservation

Unit 66: Volume Crime Scene Science

Unit 68: Forensic Strategies for Serious and Complex Investigations

Unit 69: Manage Forensic Investigations at Scenes.

Essential requirements

Learners must have the opportunity to carry out collection of photographic evidence from a simulated crime scene.

Unit 68: Forensic Strategies for Serious and Complex Investigations

Unit code	**F/650/2664**
Unit type	**Specialist**
Unit level	**5**
Credit value	**15**

Introduction

This unit is designed to introduce students to the forensic strategies for serious and complex investigations. In examining scenes, students will need to determine the types of examinations necessary, working with people in making assessments of incidents or operations. This involves reviewing information and intelligence, confirming investigative needs and determining the forensic actions required. Forensic strategies need to be monitored and may change as a consequence of outcomes throughout an investigation. Forensic strategies can be developed for incidents and operations, and can include forensic examination strategies and forensic submission strategies. Maintaining health and safety, together with the integrity and continuity of forensic materials, is of paramount importance.

As well as theoretical knowledge, students will experience the practicalities of planning and implementing the strategies for, and recovering evidence from, various crime investigations. The stress in this unit is on the multidisciplinary nature of forensic investigations and the integration of legal, practical and scientific aspects of crime scene investigations, as well as on the appropriate management skills used by crime scene managers.

On successful completion of this unit, students will be better prepared to undertake a role as a crime scene investigator as they will have an increased knowledge of developing forensic strategies and giving evidence in a court of law.

Learning Outcomes

By the end of this unit, students will be able to:

1 Investigate the legal and organisational requirements of crime scene examinations.

2 Examine effective forensic strategies, the aspects they should address, and how to set strategies that meet investigative needs.

3 Explore the roles and responsibilities of individuals involved in a criminal investigation.

4 Demonstrate how to present forensic evidence in a court of law.

Essential Content

LO1 **Investigate the legal and organisational requirements of crime scene examinations.**

Current law, policies, operating procedures and guidelines relating to the collection and preservation of forensic evidence

E.g. Police and Criminal Evidence Act (PACE) 1984

Legal powers of police

Police organisational structure

Chain of command

Health and safety when collecting forensic evidence

Information and data handling of forensic evidence

Human rights related to collection of forensic evidence

Criminal justice system

LO2 **Examine effective forensic strategies, the aspects they should address, and how to set strategies that meet investigative needs.**

Forensic strategy

The importance of effective forensic strategies, the aspects they should address, and how to set strategies that meets investigative needs

The importance of monitoring progress and outcomes of forensic strategies and the developing needs of investigations, and how to adapt strategies accordingly

Roles and responsibilities of those involved in constructing forensic strategies, including those that should be within the forensic investigative team

Evidence that suggests an offender has forensic awareness, and the impact this would have on forensic actions

Potential health and safety hazards at examinations, and how to assess and address risks to health and safety

Forensic evidence

Main types of physical evidence and methods for ensuring their effective recovery

Range of examinations that may be relevant to particular types of investigations, and their potential evidential value

The importance of setting forensic objectives for all material to be recovered, including prioritising actions necessary to recover samples

Importance of, and procedures for, maintaining the integrity and security of incident scenes, forensic items and samples

LO3 **Explore the roles and responsibilities of individuals involved in a criminal investigation.**

Roles involved with criminal investigation

Police investigative team

Crime scene investigators

Crime scene managers

Forensic scientists

Paramedics and Fire Service

Crown Prosecution Service

Maintenance of professional standards

Forensic Science Regulator

Professional standards department

Codes of conduct

International Organization for Standardization (ISO) accreditation

Quality assurance

Validation

LO4 **Demonstrate how to present forensic evidence in a court of law.**

Criminal trial procedures

Pre-trial preparation

Case file annotation

Examination in chief

Cross-examination

Debriefing session

Communication skills

Use of correct terminology

Use of correct language

Verbal communication

Non-verbal communication

Learning Outcomes and Assessment Criteria

Pass	Merit	Distinction
LO1 Investigate the legal and organisational requirements of crime scene examinations.		
P1 Investigate the legal and organisational requirements of crime scene examinations.	**M1** Analyse the legal and organisational requirements of crime scene examinations, using an example case.	**D1** Critically evaluate the legal and organisational requirements of crime scene examinations, using a range of example cases.
LO2 Examine effective forensic strategies, the aspects they should address, and how to set strategies that meet investigative needs.		**LO2 and LO3**
P2 Examine the importance of forensic strategies in investigations and how they can be made to meet investigation needs.	**M2** Analyse the importance of forensic strategies in investigations and how they can be made to meet investigation needs.	**D2** Critically evaluate the importance of forensic strategies in investigations and how they can be made to meet investigation needs, and the roles and responsibilities of individuals involved in a criminal investigation.
LO3 Explore the roles and responsibilities of individuals involved in a criminal investigation.		
P3 Explore the roles and responsibilities of individuals involved in a criminal investigation.	**M3** Analyse the roles and responsibilities of a range of individuals involved in a criminal investigation, using example cases	
LO4 Demonstrate how to present forensic evidence in a court of law.		
P4 Present forensic evidence in a moot court.	**M4** Effectively present detailed forensic evidence in a moot court.	**D3** Critically evaluate your performance in presentation of forensic evidence in moot court.

Recommended Resources

Textbooks

BELL, S. (2019) *Forensic Science: An Introduction to Scientific and Investigative Techniques.* 5th ed. Boca Raton, FL: CRC Press.

FISHER, B. A. J., FISHER, D. R. (2012) *Techniques of Crime Scene Investigation (Forensic and Police Science Series).* 8th ed. Boca Raton, FL: CRC Press.

FISHER, B. A. J., FISHER, D. R. (2022) *Techniques of Crime Scene Investigation (Forensic and Police Science Series).* 9th ed. Boca Raton, FL: CRC Press.

HAMMER, L. (2019) *Footwear and Tire Track Evidence Collection Manual.* Boca Raton, FL: CRC Press.

JACKSON, A. R. W., JACKSON, J. M., MOUNTAIN, H., BREARLEY, D. (2016) *Forensic Science*. 4th ed. Harlow: Pearson Education Ltd.

LANGFORD, A. M., DEAN, J. R., HOLMES, D., REED, R., WEYERS, J., JONES, A. (2019) *Practical Skills in Forensic Science.* 3rd ed. Harlow: Pearson Education Ltd.

MANCINI, K. (2018) *Fundamentals of Forensic Photography: Practical Techniques for Evidence Documentation on Location and in the Laboratory*. 1st Ed, London: Taylor and Francis

MOZAYANI, A., PARISH-FISHER, C. (Eds). (2017) *Forensic Evidence Management: From the Crime Scene to the Courtroom*. Boca Raton, FL: CRC Press.

PFEFFERLI, P. (2015) *Forensic Evidence Field Guide: A Collection of Best Practices.* Amsterdam: Academic Press (Elsevier).

REIBER, L. (2019) *Mobile Forensic Investigations: A Guide to Evidence Collection, Analysis, and Presentation.* 2nd ed. New York: McGraw-Hill Education.

SUTTON, R., TRUEMAN, K., MORAN, C. (Eds). (2016) *Crime Scene Management: Scene Specific Methods.* 2nd ed. Chichester: Wiley-Blackwell.

WHITE, P. C. (Ed). (2016) C*rime Scene to Court: The Essentials of Forensic Science*. 4th ed. Cambridge: The Royal Society of Chemistry.

Web

forensicmag.com - *Forensic* magazine
(research)

Links

This unit links to the following related units:

Unit 21: Criminal Investigation

Unit 22: Theories and Causes of Crime

Unit 33: Analytical Techniques for Forensic Science

Unit 34: Forensic Evidence Collection and Preservation

Unit 66: Volume Crime Scene Science

Unit 67: Undertake Forensic Examinations at Scenes of Incidents

Unit 69: Manage Forensic Investigations at Scenes.

Essential requirements

Tutors should provide a range of case studies to aid learning and assessment.

Example case studies with evidence for presentation at a moot court is also an essential requirement, as are other relevant resources to ensure that the moot course is as realistic as possible.

Unit 69: Manage Forensic Investigations at Scenes

Unit code	**H/650/2665**
Unit type	**Specialist**
Unit level	**5**
Credit value	**15**

Introduction

This unit is designed to build on previous units on forensic investigation techniques. It is designed for students to learn to manage crime scenes and preserve the scenes for further examination. Students will need to gather information at scenes and contribute to investigative processes. This will include reviewing and defining scene parameters. Students will also be introduced to the matter of controlling and preserving scenes, and establishing scene boundaries. Students will also be introduced to the requirement of establishing and maintaining communication with relevant personnel. Students will learn preventative measures to protect scene boundaries, their importance and how to maintain them during examinations.

As well as theoretical knowledge, students will experience the practicalities of managing and preserving crime scenes. Students will learn the importance of maintaining health and safety, along with the integrity and continuity of forensic materials and its paramount importance. The stress in this unit is on the multidisciplinary nature of forensic investigations, how to assess crime scenes and how to both control and preserve scenes.

On successful completion of this unit, students will be better prepared to undertake a role as a crime scene investigator (CSI) as they will have an increased knowledge of crime scene management.

Learning Outcomes

By the end of this unit, students will be able to:

1. Investigate the appropriate methods of evidence collection, packing, storage and continuity in major crime scene investigations.
2. Demonstrate correct recovery of forensic evidence in a crime scene, following accredited processes.
3. Facilitate the submission of relevant forensic material for analysis by an expert for interpretation and processing.
4. Prepare a report to accompany the submission of forensic evidence for analysis by an external expert for interpretation and processing.

Essential Content

LO1 **Investigate the appropriate methods of evidence collection, packing, storage and continuity in major crime scene investigations.**

Procedures for evidence collection

Restriction of crime scene access

Observation and recording of the crime scene

Search patterns

Recovery of trace materials

Different types of packaging

Methods of storage that preserve integrity of the evidence

Chain of continuity

Route of evidence

Types of crime scene

Domestic burglary

Sexual assault

Homicide

Armed robbery

Arson

LO2 **Demonstrate correct recovery of forensic evidence in a crime scene, following accredited processes.**

Accreditation

ISO 17020 – International Organization for Standardization 'Requirements for the operation of various types of bodies performing inspection' – ISO standard for Crime Scene Investigators (CSI)

Techniques of recovery

Fingerprints

Footwear marks

Bodily fluids

Fire scene debris

Body recovery

Ballistic trace evidence

LO3 **Facilitate the submission of relevant forensic material for analysis by an expert for interpretation and processing.**

Interpretation of evidence types by experts

Firearms

Blood spatter patterns

Deceased in situ

Chemical evidence

Bodily fluids

Footwear marks

Fingerprints

Other types of evidence interpreted by experts, e.g. entomological, geological, gunshot residue etc.

LO4 **Prepare a report to accompany the submission of forensic evidence for analysis by an external expert for interpretation and processing.**

Reporting using appropriate proformas, e.g.

MG 21 Submission of Work for Scientific Examination

MG 22 A Initial Forensic Investigation/Examination Report

MG 22 B Streamlined Forensic Report (SFR1) Stage 1 Forensic Result Report

MG 22 C Streamlined Forensic Report (SFR2) Stage 2 Report Forensic Issues report

MG 22 D Streamlined Forensic Report (SFR) Crime Scene Investigation/Forensic Examination statement

Expert witness statements

Learning Outcomes and Assessment Criteria

Pass	Merit	Distinction
LO1 Investigate the appropriate methods of evidence collection, packing, storage and continuity in major crime scene investigations.		**LO1 and LO2**
P1 Investigate appropriate methods of evidence collection, packing, storage and continuity within major crime scene investigation.	**M1** Discuss appropriate methods of evidence collection, packing, storage and continuity in major crime scene investigation.	**D1** Justify appropriate methods of evidence collection, packing, storage and continuity in major crime scene investigation, following accredited processes.
LO2 Demonstrate correct recovery of forensic evidence in a crime scene, following accredited processes.		
P2 Demonstrate accredited methods of evidence collection, packing, storage and continuity within major crime scene investigation. **P3** Summarise relevant accredited processes for recovery of forensic evidence from a crime scene.	**M2** Explain relevant accredited processes for recovery of forensic evidence from a crime scene.	
LO3 Facilitate the submission of relevant forensic material for analysis by an expert for interpretation and processing.		**LO3 and LO4**
P4 Discuss types of evidence that are interpreted by experts.	**M3** Explain the value of interpretation of forensic material by experts.	**D3** Critically evaluate the accompanying report and submission of forensic evidence to an external expert for interpretation and processing.
LO4 Prepare a report to accompany the submission of forensic evidence for analysis by an external expert for interpretation and processing.		
P5 Prepare a competent report to accompany the submission of forensic evidence for analysis by an external expert for interpretation and processing.	**M4** Prepare a proficient report to accompany the submission of forensic evidence for analysis by an external expert for interpretation and processing	

Recommended Resources

Textbooks

BELL, S. (2019) *Forensic Science: An Introduction to Scientific and Investigative Techniques.* 5th ed. Boca Raton, FL: CRC Press.

FISHER, B. A. J., FISHER, D.R. (2022) *Techniques of Crime Scene Investigation (Forensic and Police Science Series)*. 9th ed. Boca Raton, FL: CRC Press.

HALD, C., TILSTONE, W. J. AND HASTRUP, M. L. (2019) *Fisher's techniques of crime scene investigation*. CRC Press.

HAMMER, L. (2019) *Footwear and Tire Track Evidence Collection Manual.* Boca Raton, FL: CRC Press.

JACKSON, A. R. W., JACKSON, J. M., MOUNTAIN, H., BREARLEY, D. (2016) *Forensic Science.* 4th ed. Harlow: Pearson Education Ltd.

LANGFORD, A. M., DEAN, J. R., HOLMES, D., REED, R., WEYERS, J., JONES, A. (2019) *Practical Skills in Forensic Science.* 3rd ed. Harlow: Pearson Education Ltd.

MOZAYANI, A., PARISH-FISHER, C. (Eds). (2017) *Forensic Evidence Management: From the Crime Scene to the Courtroom*. Boca Raton, FL: CRC Press.

PFEFFERLI, P. (2015) *Forensic Evidence Field Guide: A Collection of Best Practices.* Amsterdam: Academic Press (Elsevier).

REIBER, L. (2019) *Mobile Forensic Investigations: A Guide to Evidence Collection, Analysis, and Presentation.* 2nd ed. New York: McGraw-Hill Education.

SUTTON, R., TRUEMAN, K., MORAN, C. (Eds). (2016) *Crime Scene Management: Scene Specific Methods.* 2nd ed. Chichester: Wiley-Blackwell.

WALLACE, E. (2016) *Crime Scene Unit Management: A Path Forward.* London: Routledge.

WHITE, P. C. (Ed). (2016) *Crime Scene to Court: The Essentials of Forensic Science.* 4th ed. Cambridge: The Royal Society of Chemistry.

Web

forensicmag.com – *Forensic* magazine (research)

https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/891370/Manual-of-guidance-MG-forms-v11ext.pdf

https://www.gov.uk/government/publications/manual-of-guidance-and-mg-forms – *Manual of guidance and MG forms*

https://www.cps.gov.uk/legal-guidance/streamlined-forensic-reporting-guidance-and-toolkit – Streamlined forensic reporting guidance and toolkit

Links

This unit links to the following related units:

Unit 21: Criminal Investigation

Unit 22: Theories and Causes of Crime

Unit 33: Analytical Techniques for Forensic Science

Unit 34: Forensic Evidence Collection and Preservation

Unit 66: Volume Crime Scene Science

Unit 67: Undertake Forensic Examinations at Scenes of Incidents

Unit 68: Forensic Strategies for Serious and Complex Investigations.

Essential requirements

Tutors must facilitate learners to carry out evidence collection from a simulated crime scene for expert analysis.

Case studies and example expert reports will be necessary and useful teaching, learning and assessment.

Unit 70 Histology and Haematology

Unit code	**A/650/3373**
Unit type	**Specialist**
Unit level	**5**
Credit value	**15**

Introduction

Histopathology and haematology (like clinical chemistry and medical microbiology) are specialisms within laboratory medicine/pathology departments. The aim of this unit is to introduce the activities that take place within histopathology and haematology and with diagnoses that might by supported by these disciplines.

Histology is a study of cells and tissues. Histopathology relates the appearance of cells and tissues (histology) to diseases and disorders. It involves taking tissue samples/biopsies, cutting them very thinly and staining them so that important detail may be seen under the microscope. Comparisons may be made with healthy sections and this facilitates diagnosis of diseased tissue.

Haematology is part of the wider grouping of blood science. Whereas clinical chemistry may involve analysis of blood serum, separated from cells and other components by centrifugation, haematology is generally focused on whole blood or the cells and other suspended components.

By raising awareness of the scope of two specialisms, this unit is useful for those entering a career or further study in biomedical science. Students should, if possible, visit pathology laboratories where histology samples are prepared for review by specialist and where blood and suspended blood components are analysed. Students should carry out as much related practical work as possible.

Learning Outcomes

By the end of this unit, students will be able to:

1 Explore the preparation of histology samples

2 Investigate the use of histology samples in diagnosis of disorders and disease

3 Discuss the structure, function and disorders of the human blood and blood forming tissues

4 Undertake a range of laboratory investigations using haematological techniques.

Essential Content

LO1 Explore the preparation of histology samples

Tissue fixation:

Cellular changes prior to fixation; safe handling methods; fixing agents; contributory factors which affect fixation; cryo-preservation; common artefacts (e.g. from pre-fixation, fixation, bone, tissue-processing, microtomy, flotation, mounting, staining).

Decalcification:

Types of tissue requiring decalcification; benefits of decalcification.

Processing tissues:

Dehydration with ethanol; clearing (e.g. with xylene or alternative solvent); infiltration with wax; automation (e.g. use of cassettes and tissue-processing machines); embedding (e.g. use of mould, warm wax, orientation of the tissue sample, solidifying); tissue blocks.

Sectioning:

Safe use of microtomes; use of ice and water baths; trimming blocks; cutting sections; minimisation of scoring of sections with microtome blades; slide preparation (e.g. floating wax ribbons, picking them up on a slide, drying slides); decalcification.

Staining tissues:

Haematoxylin staining to highlight cell nuclei; different types of haematoxylin; eosin to highlight cytoplasm and other structures; haematoxylin and eosin (H&E) staining process; automation; checking for optimum staining; other specialist staining methods; cover-slipping of slides.

Quality of tissue slides:

Features of high-quality tissue slides: tissue that is properly sampled, fixed, processed, embedded, microtomed, and stained without artifacts. High quality slides will show the presence of features of diagnostic interest.

Factors contributing to the quality of slides: e.g. training; use of standard validated protocols; regular checking at each stage of the process (sampling, fixing, processing, embedding, microtoming and staining).

Labelling and storage of blocks and slides:

Appropriate conventions e.g. number of patient identifiers; issues caused by mislabelling of blocks and slides; examples of good practice.

Electron microscopy:

Aspects of methodology: e.g. glutaraldehyde fixative; osmium tetroxide for fatty acid stabilisation; acrylic or epoxy resin; semi thin section for orientation; ultra-microtome; ultra-thin sections; staining with a heavy metal salt; immunostaining using gold microspheres etc.

Immunohistochemistry and immunocytochemistry:

Principles of immunohistochemistry and immunocytochemistry: antigen retrieval; making cell membranes permeable to visualisation agents (immunocytochemistry); visualisation of proteins/antigens in cells; use of primary antibodies; binding to specific secondary antibodies containing a chromophore or fluorophore; use of a fluorescence microscope.

Scope of histopathology samples:

Tissue biopsy, screening, aspiration, skin tests for allergic reactions.

LO2 Investigate the use of histology samples in the diagnosis of disorders and disease

Types of microscope:

Principles of light microscopes (e.g., compound, dark ground, polarising, phase contrast, fluorescence); use of compound light microscope to examine prepared tissue specimens; limits of magnification and resolution.

Transmission electron microscope: principles, indications for use in diagnosis, interpretation of images.

Confocal microscopy (confocal laser scanning microscopy): principles, benefits, indications in diagnosis.

Photography:

Photo-microscopy, digital pathology and telepathology.

Aetiology, epidemiology and diagnosis of diseases affecting tissues in humans:

Identification of cell injury, adaptation and death.

Examples of diseases where histology may contribute to a diagnosis, e.g., liver disease, malignancies, thyroid disorders.

Autoimmune conditions e.g. multiple sclerosis, rheumatoid arthritis, lichen planus.

Quality assurance:

Quality assurance practices e.g. quality management system, second checking of reported results.

LO3 Discuss the structure, function and disorders of the human blood and blood forming tissues

Cellular structure and functions of the human blood:

Structure and functions of blood-forming organs (bone marrow, lymph nodes and spleen).

Components of the blood: red blood cells, white blood cells (neutrophils, lymphocytes, monocytes, eosinophils, basophils), plasma, platelets. Functions of components of blood.

Haematopoiesis in adults; factors regulating cell maturation and differentiation; synthesis and function of haemoglobin.

Haemostasis, thrombosis, clotting pathways.

Disorders:

Bleeding disorders: haemophilias, platelet and coagulation disorders. Use and monitoring of anticoagulant therapy.

Introduction to haematological malignancies: leukaemias, lymphomas, myelomas.

Inherited abnormalities of red cells; anaemias – acquired and inherited.

Examples of specific tests used to detect disorders:

Full and differential blood count; reticulocyte count; blood film; haemoglobin; abnormal haemoglobins; coagulation factors; platelet aggregation; partial thromboplastin time; fibrinogen etc.

Reference Ranges and Normal Values:

Tabulated values.

Effects of factors that may affect results e.g. circadian rhythms, age, exercise, smoking, alcohol and other substances of abuse.

Ambiguity of test results:

Examples of test results that may indicate several disorders/diseases or may be at the limit of the normal range.

Follow-up investigations that make diagnoses more specific.

Consequences of misdiagnoses.

Blood group serology:

ABO and Rh (rhesus) grouping and irregular antibodies (those not associated with the ABO and Rh systems).

Transfusion:

Blood transfusion: uses; principles of separation and storage of blood products; quality control/assurance procedures for blood products including screening for specific diseases e.g. human immunodeficiency virus (HIV).

LO4 Undertake a range of laboratory investigations using haematological techniques

It is recommended that human blood is not used except in fixed slides. Samples can be modified to simulate disorders.

Microscopic observation of blood disorders:

Full blood count (FBC)/complete blood count (CBC).

Spectrophotometric estimation of haemoglobin.

Preparation, staining and microscopic examination of blood films.

Erythrocyte counting using a haemocytometer or Neubauer counting chamber.

Examples of tests:

Epstein-Barr Virus (EBV) test.

Blood group serology based on detection of antibody/antigen reactions (Ab/Ag reactions) (agglutination reactions).

Quality of haematology tests:

Quality defined in relation to closeness to the true value, repeatability and reproducibility.

Differences between testing carried out at the centre and within a clinical laboratory:

For example: types of sample that may be analysed, comparison of equipment; use of automation, labelling and documentation.

Learning Outcomes and Assessment Criteria

Pass	Merit	Distinction
LO1 Explore the preparation of histology samples		
P1 Analyse the processes involved in preparing tissue slides for specialist review **P2** Report on how tissue blocks and slides are stored, labelled and made traceable in relation to patient identity	**M1** Discuss artefacts that may affect the quality of prepared tissue slides	LO1 and LO2 **D1** Critically evaluate the processes involved in preparing high quality tissue slides used in the diagnosis of a range of disorders and disease
LO2 Investigate the use of histology samples in the diagnosis of disorders and disease		
P3 Analyse the features of microscopes used to study tissue slides **P4** Investigate features of tissue slides indicative of the presence of disorders or disease	**M2** Discuss different types of diagnoses that are supported by analysis of histology samples	
LO3 Discuss the structure, function and disorders of human blood and blood forming tissues		
P5 Analyse the structure and function of the main components of blood and blood forming tissues **P6** Illustrate how different diseases affect the composition of blood	**M3** Discuss in detail how disorders alter the normal structure, ranges and functions of selected blood components	LO3 and LO4 **D2** Critically analyse the diagnostic significance of laboratory investigations of haematological samples in order to detect or rule out disorders of the blood
LO4 Undertake a range of laboratory investigations using haematological techniques		
P7 Undertake practical diagnostic investigations on samples of blood in order to detect or rule out diseases or disorders of the blood **P8** Report on the diagnostic investigations including results and conclusions	**M4** Evaluate the quality of the laboratory investigations undertaken	

Recommended Resources

Textbooks

BAIN, B.J. (2020). *Haematology: A Core Curriculum* 2nd Ed. London: World Scientific Publishing Europe Ltd.

BAIN, B.J., Bates, I., Laffan, M.A. (2017). *Dacie and Lewis Practical Haematology* 12th Ed. London: Elsevier

GARTNER, L.P. (2021). *Textbook of Histology* 5th ed. Philadelphia: Elsevier

KIERSZENBAUM, A.L., Tres, L.L. (2019). *Histology and Cell Biology: An Introduction to Pathology* 5th ed. Philadelphia: Elsevier

LOTT, R., TUNNICLIFFE, J., SHEPPARD, E., SANTIAGO, J., HLADIK, C., NASIM, M., ZEITNER, K., HAAS, T., KOHL, S., MOVAHEDI-LANKARANI, S. (2020). *Practical Guide to Specimen Handling in Surgical Pathology* Version 9. Northfield: College of American Pathologists

MCKENZIE, S.B., WILLIAMS, J.L. (2016). *Clinical Laboratory Hematology*. 3rd ed. Harlow, Essex: Pearson

MESCHER, A.L. (2021) *Junqueira's Basic Histology: Text and Atlas*, 16th ed. New York: McGraw Hill.

NAKHEY, R.E,. VOLMAR, K.E. (Eds.) (2019). *Error Reduction and Prevention in Surgical Pathology*. 2nd ed. Cham: Springer.

NAYAK, R. (2017). *Histology Techniques and Its Management*. New Delhi: Jaypee Brothers Medical Publishers (P) Ltd.

O'DOWD, G., BELL, S., WRIGHT, S. (2020). *Wheater's Pathology: A Text, Atlas and Review of Histpathology E-Book*: With STUDENT CONSULT Online Access 6th ed. Edinburgh: Elsevier

ORCHARD, G., NATION, B., (Editors) (2017). *Histopathology (Fundamentals of Biomedical Science)*. Oxford: Oxford University Press

OVALLE, W.K., NAHIRNEY, P.C. (2020). *Netter's Essential Histology*: With Correlated Histopathology (Netter Basic Science) 3rd ed. Philadelphia: Elsevier

Journal articles

MORELLI, P, PORAZZI, E., RUSPINI, M., RUSTELLI, U., BANFI, G. (2013). Analysis of errors in histology by root cause analysis: a pilot study. J. Prev. Med. Hyg. 54, 90-96.

TAQI, S.A,, SAMI, S.A., SUNU, L.B., ZAKI, S.A. (2018): A review of artifacts in histopathology.

Journal of oral and Maxillofacial Pathology. 22 (2) 279

YAEL,K.H., YIGU, C., PYATIBRAT, S., YOON, E., GOLDSMITH, J.D., SANDS, K.E. (2016). Achieving High Reliability in Histology. An Improvement Series to Reduce Errors. Am. J. Clin. Pathol. 146, 554-560.

Websites

cap.org	College of American Pathologists
frontierspartnerships.org/journals/british-journal-of-biomedical-science	*British Journal of Medical Science - o*pen access journal
ibms.org	Institute of Biomedical Science
labtestsonline.org.uk	Lab Tests Online UK Patient-centred information about tests used in laboratory medicine
pch-pathlab.com/cms/?q=specimen-labelling	North West Anglia NHS Foundation Trust Pathology Services Example of guidance on labelling specimens

Links

This unit links to the following related units:

Unit 4: Cell Biology

Unit 6: Anatomy and Human Physiology

Unit 17: Fundamentals of Biochemistry

Unit 29: Biochemistry of Macromolecules and Metabolic Pathways

Unit 51: Specialists Scientific Techniques and Experimentation

Unit 71: Medical Microbiology

Unit 72: Clinical Chemistry

Essential Requirements

Students should have access to a well-equipped laboratory. This should include compound microscopes, haemocytometers, graticule eyepieces with a calibration slide and prepared tissue slides of healthy and diseased tissues. Recorded electronic images of tissue would be a useful resource.

Delivery

Tutors should establish links with a medical pathology laboratory or veterinary pathology laboratory. It is important for students to see techniques (e.g. tissue fixing, processing, embedding, cutting, staining, slide preparation, centrifugation of blood samples, blood counts, blood smears) being carried out in working laboratories. There are also many online videos showing key aspects of techniques. Students could have the opportunity to carry out some of the tissue slide preparation techniques on the bench (e.g. with meat/offal).

Students should carry out haematology testing of permitted blood samples or simulated samples. The use of human blood (except fixed slide specimens) is not recommended. Students should assess factors affecting the accuracy of their results and their repeatability and reproducibility in comparison with the results that would be obtained by trained technicians, some parts of whose processes may be automated.

Assessment

Assignment briefs should address all criteria for one or more learning outcomes in as holistic a way as possible. LO1 and LO2 must be assessed together because of the shared distinction criterion. LO3 and LO4 must be assessed together for the same reason. Whole unit assignment briefs are acceptable, providing they meet the needs of the students. The assignment briefs and tasks should be aimed at distinction level students and should allow students to achieve at pass, merit or distinction level.

LO1 is looking at the student's knowledge and understanding of the processes involved in preparing and storing tissue slides in a diagnostic context. It will be useful for students to consider practice in a working laboratory in order to fully appreciate the advantages of using standard protocols and the issues with some of the systems used. Students should be able to analyse the processes in terms of what is happening at each stage and the underpinning science. Merit level students should be able to discuss specific factors that are important in ensuring that the slides are of high quality in addition to the pass level requirement to understand the procedures used to prepare and store tissue blocks and slides.

LO2 is focused on the value of histology slides to the diagnosis of disease. In addition to the pass level requirements of analysing different histology microscopic techniques and specific features of slides used to diagnose specific diseases (at least two), merit level students will be able to demonstrate the breadth of the diagnostic power of histology by discussing diagnostic features for several different types of tissue and/or disease.

For LO1 and LO2 Distinction level students will be able to evaluate the features of the systems that allow good quality slides and blocks to be prepared, stored and retrieved from storage so that specialists may make and report diagnostic judgements that are then reported to appropriate clinicians. Students should consider whether there is scope for improvements to procedures, instrumentation, storage or training as part of the evaluation. Students will be able to provide a detailed overview of a range of diagnoses of specific diseases and show understanding of whether reliable diagnoses would be possible by other means. They will demonstrate detailed understanding of the diagnostic features of the diseased tissue and whether improved microscopy would be of significant benefit.

For LO3, pass level students will be able to use a range of information sources to support descriptions of the structure and function of blood components and the origin of the components in the blood-forming tissues. They will be able to use examples to explain the differences in blood composition caused by at least two different disorders and how tests may be used to detect the diseases. Merit level learners will be able discuss the changes caused by the disorders, and why specific tests provide information about disease and the extent to which the tests results are unambiguous.

LO4 requires learners to carry out and report on at least two laboratory investigations used in haematology. Pass level learners will document investigations that they have carried out and they may need to be directed to appropriate methods. Merit level learners will evaluate the quality of the techniques used.

For LO3 and LO4, distinction level students will provide critical analysis of their choices of investigations and the quality of their work. They will justify whether additional investigations are needed to ensure that diagnoses are correct. Students could also consider investigations, routinely undertaken in the clinical setting, that they may not be able to perform themselves in the course of the unit.

Employer Engagement and Vocational Contexts

A work experience placement in a medical laboratory would provide an excellent opportunity to learn about histopathology and haematology. Specialist biomedical scientists, technicians and pathologists could provide explanation of how the subjects are used in a diagnostic setting.

Unit 71: Medical Microbiology

Unit code	**D/650/3374**
Unit type	**Specialist**
Unit level	**4**
Credit value	**15**

Introduction

This unit prepares students for further study in microbiology and makes them familiar with aseptic technique, which facilitates them working in a microbiology laboratory.

Th unit introduces students to a range of practical microbiology techniques in the context of medical microbiology. Practical work should generally involve Risk Group 1 (RG1) bacteria, unless the centre has access to Risk Group 2 facilities and the students have had sufficient safety training.

Students will investigate different types of pathogenic microorganisms. They will research appropriate collection of patient samples and how bacteria are isolated and identified. Isolation and identification of bacteria should be carried out with Group 1 bacteria. Students should explore antibiotic sensitivity both practically and through research.

Suggested reference material contains details of how to carry out practical techniques and also provides information about pathogens, disease and how pathogens may be controlled.

Learning Outcomes

By the end of this unit, students will be able to:

1 Investigate characteristics of a range of microbiological pathogenic agents.

2 Research appropriate methods for the collection of medical samples.

3 Explore methods for the isolation and identification of bacteria.

4 Demonstrate how diseases of bacterial or viral origin may be treated.

Essential Content

LO1 **Investigate characteristics of a range of microbiological pathogenic agents**

Taxonomy of microorganisms:

Groups of microorganisms: algae, protozoa, slime moulds, fungi, bacteria, archaea, viruses.

Features of selected pathogenic microorganisms:

Fungi: main structural features of named pathogenic fungi, e.g. *Tinea*, *Candida*; methods for their isolation.

Bacteria: structure and shape of bacterial cells; differences between Gram-positive and Gram-negative bacteria; normal flora of gut and skin; intracellular bacteria (chlamydia and rickettsia). Growth curves, nutrient requirements, outline of pathogenic mechanisms for selected diseases, concepts of infectivity and virulence.

Viruses:

Nature and composition; techniques for the isolation and identification of viruses; molecular and serological tests, including role of polymerase chain reaction (PCR); outline of pathogenic mechanisms for selected diseases.

Other pathogens:

Isolation and identification of pathogens likely to be encountered in the medical microbiology laboratory; parasitic diseases.

LO2 **Research appropriate methods for the collection of medical samples**

Types of specimens:

For example: blood; urine; faeces; skin samples; sputum; biopsies.

Collection of specimens:

Safety precautions. protocols, training, personal protective equipment (PPE).

Collection method; type and design of container; preservative; avoidance of cross-contamination; method of transport; temperature; labelling of samples; receipt of sample in the laboratory.

Risk groups of pathogenic organisms:

Risk groups and associated laboratory safety classes and area of work (e.g. open bench for Risk Group 1 and class 2 biosafety cabinet for Risk Group 2)

- RG1, e.g. *Escherichia coli* K-12, *Saccharomyces cerevisiae* (yeast), *Lactobacillus*, *Bacillus subtilis*
- RG2, e.g. *Streptococcus*, *Legionella*, herpesvirus, most mammalian cell lines
- RG3, e.g. *Yersinia pestis* (black plague), HIV (human immunodeficiency viruses), SARS (severe acute respiratory syndrome) viruses
- RG4, e.g. *Ebolavirus*, *Marburgvirus*, Lassa virus.

LO3 **Explore methods for the isolation and identification of bacteria**

Isolation of bacteria:

PPE; use of appropriate bench or safety cabinet; disinfection; autoclaving of waste; aseptic technique; specialist equipment; serial dilution; correct labelling of plates; use of lawn and streak plates to isolate colonies; choice of organisms (reflecting the working area, which will generally be Group 1 for students); additional safety required for organisms in other groups.

Isolation:

Preparation of specimens; growth conditions; microscopy; aseptic techniques; possible use of soil as a matrix for practical exercises instead of a human specimen.

Primary identification:

Colony 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 on selection of media; pros and cons of making and sterilisation of media and pouring plates compared with buying pre-prepared plates.

Practical work to identify bacteria:

Identify examples of Risk Group 1 bacteria.

Identification of other medically important bacteria:

Taxonomic classification; Gram-positive and Gram-negative, cocci, bacilli; other bacteria, e.g. Spirochaetales, *Chlamydiaceae*, *Mycoplasmataceae*, *Rickettsiaceae*; diseases caused; use of identification charts.

Testing systems:

Biochemical; serological; coagulase; deoxyribonucleic acid (DNA)-based test (rapid diagnosis) for classification; influence of the nature of the sample; clinical findings.

Test kits:

Biochemical tests, e.g. Analytical Profile Index (API) 20E (fast identification system involving micro test tube reactions); serological test, e.g. streptococcal grouping kit; Clostridium difficile kit.

LO4 **Demonstrate how diseases of bacterial or viral origin may be treated**

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.

Modes of action and clinical indications for antibiotics:

For example: aminoglycosides; tetracyclines; sulphonamides; trimethoprim; rifampicin etc.

Mode of action and clinical indications for anti-viral drugs:

For example, for

- respiratory viruses (e.g. oseltamivir, zanamivir, amantadine, rimantadine)
- SARS-CoV-2 (severe acute respiratory syndrome coronavirus 2, the virus causing the disease COVID-19), (antivirals, e.g. nirmatrelvir, ritonavir, molnupiravir; remdesivir; monoclonal antibodies, e.g. sotrovimab)
- HIV (e.g. nucleoside reverse transcriptase inhibitors (NRTIs); non-nucleoside reverse transcriptase inhibitors (NNRTIs); protease inhibitors (PIs); entry inhibitors; integrase inhibitors; drug combinations)
- herpes simplex viruses, types 1 and 2 (HSV-1 and HSV-2) (e.g. acyclovir, famciclovir, valacyclovir).

Antibiotic and antiviral drug-resistance:

Examples of resistance to antibiotic and antiviral drugs; mechanisms of resistance; approaches to combatting drug-resistance.

Learning Outcomes and Assessment Criteria

Pass	Merit	Distinction
LO1 Investigate characteristics of a range of microbiological pathogenic agents		**LO1 and LO2** **D1** Discuss in depth the choice of collection methods for samples of pathogenic microbial agents from patients.
P1 Describe the features of different pathogenic bacteria. **P2** Characterise the features and isolation of other pathogenic organisms.	**M1** Explain the differences between Gram-positive and Gram-negative pathogenic bacteria.	
LO2 Research appropriate methods for the collection of medical samples		
P3 Investigate risk control measures involved in the safe collection of samples from patients. **P4** Describe ways in which different types of sample are collected, labelled and transported.	**M2** Justify appropriate collection methods used to collect samples from patients.	

Pass	Merit	Distinction
LO3 Explore methods for the isolation and identification of bacteria		
P5 Explain the principles of the techniques used in the isolation and identification of bacteria.	**M3** Justify the procedures you have used in the laboratory for isolating and identifying bacteria.	**LO3 and LO4** **D2** Critically evaluate the laboratory skills you have used to determine effective treatment of diseases caused by bacteria or viruses.
P6 Demonstrate safe isolation and identification of bacteria in the laboratory.		
LO4 Demonstrate how diseases of bacterial and viral origin may be treated		
P7 Apply safe techniques to carry out a practical investigation of antibiotic or antiviral sensitivity.	**M4** Explain the factors that influence antibiotic and antiviral sensitivity.	
P8 Describe how the minimum inhibitory concentration of an antibiotic may be determined.		
P9 Discuss the modes of action of antibiotics and antiviral drugs.		

Recommended Resources

Textbooks

BARER, M. R., IRVING, W., SWANN, A., PERERA, N. (Editors) (2019). *Medical Microbiology: A Guide to Microbial Infections: Pathogenisis, Immunity, Investigation and Control*. 19th Ed. London: Elsevier.

BARROW, G. I., FELTHAM, R. K. A. (Editors) (2004). *Cowan and Steel's Manual for the Identification of Medical Bacteria*. 3rd Ed. Cambridge: Cambridge University Press.

CAPPUCCINO, J. G., WELSH, C. (2020). *Microbiology: A Laboratory Manual*. 12th ed. Harlow: Pearson.

FORD, M. (Editor) (2019). *Medical Microbiology (Fundamentals of Biomedical Science)*. 3rd Ed. Oxford: Oxford University Press.

TORTORA, G. J, FUNKE, B. R., CASE, C. L., WEDDER, D., BAIR, W. (2021). *Microbiology: An Introduction*. [Global Edition] 13th ed. Harlow: Pearson.

GILLESPIE, S. H., BAMFORD, K. B. (2022). *Medical Microbiology and Infection at a Glance*. 5th Ed. Chichester: Wiley-Blackwell.

MADIGAN, M. T., BENDER, K. S., BUCKLEY, D. H., SATTLEY, W. M., STAHL, D. A. (2021). *Brock Biology of Microorganisms*. [Global Edition] 16th ed. Harlow: Pearson.

MURRAY, P. R, ROSENTHAL, K. S., PFALLER, M. A. (2020). *Medical Microbiology*. 9th ed. Philadelphia: Elsevier.

PITT, T. L. and BARER, M. R. (2012) Classification, identification and typing of micro-organisms, in Greenwood, D., Barer, M. R., Slack, R. and Irving, W. (eds.) *Medical Microbiology*. 18th ed. Edinburgh: Churchill Livingston, pp. 24–38.

Riedel, S., Morse, S. A., Mietzner, T., Miller, S. (Editors) (2019). *Jawetz, Melnick & Adelberg's Medical Microbiology*. 28th ed. New York: McGraw Hill.

Sastry, S. A., Bhat, S. (2020). *Essentials of Practical Microbiology*. 2nd ed. New Delhi: Jaypee Brothers Medical Publishers (P) Ltd.

Journal article

Giuliano, C., Patel, C. R., Kale-Pradhan, P. B. (2019). A Guide to Bacterial Culture Identification and Results Interpretation. Pharmacy and Therapeutics, 44 (4), 192–200

Other

Public Health England. (2021). UK Standards for *Microbiology Investigations: Introduction to the preliminary identification of medically important bacteria and fungi from culture*. London: Standards Unit Public Health England.

Web

frontierspartnerships.org/journals/british-journal-of-biomedical-science	*British Journal of Biomedical Science* – open access journal.
futurelearn.com/info/courses/introduction-to-microbiology/0/steps/51420	Practical demonstration of making lawn plates and streak plates from a soil sample and making a stained slide that allows the bacterium to be identified.
ibms.org	Institute of Biomedical Science
leedsth.nhs.uk/a-z-of-services/pathology/microbiology-2/sample-requirements-and-advice/	The Leeds Teaching Hospitals NHS Trust: useful practical guidance on patient samples.
microbiologysociety.org	Microbiology Society

Links

This unit links to the following related units:

Unit 70: Histology and Haematology

Unit 72: Clinical Chemistry.

Essential requirements

Students should have access to a well-equipped laboratory suitable for carrying out microbiology (for example with sealed bench tops). Tutors and technicians should be suitably trained in microbiological techniques.

During laboratory practice, care will be needed to prevent the release of antibiotics or potentially antibiotic-resistant organisms. Appropriate risk assessments should be carried out before any practical work takes place.

Delivery

This unit should include a high proportion of practical work. It will be useful for students to visit a working microbiology laboratory, even if it is not a medical laboratory.

Assessment

Assignment briefs should be designed to be as holistic as possible and should cover all the criteria (Pass, Merit and Distinction).

Employer engagement and vocational contexts

It is recommended that centres make links with local organisations that carry out clinical chemical analysis on patient samples.

Tutors should ensure that the laboratories they link with provide students with sufficient experience in current practice.

Unit 72: Clinical Chemistry

Unit code	**F/650/3375**
Unit type	**Specialist**
Unit level	**5**
Credit value	**15**

Introduction

Clinical chemistry is the chemical analysis that is undertaken in order to diagnose and monitor treatment of pathological conditions. Other terms are used for ‘clinical chemistry’, including ‘clinical biochemistry’, ‘medicinal biochemistry’, ‘chemical pathology’, ‘pathological biochemistry’ and ‘biochemical medicine’. Clinical chemistry provides information about levels of chemical species that are involved in biochemical pathways in the body and which may provide an indication of potential diseases or disorders. It is a tool for diagnosis and for monitoring progress of treatments.

To make this unit as relevant as possible to students, a case study approach may be used. Students should be encouraged to take advantage of links with local organisations where clinical chemistry takes place (such as a local hospital). They should be enabled to investigate the clinical chemistry that takes place there and to find out about diagnoses of medical conditions of interest to them while investigating how the quality assures the results that it produces.

Students should be given the opportunity to carry out practical work on (potentially simulated) serum and urine. They should assess how reliable the results are, how they compare with guide ranges of values for a healthy individual and what the clinical implications are for the patient whose sample was analysed.

This unit gives students an insight into the work of a clinical chemistry laboratory and prepares them for further study in this area.

Learning Outcomes

By the end of this unit, students will be able to:

1 Investigate how biochemical markers may provide information about specific pathologies.

2 Explore processes used in clinical chemistry.

3 Review the scope and principles of analytical techniques used in clinical chemistry.

4 Carry out a range of clinical chemistry analyses.

Essential Content

LO1 **Investigate how biochemical markers may provide information about specific pathologies**

Examples of disorders, conditions and activities, for which biochemical analyses are commonly used, e.g.:

- kidney disease
- fluid and electrolyte disorders
- acid-base disorders
- thyroid disease
- diabetes mellitus and hypoglycaemia
- heart disease
- liver disease.

Examples of biochemical analyses – determination of:

- urine albumin and creatinine to detect kidney problems
- thyroid stimulating hormone (TSH); free thyroxine (T4) free triiodothyronine (T3)
- glucose and HbA1c (in relation to diabetes)
- troponin (by immunoassay) in the event of a heart attack
- liver function tests (enzymes (alanine aminotransferase, alkaline phosphatase, aspartate aminotransferase, gamma-glutamyltransferase (GGT), L-lactate dehydrogenase (LD)), bilirubin and protein).

Types of samples:

Serum; plasma; urine; others (e.g. sputum, gastric fluid, semen).

Reference values:

Normal ranges for biochemical analytes; differences in normal ranges (related to, e.g., age, gender, race).

Clinical factors affecting results:

Specific clinical factors affecting measured concentrations of analytes in relation to conditions and disorders/diseases.

LO2 **Explore processes used in clinical chemistry**

Processes involved in quality assurance:

Use of standard procedures/protocols.

Validation of analytical methods.

Staff training, refresher training and ongoing professional development; maintenance and calibration of equipment.

Checking results, investigation of unexpected results, interpretation of results.

Factors involved in the collection, reception and preparation of samples:

Collection of sample; sample tubes; role of the phlebotomist; information accompanying samples; preservatives.

Transport of sample.

Sample reception process at the laboratory; labelling and barcoding.

Sample preparation: centrifugation of blood samples; addition of substances prior to analysis; courses of action where sample tubes are damaged, or samples have deteriorated.

Considerations in relation to data protection and health, safety and environmental legislation:

Confidentiality of patient information.

Data security and information protection.

Health and safety rules, legislation and compliance procedures, e.g.

- manual handling
- hazardous substances
- display screen equipment
- risk assessment
- safety cabinets and extraction
- personal protective equipment (PPE)
- environmental legislation including segregation and disposal of waste and reagents, and energy efficiency.

Quality assurance standards:

Quality manuals; quality systems; internal and external audit; accreditation to International Organization for Standardization (ISO) standards, e.g., ISO 15189; monitoring efficiency; analysis and response to customer complaints.

LO3 **Review the scope and principles of analytical techniques used in clinical chemistry**

Analytical techniques – principles, mechanisms of function and techniques:

Choice of examples, reflecting different types of analysis being carried out in a local medical laboratory.

Underlying principles that ensure accuracy of the techniques utilised

- spectroscopy: ultraviolet-visible spectrophotometry, infrared spectroscopy, inductively coupled plasma (ICP) techniques, X-ray diffraction
- chromatography: thin layer chromatography, high performance liquid chromatography (HPLC), gas chromatography (GC)
- titration and auto-titrators
- electrochemistry: ion-selective electrodes, electro oxidative/reductive techniques, electrophoresis
- immunoassay and test kits.

Aspects of automation:

For example

- large automatic analysers
- preparation of large volumes of reagents
- use of bar-codes
- correct loading of auto-samplers
- use of control samples and blanks
- robot testing
- pneumatics
- multichannel pipettes
- fitting/removing caps
- sorting tubes
- tube carriers
- labelling
- robotic sample preparation
- pod-system for delivery of samples
- track systems to take bar-coded samples where they need to go.

Innovative analytical approaches:

For example

- automation of part(s) of the process
- changing the technique to one that gives results of the required quality faster
- re-organising workflow
- changing the storage of consumables to reduce time spent collecting them
- 5S approach (sort, set in order, shine, standardise and sustain)
- replacing a material with a cheaper one
- changing responsibilities.

Benefits of innovation, e.g.:

- greater accuracy
- greater precision
- greater reproducibility
- cheaper analysis
- quicker analysis
- using less material
- providing information in a more useful format for clinical customer.

LO4 **Carry out a range of clinical chemistry analyses**

Origin of samples:

Simulated samples or permitted real samples of serum or urine.

Tests and techniques:

For example

- albumin analysis (e.g. visible spectroscopy methods involving dye-binding, biuret, Lowry or electrophoretic method)
- measurement of sodium and potassium using ion-selective electrodes or flame photometry
- hydrogen carbonate (bicarbonate) determination using ion-selective electrode or titration
- glucose analysis using oxidase with quantification by visible spectrophotometry.

Interpretation of each analysis:

Assessment of accuracy/precision/repeatability/reproducibility/validity.

Comparison with normal values.

Clinical implications of the result.

Learning Outcomes and Assessment Criteria

Pass	Merit	Distinction
LO1 Investigate how biochemical markers may provide information about specific pathologies		
P1 Discuss a minimum of three pathologies for which biochemical analysis may support diagnosis. **P2** Investigate specific types of biochemical marker analyses used in diagnosis or monitoring the treatment of pathologies.	**M1** Assess the factors that may affect levels of analytes in relation to normal ranges.	**LO1 and LO2** **D1** Critically evaluate how accreditation-compliant clinical chemistry processes facilitate timely and effective diagnosis, treatment.
LO2 Explore processes used in clinical chemistry		
P3 Explore the processes that ensure that the correct results are reported to the person requesting testing. **P4** Discuss sample collection, reception and preparation processes. **P5** Investigate how compliance with data protection and health, safety and environmental legislation is ensured.	**M2** Evaluate the quality assurance measures involved in supplying valid, accurate analytical data.	

Pass	Merit	Distinction
LO3 Review the scope and principles of analytical techniques used in clinical chemistry		**D2** Critically evaluate the range and efficiency of analyses provided by a specific organisation in relation to clinical requirements.
P6 Discuss the types of clinical chemistry analyses provided by a specific organisation.	**M3** Analyse innovation in specific analytical processes.	
P7 Review the principles underpinning two types of analysis undertaken at the organisation.		
P8 Illustrate how automation is used in a specific analytical process.		
LO4 Carry out a range of clinical chemistry analyses		**D3** Critically analyse the clinical implications of the results of the analyses undertaken.
P9 Carry out three types of clinical chemistry analysis.	**M4** Evaluate the accuracy, precision and validity of results obtained.	
P10 Report on the analyses carried out and the underpinning scientific principles.		

Recommended Resources

Textbooks

AHMED, N. (2016) (Editor). *Clinical Biochemistry (Fundamentals of Biomedical Science)*, 2nd ed. Oxford: Oxford University Press.

CLARKE, W., MARZINKE, M. (Editors) (2020). *Contemporary Practice in Clinical Chemistry*, 4th ed. Oxford: Academic Press.

MARSHALL, W. J., LAPSLEY, M., DAY, A., SHIPMAN, K. (2020). *Clinical Chemistry*, 9th ed. St Louis: Elsevier.

MURPHY, M., SHRIVASTAVA, R., DEANS, K. (2019): *Clinical Biochemistry*, 6th ed. Edinburgh: Elsevier.

RIFAI, N., HORVATH, A. R., WITWERR, C. T. (Editors) (2019). *Tietz Fundamentals of Clinical Chemistry and Molecular Diagnostics*, 8th ed. St Louis: Elsevier.

UPSTONE, S. I. (2022). Ultraviolet/Visible Light Absorption Spectrophotometry and Fluorescence Spectroscopy in Clinical Chemistry. In E*ncyclopaedia of Analytical Chemistry*, Meyers, R. A. (Editor). Chichester: John Wiley & Sons Ltd.

WHITE, D., LAWSON, N., MASTERS, P., MCLAUGHLIN, D. (2017): *Clinical Chemistry*, Abingdon: Garland Science (Taylor Francis Group).

Journal articles

Bertholf, R. L. (2014) 'Proteins and Albumin', *Laboratory Medicine*, 45(1), pp. e25-e41.

Finlayson, D., Rinaldi, C., Is Infrared Spectroscopy Ready for the Clinic*?*

Baker, M. J. (2019). *Analytical Chemistry*, 91, 12117–12128.

Seger, C., Salzmann, L. (2020). After another decade: LC-MS/MS became routine in clinical diagnostics. *Clinical Biochemistry*, 82, 2–11.

Tahmasebi, H., Travcevski, K., Higgins, V., Adeli, K. (2018): Influence of Ethnicity on Population Reference Values for Biochemical Markers, *Crit. Rev. Clin. Lab. Sci., 55 (5) 359–375*.

Other

Fuggle, S. (2020) *Clinical Biochemistry Reference Ranges Handbook* [clinical handbook], East Sussex: East Sussex Healthcare NHS Trust. Available at: https://www.esht.nhs.uk/wp-content/uploads/2017/08/Clinical-Biochemistry-reference-ranges-handbook.pdf.

Web

frontierspartnerships.org/journals/british-journal-of-biomedical-science	British Journal of Biomedical Science The official journal of the Institute of Biomedical Sciences
jmhsci.org	*British Journal of Medical & Health Sciences* Open access journal
labtestsonline.org.uk	The Association for Clinical Biochemistry & Laboratory Medicine A patient guide to understanding laboratory tests
nhs.uk/conditions	National Health Service A-Z guide of health

Links

This unit links to the following related units:

Unit 70: Histology and Haematology

Unit 71: Medical Microbiology.

Essential requirements

This unit is based on practice in one or more clinical chemistry laboratories and it would be ideal if students were able to undertake placements in clinical chemistry laboratories.

Students must have access to a suitable well-equipped laboratory. Practical work undertaken by students at the centre should be as similar as possible to analyses carried out in clinical chemistry laboratories.

Delivery

Delivery should be as relevant as possible to students' own context. Making use of links with local organisations and professionals delivering clinical chemistry testing will help students to learn first-hand how the testing is carried out.

Ideally, students should observe several techniques and tests being carried out in a local organisation.

Assessment

Assignment briefs should be designed to be as holistic as possible and should cover all the criteria (Pass, Merit and Distinction).

Employer engagement and vocational contexts

It is recommended that centres make links with local organisations that carry out clinical chemical analysis on patient samples.

Tutors should ensure that the laboratories they link with provide students with sufficient experience in current practice.

Unit 73: Environmental Pollutants and Water Testing

Unit code: D/650/4391

Unit level: 4

Credit value: 15

Introduction

This unit provides an introduction to analysis carried out in the context of protecting the environment. A study of sources, effects and analysis of pollutants will be made. A case study approach will be used to limit the scope of the study so that various aspects may be explored in depth.

Students will focus on at least one significant industrial or agricultural process local to them or of interest to them. (It is recommended that, although assessment is based on one process, other processes are investigated during delivery.) The nature and operation of the process will be researched in detail. Specific potential pollutants associated with the process will be identified and their effect on people and the environment analysed. Students will find out how the environmental impact of the process is controlled by legislation, best practice guidance and regulatory agencies. The role of the organisation operating the process in minimising discharges and emissions of pollutants will be explored. Pollutant levels are likely to be measured or monitored by the organisations generating the pollutants and by regulatory agencies. Students will research the analytical techniques used industrially and use techniques in the centre's laboratory to analyse water samples for typical pollutants.

This unit will provide students with a framework for researching the control of environmental pollution and carrying out environmental analysis. It will give students a foundation on which to build further environmental study.

Learning Outcomes

By the end of this unit a student will be able to:

1. Explore the potential environmental harm associated with pollutants from an industrial or agricultural process
2. Investigate how an industrial or agricultural process is regulated
3. Explore monitoring of pollutants from an industrial or agricultural process
4. Carry out analysis of water pollutants.

Essential Content

LO1 Explore the potential environmental harm associated with pollutants from an industrial or agricultural process

Industrial processes

For example: operating an industrial boiler, effluent treatment, distillation, particle board manufacture, paper manufacture, manufacture of nuclear fuel, incineration of waste, cement manufacture, glass manufacture, coatings manufacture and application, acrylamide manufacture, flexible cellulose film manufacture, steel manufacture.

Point sources, e.g., stacks, ducts and pipes.

Diffuse sources, e.g., run-off from roads.

Industrial pollutants

For example: oxides of nitrogen, oxides of sulphur, oxides of carbon, ammonia, excess acidity or alkalinity, suspended solids, hydrogen cyanide, particulates, dioxins, d-block and p-block metal compounds, carbon disulphide, radioactive isotopes.

Agricultural processes

For example: growing crops (may include slurry storage and spreading, application of fertiliser), keeping animals and poultry (may include use and storage of silage, application of pesticides or herbicides, use of sheep dip), dairy operations, fish farming (may include pesticides).

Point sources, e.g., drainage ditches.

Diffuse sources of pollution, e.g., run-off from fields.

Agricultural pollutants

Specific pollutants associated with specific processes, e.g., nitrates, phosphates, silage liquor, milk, rodenticides, insecticides, sheep dip, oxides of nitrogen, ammonia, methane and non-methane volatile organic compounds (NMVOCs).

Environmental impacts of pollutants

Specific effects associated with specific pollutants, e.g., acid rain, ozone depletion, global warming, eutrophication, high chemical oxygen demand, blocking light and preventing photosynthesis, contaminated land, bioaccumulation of pollutants, respiratory problems, toxicity, mutagenicity, reproductive changes, changes to biodiversity.

LO2 Investigate how an industrial or agricultural process is regulated

Legislation relevant to industrial processes, e.g., in the UK

Environmental Protection Act (1990)

Environmental Protection (Prescribed Processes and Substances) Regulations 1991

Environment Act (1995)

Environment Act (2021)

Water Industry Act (1991)

The Trade Effluents (Prescribed Processes and Substances) Regulations 1989

Water Act (2014)

The Environmental Permitting (England and Wales) Regulations (2016)

The Urban Waste Water Treatment (England and Wales) Regulations 1994

Legislation relevant to agricultural processes, e.g., in the UK

The Control of Pesticides Regulations 1986

The Control of Pollution (Silage, Slurry and Agricultural Fuel Oil) Regulations (Northern Ireland) 2003 SR 219

Control of Pollution (Silage, Slurry and Agricultural Fuel Oil) Regulations (England and Wales) 1991

Control of Pollution (Oil Storage) Regulations 2010 and Amendment (2011) (Northern Ireland) 2020/2011 SR 412/385

The Action Programme for Nitrate Vulnerable Zones (England and Wales) Regulations 1998

Protecting our Water Soil and Air: A Code of Good Agricultural Practice for farmers, growers and land managers

Regulatory bodies, e.g., in the UK

Health and Safety Executive (HSE)

Environment Agency (England only)

Environment Agency Wales

Department for Environment, Food & Rural Affairs (Defra)

The Northern Ireland Environment Agency (NIEA) (part of the Department of Agriculture, Environment and Rural Affairs (DAERA))

Local authorities (in relation to air pollution)

Water companies (responsible for regulating discharges to sewer)

The Office for Environmental Protection (OEP)

Concepts to consider in relation to industrial processes include, e.g., in the UK

Prescribed processes (Part A1, Part A2 and Part B) and prescribed substances.

Other potential pollutants.

Process descriptions.

Best available techniques not entailing excessive cost (BATNEEC) principles.

Public register.

Examples of typical environmental permits or consents to discharge to sewer.

Monitoring and reporting requirements.

Sanctions/fines.

LO3 Explore monitoring of pollutants from an industrial or agricultural process

Examples of topics to explore in relation to industrial processes

Stack monitoring; isokinetic sampling.

Ambient air monitoring.

Testing effluent for discharge to controlled waters or to sewers.

Continuous monitoring methods.

Sampling methods.

Sample handling.

Sample storage.

Monitoring Certification Scheme (MCERTS).

Operator monitoring assessment (OMA).

Selection of methods.

Quality of methods, e.g., approved, validated in-house.

Standing Committee of Analysts (SCA).

Blue book methods (SCA) (water analysis).

Principles underpinning the analytical techniques (how the techniques work).

Monitoring requirements, e.g., frequency.

Allowed limits for pollutants.

Reporting requirements.

Permits and consents on public registers as examples.

Topics to consider in monitoring agricultural processes, e.g.

Diffuse pollution – difficult to measure pollutant amounts.

Surveys of how processes are carried out in relation to best practice.

LO4 Carry out analysis of water pollutants

Carrying out could include

Risk assessment.

Control of Substances Hazardous to Health (COSHH) assessments.

Sampling.

Sample storage.

Selection of appropriate techniques.

Calibration of equipment.

Testing for, e.g., suspended solids, pH, chloride, nitrate, metal ions, micro-organisms.

Comparison of concentrations with limits or expected values.

Comparison of methods and techniques with those used in industry.

Learning Outcomes and Assessment Criteria

Pass	Merit	Distinction
LO1 Explore the potential environmental harm associated with pollutants from an industrial or agricultural process		**LO1 and LO2**
P1 Explain the nature and origin of pollutants associated with an industrial or agricultural process. **P2** Describe the potential environmental and health impacts of pollutants associated with an industrial or agricultural process.	**M1** Analyse the potential for a specific industrial or agricultural process to harm health and pollute the environment.	**D1** Assess how effective the regulatory framework is in minimising the impact of pollution from an industrial or agricultural process.
LO2 Investigate how an industrial or agricultural process is regulated		
P3 Review the legislation related to the process. **P4** Investigate the steps taken by an industrial or agricultural organisation in response to legislation and best practice guidance. **P5** Describe how the regulatory body regulates the process.	**M2** Discuss how the regulatory protocol limits the risk to the environment from pollutants associated with an industrial or agricultural process.	

Pass	Merit	Distinction
LO3 Explore monitoring of pollutants from an industrial or agricultural process		**LO3 and LO4**
P6 Describe how the pollutants from an industrial or agricultural process are monitored. **P7** Explain the principles underpinning techniques for monitoring pollutants from an industrial or agricultural process.	**M3** Discuss how techniques and methods for monitoring pollutants from an industrial or agricultural process are selected and used.	**D2** Evaluate the contribution of monitoring and analysis techniques to minimisation of pollution from an industrial or agricultural process.
LO4 Carry out analysis of water pollutants		
P8 Use appropriate methods to sample and analyse water for pollutants. **P9** Report on the analysis of water for pollutants.	**M4** Interpret the quality of the outcomes from the sampling and analysis of water.	

Recommended Resources

Textbooks

BARBOOTI, M. (2015) (Ed.). *Environmental Applications of Instrumental Chemical Analysis.* Ontario: Apple Academic Press.

BELCHAM, A. (2015). *Environmental Management: Revision Guide for the IEMA Associate Membership Exam and NEBOSH Diploma in Environmental Management.* Abingdon: Routledge.

HARRISON, R. M. (Ed.) (2014). *Pollution: Causes, Effects and Control.* (5th Ed.). Cambridge: The Royal Society of Chemistry.

HILL, M. T. (2020) *Understanding Environmental Pollution.* 4th Ed. Cambridge: Cambridge University Press.

PATNAIK, P. (2017) *Handbook of Environmental Analysis: Chemical Pollutants in Air, Water, Soil, and Solid Wastes.* 3rd Ed. Boca Raton, FL: CRC Press.

POPEK, E. P. (2017) *Sampling and Analysis of Environmental Chemical Pollutants: A Complete Guide.* 2nd Ed. Amsterdam: Elsevier.

THEODORE, M. K. and THEODORE, L. (2021). *Introduction to Environmental Management* (2nd. Ed.). Abingdon: CRC Press.

WATERS, B. (2020). *Introduction to Environmental Management: For The NEBOSH Certificate in Environmental Management.* Abingdon: Routledge.

Other reading

DEPARTMENT FOR ENVIRONMENT, FOOD AND RURAL AFFAIRS (DEFRA) (2002) *Sewage Treatment in the UK.* London: DEFRA Publications.

Websites

anglianwater.co.uk	Anglian Water Details of consents to discharge to sewer (General Reference)
daera-ni.gov.uk	Department of Agriculture, Environment and Rural Affairs (Northern Ireland) (General Reference)
dwi.defra.gov.uk	Drinking Water Inspectorate information leaflets Drinking water standards/regulations (Report)
dwrcymru.com	Welsh Water Details of consents to discharge to sewer (General Reference)
eastriding.gov.uk	East Riding of Yorkshire Council Public register information relating to environmental permits (General Reference)
gov.uk	Department for Environment, Food and Rural Affairs (Defra) (2018). *Code of Good Agricultural Practice (COGAP) for Reducing Ammonia Emissions* (General Reference)
gov.uk	Department for Environment, Food and Rural Affairs (Defra) (2009). *Protecting our Water Soil and Air (A Code of Good Agricultural Practice for farmers, growers and land managers.)* (General Reference)
gov.uk	Monitoring Emissions to Air, Land and Water – MCERTS (General Reference)
gov.uk	Environment data Links to public registers related to environmental permits (General Reference)

legislation.gov.uk	The Environmental Permitting (England and Wales) Regulations (2016) (Regulation)
naturalresourceswales.gov.uk	Department for Agriculture, Environment and Rural Affairs (General Reference)
netregs.org.uk	NetRegs Environmental Legislation in relation to Northern Ireland and Scotland (General Reference)
niwater.com	Northern Ireland Water Details of consents to discharge to sewer (General Reference)
sheffield.gov.uk	Sheffield City Council Public register information relating to environmental permits (General Reference)
southernwater.co.uk	Southern Water Details of consents to discharge to sewer (General Reference)
standingcommitteeofanalysts.co.uk	The Standing Committee of Analysts Methods – Microbiology of Drinking Water Methods – Microbiology of Sewage Sludge (General Reference)
thameswater.co.uk	Thames Water Details of consents to discharge to sewer (General Reference)
unitedutilities.com	United Utilities Water for the North West Details of consents to discharge to sewer (General Reference)

www.nwl.co.uk	Northumbrian Water Details of consents to discharge to sewer (General Reference)

Links

This unit links to the following related units:

Unit 3: Regulation and Quality in the Applied Sciences (Pearson-set)

Unit 35: Analytical Chemistry

Unit 39: Environmental Monitoring and Analysis

Unit 40: Water and Wastewater Management

Unit 65: Further Analytical Chemistry.

Essential Requirements

Students should have access to a well-equipped laboratory in relation to Learning Outcome 4. For Learning Outcomes 1, 2 and 3, students should have access to environmental permit information and best practice information, relating to one or more specific industrial or agricultural processes.

Delivery

Tutors should identify industrial and/or agricultural processes on which to base delivery for Learning Outcomes 1, 2 and 3; they should be local to the centre or of relevance to students. Industrial or agricultural visits could be included. At least one of these processes should offer sufficient scope on which to base assignments. The processes should include several potential pollutants where effects may be researched and where levels will be monitored and controlled in order to comply with legislation and best practice guidance. For Learning Outcome 4, students should analyse water for pollutants. The methodology used should be as similar as possible to that adopted by industry and/or regulatory agencies. Analysis for Learning Outcome 4 could be based on the same process as that used in the assessment of Learning Outcomes 1, 2 and 3.

Assessment

Learning Outcomes 1, 2 and 3 could be assessed in relation to any industrial or agricultural process involving pollutants where the level must be controlled, pollution of water, air or soil may be considered. It is essential that pollutants from the process have the capability to cause environmental damage and damage to human health if not controlled so that students can address Learning Outcome 1 sufficiently. Assignment work for Learning Outcome 4 could be linked to the process, with the opportunity to reference work completed for earlier Learning Outcomes, where appropriate.

For D1, Learning Outcomes 1 and 2, students could consider specific examples of the regulatory framework minimising or failing to minimise the impact of pollutants. For D2, Learning Outcomes 3 and 4, students could consider whether monitoring and analysis of pollutants alone will ensure pollution is minimised and whether the regulatory framework should be strengthened.

Employer Engagement and Vocational Contexts

Students will benefit greatly from visits to industrial and/or environmental sites to observe how processes are operated. It will be useful for representatives from organisations operating the processes to be able to talk students through pollution legislation with which they must comply, permits/consents and the allowed levels of pollutants that may be emitted or discharged, and to describe how the processes are operated and monitored to minimise releases of polluting substances. If the speaker's organisation monitors or analyses water quality, it will be interesting for students to observe how this is done.

Remote or face-to-face visits from representatives of bodies with responsibility for regulating pollution, for example the Environment Agency, water companies, local authorities, can help students to understand how permitting/consent systems work.

11 Appendices

Appendix 1: Mapping of HND in Applied Sciences against FHEQ Level 5

Key	
KU	Knowledge and Understanding
CS	Cognitive Skills
AS	Applied Skills
TS	Transferable Skills

The qualification will be awarded to students who have demonstrated:

FHEQ Level 5 descriptor		Applied Sciences HND Programme Outcome
Knowledge and critical understanding of the well established principles of their area(s) of study, and of the way in which those principles have developed	KU1	Knowledge and understanding of relevant legislation, e.g. health and safety legislation, environmental legislation, specialist/niche legislation.
	KU2	Good working knowledge and understanding of health and safety practices in the sector.
	KU3	Knowledge and understanding of aspects of how organisations operate within the relevant sector, in terms of their functions, working practices and how they are internally and externally regulated and managed.
	KU4	Knowledge and understanding of appropriate theories, concepts and facts relevant to the sector (biology, biotechnology, forensic science, chemistry, waste and wastewater, environmental sustainability, food science, technology and nutrition and polymer science and technology).
	KU5	Knowledge and understanding of the principles underpinning experimental and investigative techniques within the relevant sector.
	KU6	Knowledge and understanding of emerging topics of importance in the relevant sector.
	KU7	Knowledge and understanding of mathematical, statistical and other data analysis methods.

FHEQ Level 5 descriptor		Applied Sciences HND Programme Outcome
	CS1	Interpretation and recognition of patterns and trends in data collected from (or typical of) practical activities associated with the sector.
	CS2	Formulating lines of argument or solving problems by combining knowledge and understanding from different topics.
	CS3	Design of appropriate spreadsheets and/or production graphical representations, to support data analysis, relevant to the sector.
	CS4	Identifying and carrying out the appropriate calculations, relevant to sector concepts.
	CS5	Use of appropriate means and styles of communication in relation to the sector specific issues being addressed.
	CS6	Ability to select and use material from sector case studies and visits and speakers appropriately.

FHEQ Level 5 descriptor		Applied Sciences HND Programme Outcome
Ability to apply underlying concepts and principles outside the context in which they were first studied, including, where appropriate, the application of those principles in an employment context	AS1	Ability to apply concepts and principles to activities carried out within organisations in the relevant sector or to simulation of those activities.
	AS2	Ability to apply concepts and principles from one topic in the context of another.
	AS3	Ability to carry out practical work appropriate to the relevant sector independently.
	AS4	Ability to use appropriate mathematical, statistical and data handling techniques in the specific sector context.
	AS5	Ability to use procedures based on sector specific quality systems and practices.
Knowledge of the main methods of enquiry in the subject(s) relevant to the named award, and ability to evaluate critically the appropriateness of different approaches to solving problems in the field of study.	TS1	Effective use of digital and library resources to investigate issues and carry out tasks related to the sector
	AS6	The ability to identify, source and effectively use the information that may be gained from contact (visit, speaker, fieldwork, use of specialised equipment etc.) with an organisation operating within the relevant sector.
	TS2	Use of inter-personal skills (e.g. discussions, team work, questioning techniques etc.) to maximise the depth of knowledge and understanding that may be gained when investigating a topic.
	TS3	Use of a consistent system of in-text citation and organisation of reference material.
	CS7	Critical evaluation of different approaches to investigation or to problem solving.
	KU8	A good working knowledge of the information that may be gathered from use of relevant practical techniques and its limitations.

FHEQ Level 5 descriptor		Applied Sciences HND Programme Outcome
An understanding of the limits of their knowledge, and how this influences analysis and interpretations based on that knowledge.	TS4	The ability to reflect accurately on the extent of their own knowledge.
	TS5	The ability to identify and critically analyse the benefits of suitable additional sources of support and information.
	TS6	The ability to use an evidence-based approach to justify fully investigative approaches, conclusions and outcomes of analysis.

Typically, holders of the qualification will be able to:

FHEQ Level 5 descriptor		Applied Sciences HND Programme Outcomes
Use a range of established techniques to initiate and undertake critical analysis of information, and to propose solutions to problems arising from that analysis.	CS8	Select and use appropriate mathematical or statistical techniques in analysis of data and information relevant to the sector.
	CS9	Use appropriate aspects of different theories when analysing information, carrying out investigations and solving specific problems in the context of the sector.
Effectively communicate information, arguments and analysis in a variety of forms to specialist and non-specialist audiences, and deploy key techniques of the discipline effectively.	CS10	Communicate effectively in the context of the sector, using text, formatted to address task requirements.
	CS11	Use a form of communication other than formatted text, such as a scientific report, scientific poster, scientific essay, scientific article, leaflet, slide presentation, professional discussion, effectively and appropriately in relation to the context
Undertake further training, develop existing skills and acquire new competences that will enable them to assume significant responsibility within organisations	TS7	Demonstrate development of skills that will facilitate gaining placements, employment or further responsibility in an organisation within the relevant sector.
	TS8	Identify opportunities for further skills development, related to personal and professional goals, that may facilitate gaining significant responsibility within an employing organisation

Holders will also have:

FHEQ Level 5 descriptor		Applied Sciences HND Programme Outcomes
The qualities and transferable skills necessary for employment requiring the exercise of personal responsibility and decision-making.	TS9	The ability to organise significant activities appropriately into discrete tasks and to set and prioritise goals.
	TS10	The ability to organise time effectively to plan and undertake tasks efficiently in the context of the sector
	TS11	The ability to take decisions, based on critical analysis of information from a range of appropriate sources.

Appendix 2: HNC/HND Applied Sciences programme outcomes for students mapped to FHEQ level 5 descriptors

	Knowledge and understanding (KU from appendix 1)								Cognitive skills (CS from appendix 1)											Applied skills (AS from appendix 1)						Transferable skills (TS from appendix 1)										
Unit	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**1**	**2**	**3**	**4**	**5**	**6**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**
1		X	X		X		X		X		X	X	X			X			X			X	X	X		X		X	X			X	X			
2							X		X		X	X				X					X							X				X				
3	X	X	X									X		X				X		X					X	X	X	X			X	X		X	X	X
4				X														X								X		X								
5				X									X					X				X						X								
6				X									X					X										X								
7		X		X														X	X			X						X								
8		X		X	X													X	X			X				X		X								
9		X		X	X		X				X	X				X		X	X		X	X						X								
10				X		X							X					X								X		X				X				
11				X	X					X			X					X			X					X		X				X				
12			X	X		X							X					X			X					X		X								
13				X		X				X			X					X			X					X		X			X					
14	X	X	X	X	X					X			X					X		X	X	X		X		X	X	X				X				
15				X	X				X				X					X		X						X		X				X				
16			X	X						X			X	X				X		X	X					X		X			X	X		X		X
17				X	X		X		X				X					X			X	X	X			X		X								
18		X		X	X	X	X	X	X	X	X	X	X		X	X		X	X	X	X	X	X			X		X				X				X
19	X	X	X	X	X	X				X			X	X			X	X	X	X	X					X	X	X				X				X
20				X									X					X								X		X								
21	X		X	X	X								X	X				X		X	X			X		X		X				X				
22	X		X	X		X							X				X	X		X	X					X		X				X				
23		X	X	X						X			X	X			X	X		X	X					X		X				X				

	Knowledge and Understanding								**Cognitive Skills**											**Applied Skills**						**Transferable Skills**										
Unit	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**1**	**2**	**3**	**4**	**5**	**6**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**
24				X									X					X		X	X					X		X								
25			X	X						X			X					X	X							X	X	X	X			X	X			
26				X	X				X	X			X		X	X			X	X	X	X	X			X	X	X		X	X	X		X	X	X
27							X		X		X	X	X			X		X	X				X			X		X								
28		X		X	X	X	X	X	X	X	X	X	X	X		X	X	X	X	X	X	X	X	X		X	X	X	X	X	X	X	X	X	X	X
29				X	X		X	X	X	X	X	X	X			X		X	X		X	X	X			X		X								
30				X	X	X	X	X	X	X		X	X				X	X	X		X	X	X			X		X				X				X
31				X		X				X			X		X			X			X					X		X			X					
32				X	X	X	X	X	X	X		X	X			X	X	X	X	X	X	X	X	X		X		X			X	X		X	X	X
33				X	X	X	X	X	X	X		X	X	X			X	X	X	X	X	X	X	X	X	X	X	X			X	X		X	X	X
34	X		X	X	X	X	X	X		X			X	X				X	X	X	X	X		X	X	X	X	X			X	X		X	X	X
35				X	X		X		X		X	X	X			X		X	X		X	X	X			X		X				X		X		
36		X		X	X					X			X				X	X	X		X	X				X		X			X	X		X	X	X
37		X		X	X		X		X	X		X	X				X	X	X							X		X			X	X		X	X	X
38			X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X			X	X	X			X	X		X	X	X
39				X	X		X	X	X	X		X	X	X		X		X	X		X	X	X	X	X	X	X	X			X	X		X	X	X
40	X		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X		X	X	X	X	X	X	X	X			X	X		X	X	X
41	X			X	X	X	X		X	X			X	X	X		X	X		X			X	X		X		X			X	X		X	X	X
42				X		X							X	X				X			X					X		X			X					
43				X	X		X	X	X	X	X	X	X			X	X	X	X	X	X	X	X		X	X	X	X			X	X		X	X	X
44				X		X	X		X	X			X	X			X	X		X	X		X		X	X		X			X	X		X	X	X
45				X		X				X			X	X			X	X		X	X					X	X	X			X	X		X	X	X
46			X	X	X	X		X		X			X	X			X	X		X	X				X	X	X	X			X	X		X	X	X

	Knowledge and Understanding								Cognitive Skills											Applied Skills						Transferable Skills										
Unit	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**1**	**2**	**3**	**4**	**5**	**6**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**
47				X		X		X		X			X	X			X	X		X	X				X	X	X	X			X	X		X	X	X
48			X	X	X	X	X	X	X	X	X	X	X	X		X	X	X		X	X		X	X	X	X	X	X		X	X	X	X	X	X	X
49			X	X			X		X	X		X	X	X		X	X	X		X	X		X			X		X			X			X	X	X
50	X			X	X				X	X	X	X	X	X		X	X	X		X	X	X	X			X		X			X			X	X	X
51		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
52		X	X	X	X	X		X		X			X	X				X		X	X	X		X	X	X	X	X			X	X		X	X	X
53	X	X	X	X	X	X		X		X			X	X			X	X		X	X				X	X	X	X			X	X		X	X	X
54	X		X	X		X				X			X	X				X		X	X				X	X	X	X			X	X		X	X	X
55				X		X				X			X	X				X			X				X	X		X			X			X	X	X
56	X			X		X				X			X	X				X			X				X	X	X	X			X			X	X	X
57				X	X	X		X	X	X			X	X				X			X	X	X	X		X		X			X			X	X	X
58			X	X	X	X		X	X	X		X	X	X		X	X	X		X	X	X	X	X	X	X	X	X			X	X		X	X	X
59				X		X				X			X	X			X	X			X				X	X	X	X			X			X	X	X
60	X			X		X				X			X	X				X		X	X				X	X	X	X			X			X	X	X
61	X	X	X	X						X			X	X			X	X		X	X			X	X	X	X	X			X	X		X	X	X
62			X	X						X			X	X			X	X		X	X				X	X	X	X			X	X		X	X	X
63			X	X				X		X	X	X	X	X		X	X	X	X	X	X	X	X	X	X	X	X	X			X	X		X	X	X
64				X	X	X	X	X	X	X	X	X	X		X	X	X	X	X	X	X	X	X		X	X		X	X	X	X	X		X	X	X
65			X	X	X	X	X	X	X	X	X	X		X	X	X	X	X	X	X	X	X	X	X		X			X	X	X	X		X	X	X
66	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
67	X	X	X	X	X	X		X		X				X	X			X	X	X	X	X		X	X	X		X	X	X	X	X	X	X	X	X
68	X	X	X	X	X	X		X	X	X			X	X	X			X	X	X	X	X		X	X	X	X	X		X	X	X	X	X	X	X
69	X	X	X	X	X	X				X			X	X	X			X	X	X	X	X		X	X	X	X	X	X	X	X	X	X	X	X	X
70				X	X			X	X									X		X	X	X	X	X	X	X		X			X			X	X	X
71	X	X		X	X			X												X	X	X	X	X		X		X		X	X			X	X	X
72	X	X		X	X			X									X			X	X	X		X	X	X		X			X			X	X	X
73	X	X	X			X	X	X									X	X	X	X				X	X	X				X			X	X	X	X

Appendix 3: Glossary of terms used for internally assessed units

This is a summary of the key terms used to define the requirements within units.

Term	Definition
Analyse	Present the outcome of methodical and detailed examination either: • breaking down a theme, topic or situation in order to interpret and study the interrelationships between the parts and/or • of information or data to interpret and study key trends and interrelationships. Analysis can be through activity, practice, written or verbal presentation.
Apply	Put into operation or use. Use relevant skills/knowledge/understanding appropriate to context.
Arrange	Organise or make plans.
Assess	Offer a reasoned judgement of the standard/quality of a situation or a skill informed by relevant facts.
Calculate	Generate a numerical answer with workings shown.
Compare	Identify the main factors relating to two or more items/situations or aspects of a subject that is extended to explain the similarities, differences, advantages and disadvantages. This is used to show depth of knowledge through selection of characteristics.
Compose	Create or make up or form.
Communicate	Convey ideas or information to others. Create/construct skills to make or do something, for example a display or set of accounts.
Create/ Construct	Skills to make or do something, for example, a display or set of accounts.

Term	Definition
Critically analyse	Separate information into components and identify characteristics with depth to the justification.
Critically evaluate	Make a judgement taking into account different factors and using available knowledge/experience/evidence where the judgement is supported in depth.
Define	State the nature, scope or meaning.
Describe	Give an account, including all the relevant characteristics, qualities and events.
Discuss	Consider different aspects of a theme or topic, how they interrelate, and the extent to which they are important.
Demonstrate	Show knowledge and understanding.
Design	Plan and present ideas to show the layout/function/workings/object/system/process.
Develop	Grow or progress a plan, ideas, skills and understanding
Differentiate	Recognise or determine what makes something different.
Discuss	Give an account that addresses a range of ideas and arguments.
Evaluate	Work draws on varied information, themes or concepts to consider aspects, such as: • strengths or weaknesses • advantages or disadvantages • alternative actions • relevance or significance. Students' inquiries should lead to a supported judgement showing relationship to its context. This will often be in a conclusion. Evidence will often be written but could be through presentation or activity.
Explain	To give an account of the purposes or reasons.
Explore	Skills and/or knowledge involving practical research or testing.
Identify	Indicate the main features or purpose of something by recognising it and/or being able to discern and understand facts or qualities.

Term	Definition
Illustrate	Make clear by using examples or provide diagrams.
Indicate	Point out, show.
Interpret	State the meaning, purpose or qualities of something through the use of images, words or other expression.
Investigate	Conduct an inquiry or study into something to discover and examine facts and information.
Justify	Students give reasons or evidence to: • support an opinion • prove something is right or reasonable.
Outline	Set out the main points/characteristics.
Plan	Consider, set out and communicate what is to be done.
Produce	To bring into existence.
Reconstruct	To assemble again/reorganise/form an impression.
Report	Adhere to protocols, codes and conventions where findings or judgements are set down in an objective way.
Review	Make a formal assessment of work produced. The assessment allows students to: • appraise existing information or prior events • reconsider information with the intention of making changes, if necessary.
Show how	Demonstrate the application of certain methods/theories/concepts.
Stage and manage	Organisation and management skills, for example, running an event or a [Sector] pitch.
State	Express.
Suggest	Give possible alternatives, produce an idea, put forward, for example, an idea or plan, for consideration.
Undertake/ carry out	Use a range of skills to perform a task, research or activity.

This is a key summary of the types of evidence used for BTEC Higher Nationals:

Type of evidence	Definition
Case study	A specific example to which all students must select and apply knowledge.
Project	A large-scale activity requiring self-direction of selection of outcome, planning, research, exploration, outcome and review.
Independent research	An analysis of substantive research organised by the student from secondary sources and, if applicable, primary sources.
Written task or report	Individual completion of a task in a work-related format, for example, a report, marketing communication, set of instructions, giving information.
Simulated activity/role play	A multi-faceted activity mimicking realistic work situations.
Team task	Students work together to show skills in defining and structuring activity as a team.
Presentation	Oral or through demonstration.
Production of plan/Business plan	Students produce a plan as an outcome related to a given or limited task.
Reflective journal	Completion of a journal from work experience, detailing skills acquired for employability.
Poster/leaflet	Documents providing well-presented information for a given purpose.

Appendix 4: Assessment methods and techniques for Higher Nationals

Assessment technique	Description	Transferable skills development	Formative or Summative
Academic graphic display	This technique asks students to create documents providing well-presented information for a given purpose. Could be a hard or soft copy.	Creativity Written communication Information and communications Technology Literacy	Formative Summative
Case study	This technique present students with a specific example to which they must select and apply knowledge.	Reasoning Critical thinking Analysis	Formative Summative
Discussion forum	This technique allows students to express their understanding and perceptions about topics and questions presented in the class or digitally, for example, online groups, blogs.	Oral/written communication Appreciation of diversity Critical thinking and reasoning Argumentation	Formative

Assessment technique	Description	Transferable skills development	Formative or Summative
Independent research	This technique is an analysis of research organised by the student from secondary sources and, if applicable, primary sources.	Information and communications technology Literacy Analysis	Formative
Oral/Viva	This technique asks students to display their knowledge of the subject via questioning.	Oral communication Critical thinking Reasoning	Summative
Peer review	This technique asks students to provide feedback on each other's performance. This feedback can be collated for development purposes.	Teamwork Collaboration Negotiation	Formative Summative
Presentation	This technique asks students to deliver a project orally or through demonstration.	Oral communication Critical thinking Reasoning Creativity	Formative Summative

Assessment technique	Description	Transferable skills development	Formative or Summative
Production of an artefact/ performance or portfolio	This technique requires students to demonstrate that they have mastered skills and competencies by producing something. Some examples are business plans, using a piece of equipment or a technique, building models, developing, interpreting, and using maps.	Creativity Interpretation Written and oral communication Interpretation Decision-making Initiative Information and Communications Technology Literacy, etc.	Summative
Project	This technique is a large scale activity requiring self-direction, planning, research, exploration, outcome and review.	Written communication Information Literacy, Creativity, Initiative.	Summative

Assessment technique	Description	Transferable skills development	Formative or Summative
Role playing	This technique is a type of case study, in which there is an explicit situation established, with students playing specific roles, understanding what they would say or do in that situation.	Written and oral communication Leadership Information literacy Creativity Initiative.	Formative
Self-reflection	This technique asks students to reflect on their performance, for example, to write statements of their personal goals for the course at the beginning of the course, what they have learned at the end of the course and their assessment of their performance and contribution; completion of a reflective journal from work experience, detailing skills acquired for employability.	Self-reflection Written communication Initiative Decision-making Critical thinking	Summative

Assessment technique	Description	Transferable skills development	Formative or Summative
Simulated activity	This technique is a multi-faceted activity based on realistic work situations.	Self-reflection Written communication Initiative Decision-making Critical thinking	Formative Summative
Team assessment	This technique asks students to work together to show skills in defining and structuring an activity as a team. All team assessment should be distributed equally, each of the group members performing their role, and then the team collates the outcomes, and submits it as a single piece of work.	Collaboration Teamwork Leadership Negotiation Written and oral communication	Formative Summative

Assessment technique	Description	Transferable skills development	Formative or Summative
Tiered knowledge	This technique encourages students to identify their gaps in knowledge. Students record the main points they have captured well and those they did not understand.	Critical thinking Analysis Interpretation Decision-making Oral and written communication	Formative
Time constrained assessment	This technique covers all assessment that needs to be done within a centre-specified time constrained period on-site.	Reasoning Analysis Written communication Critical thinking Interpretation	Summative
Top ten	This technique asks students to create a 'top ten' list of key concepts presented in the assigned reading list.	Teamwork Creativity Analysis Collaboration	Formative

Assessment technique	**Description**	**Transferable skills development**	**Formative or Summative**
Written task or report	This technique asks students to complete an assignment in a structured written format, for example, a business plan, a report, marketing communication, set of instructions, giving information.	Reasoning Analysis Written communication Critical thinking, interpretation.	Summative

Appendix 5: Transferable skills mapping

Pearson BTEC Level 4 Higher National Certificate in Applied Sciences: mapping of transferable employability and academic study skills

Skill Set	Cognitive skills						Intra-personal Skills					Interpersonal Skills		
Unit	Problem Solving	Critical Thinking/ Analysis	Decision Making	Effective Communication	Digital Literacy	Numeracy	Creativity	Plan Prioritise	Self Management	Independent learning	Self Reflection	Team Work	Leadership	Cultural Awareness
1	X	X	X	X	X	X		X	X	X	X	X		
2	X	X	X	X	X	X	X	X	X	X	X			
3	X	X	X	X			X	X	X	X	X	X		X
4	X	X	X	X				X	X	X				
5	X	X	X	X		X		X	X	X	X			
6	X	X	X	X			X	X	X	X				
7	X	X	X	X		X		X	X	X				
8	X	X	X	X				X	X	X				
9	X	X	X	X	X	X		X	X	X	X			
10	X	X	X	X			X	X	X	X				X
11	X	X	X	X			X	X	X	X				
12	X	X	X	X			X	X	X	X		X		X
13	X	X	X	X		X	X	X	X	X				X
14	X	X	X	X	X	X	X	X	X	X	X			X

Skill Set	**Cognitive skills**						**Intra-personal Skills**					**Interpersonal Skills**		
Unit	Problem Solving	Critical Thinking/ Analysis	Decision Making	Effective Communication	Digital Literacy	Numeracy	Creativity	Plan Prioritise	Self Management	Independent learning	Self Reflection	Team Work	Leadership	Cultural Awareness
15	X	X	X	X		X	X	X	X	X				
16	X	X	X	X				X	X	X				
17	X	X	X	X		X		X	X	X	X			
18	X	X	X	X		X		X	X	X	X			
19	X	X	X	X	X	X	X	X	X	X			X	X
20	X	X	X	X		X	X	X	X	X				
21		X	X	X				X	X	X				X
22	X	X	X	X			X	X	X	X				X
23		X	X	X				X	X	X				X
24		X	X	X		X		X	X	X				
25	X	X	X	X			X	X	X	X	X			X
26	X	X	X	X	X		X	X	X	X	X	X	X	X
35	X	X	X	X		X		X	X	X				
64	X	X	X	X	X	X	X	X	X	X	**X**			
71	X	X						X	X					

Pearson BTEC Level 5 Higher National Diploma in Applied Sciences: mapping of transferable employability and academic study skills

Skill Sets	Cognitive skills							Intra-personal Skills				Interpersonal Skills			
Unit	Problem Solving	Critical Thinking/ Analysis	Decision Making	Effective Communication	Digital Literacy	Numeracy	Creativity	Plan Prioritise	Self Management	Independent learning	Self Reflection	Team Work	Leadership	Cultural Awareness	Interpersonal Skills
27	X	X	X	X	X	X	X	X	X	X	X				
28	X	X	X	X	X	X	X	X	X	X	X				
29	X	X	X	X		X		X	X	X	X				
30	X	X	X	X		X	X	X	X	X	X			X	
31	X	X	X	X			X	X	X	X	X				
32	X	X	X	X		X		X	X	X	X				
33	X	X	X	X		X	X	X	X	X	X				
34	X	X	X	X	X	X	X	X	X	X	X				
36	X	X	X	X		X		X	X	X	X				
37	X	X	X	X		X		X	X	X	X				
38	X	X	X	X	X	X	X	X	X	X	X	X			
39	X	X	X	X	X	X	X	X	X	X	X	X			X
40	X	X	X	X		X	X	X	X	X	X	X			X
41	X	X	X	X		X	X	X	X	X	X	X		X	X
42	X	X	X	X			X	X	X	X	X			X	
43	X	X													
44	X	X	X	X		X	X	X	X	X					
45	X	X	X	X			X	X	X	X				X	
46	X	X	X	X			X	X	X	X					
47	X	X	X	X		X	X	X	X	X					
48	X	X	X	X		X	X	X	X	X					

Skill Sets	**Cognitive skills**							**Intra-personal Skills**				**Interpersonal Skills**			
Unit	Problem Solving	Critical Thinking/ Analysis	Decision Making	Effective Communication	Digital Literacy	Numeracy	Creativity	Plan Prioritise	Self Management	Independent learning	Self Reflection	Team Work	Leadership	Cultural Awareness	Interpersonal Skills
49	X	X	X	X		X	X	X	X	X				X	
50	X	X	X	X		X	X	X	X	X				X	
51	X	X	X	X	X	X	X	X	X	X	X				X
52	X	X	X	X			X	X	X	X				X	X
53	X	X	X	X			X	X	X	X					
54	X	X	X	X			X	X	X	X					
55	X	X	X	X			X	X	X	X				X	
56	X	X	X	X			X	X	X	X				X	
57	X	X	X	X		X	X	X	X	X				X	
58	X	X	X	X		X	X	X	X	X				X	
59	X	X	X	X	X		X	X	X	X				X	
60	X	X	X	X			X	X	X	X				X	
61	X	X	X	X			X	X	X	X		X			
62	X	X	X	X			X	X	X	X		X	X	X	X
63	X	X	X	X		X	X	X	X	X				X	X
65	x	x	x	x	x	x	x	x	x	x	x				
66	X	X	X	X	X	X		X	X	X	X	X	X		X
67	X	X	X	X	X		X	X	X	X		X	X		X
68	X	X	X	X				X	X	X	X	X	X		X
69	X	X	X	X	X		X	X	X	X	X	X	X		X
70	X	X						X	X						X
72		X	X						X	X					
73	X	X	X	X				X	X	X		X			X

Appendix 6: Pearson BTEC Level 5 Higher National Diploma in Applied Sciences Mapped to the Apprenticeship Standard Level 5 Technician Scientist

	Knowledge								Skills													Behaviours			
Unit	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
1	X		X						X	X	X		X	X					X	X	X		X		X
2			X	X										X							X				
3						X	X	X		X						X	X	X	X		X	X			X
4		X																	X		X				
5		X	X						X	X			X						X		X				
6		X																	X		X				
7	X	X	X						X	X	X		X						X		X		X		
8	X	X							X	X	X		X						X		X		X		
9	X	X	X	X					X	X			X	X			X		X		X		X		
10		X									X						X				X				
11	X	X	X								X		X				X		X		X				
12		X					X	X		X								X	X		X				
13	X	X	X	X			X				X		X				X		X		X				
14	X	X		X	X		X	X	X	X	X	X	X	X	X	X	X		X		X		X	X	X
15	X	X	X								X		X				X		X		X			X	
16		X									X						X		X		X				
17	X	X	X						X	X	X		X						X		X		X		X
18	X	X	X				X		X	X	X		X				X		X		X				X
19		X			X	X	X	X		X		X			X	X	X	X	X	X	X		X	X	

	Knowledge								Skills													Behaviours			
Unit	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
20		X									X								X		X			X	
21	X	X	X			X	X	X		X									X		X	X	X	X	
22		X																	X		X				
23		X																	X		X				
24	X	X	X						X	X	X		X						X		X				
25								X							X			X	X		X	X	X	X	X
26	X	X	X	X	X				X			X	X	X	X		X	X	X	X	X		X	X	X
27				X										X					X		X				
28	X	X	X	X	X				X	X	X	X	X		X		X	X	X	X	X		X		X
29	X	X	X	X					X	X	X								X		X		X		
30	X	X	X						X	X	X								X		X				
31		X																	X		X				
32	X	X	X						X	X	X		X						X		X				
33	X	X	X						X	X	X		X						X		X				
34	X	X				X	X		X	X	X								X		X		X		
35	X	X	X	X					X		X		X						X		X				
36	X	X	X						X	X	X		X						X		X				
37	X	X	X	X					X	X	X		X						X		X				
38	X	X	X	X					X	X	X		X						X		X				
39	X	X	X	X	X	X	X		X	X	X		X	X	X				X	X	X		X		
40	X	X	X	X	X	X	X		X	X	X		X	X	X				X		X				
41	X	X	X		X	X			X	X	X		X		X				X	X	X		X		
42		X																	X		X				
43	X	X	X		X				X	X	X		X		X				X		X				
44		X																	X		X				

	Knowledge								Skills													Behaviours			
Unit	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
45		X																	X		X				
46		X									X								X		X				
47		X		X			X				X								X		X				
48	x	x	x	x							x								x		x				
49		x					x	x		x	x								x		x				
50	x	x	x	x						x	x		x						x		x				
51	x	x	x	x		x		x	x	x	x		x	x					x	x	x		x		x
52	x	x	x			x	x	x			x								x		x				
53	x	x					x				x								x		x				
54		x					x												x		x				
55		x																	x		x				
56		x					x	x											x		x				
57	x	x	x					x	x	x	x		x						x		x				
58	x	x	x						x	x	x		x						x		x				
59		x																	x		x				
60		x																	x		x				
61		x	x	x		x	x	x						x		x		x	x		x		x		
62								x										x	x		x			x	
63																									
64	x	x	x	x	x				x	x	x		x	x					x	x	x				x
65	x	x	x	x		x			x	x	x		x	x					x	x	x				x
66			x	x	x	x	x	x		x		x			x	x	x	x	x	x	x	x		x	x
67			x		x	x	x	x		x		x			x	x	x	x	x	x	x	x		x	x
68			x		x	x	x	x		x		x			x	x	x	x	x	x	x	x		x	x
69			x		x	x	x	x		x		x			x	x	x	x	x	x	x	x		x	x

	Knowledge								Skills													Behaviours			
Unit	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
70	x	x	x						x	x	x		x		x					x	x				
71	x	x	x						x	x	x		x		x					x	x				
72	x	x	x			x	x		x	x	x		x		x					x	x				
73	x	x				x	x	x			x	x	x	x				x	x		x	x			x

Appendix 7: Recognition of Prior Learning

QCF Pearson BTEC Level 4 Higher National Certificate in Applied Biology and QCF Pearson BTEC Level 4 Higher National Certificate in Applied Chemistry unit content mapped to the Level 4 units available in the Pearson BTEC Higher National Applied Sciences programmes (RQF)

HNCs in Applied Sciences: Unit Mapping Overview

This mapping document is designed to support centres who wish to recognise student achievement in older QCF Higher Nationals within the new RQF suites. The document demonstrates where content is covered in the new suite, and where there is new content to cover to ensure full coverage of learning outcomes.

P – Partial mapping (some topics from the old unit appear in the new unit)

M – Minimal mapping (a minimal number of topics from the old unit appear in the new unit)

X – Full mapping + new (all the topics from the old unit appear in the new unit, but new unit also contains new topic(s))

F – Full mapping (no new topics)

N – New unit

Unit no.	Unit title New RQF HN programme	Maps to unit number on existing QCF HN Applied Biology programme	Level of similarity between units	Maps to unit number on existing QCF HN Applied Chemistry programme	Level of similarity between units
1	Fundamentals of Laboratory Techniques	4	P	4	P
2	Scientific Data Handling Approaches and Techniques	5	P	6	P
3	Regulation and Quality in the Applied Sciences	7 26	P P	7 21	P P
4	Cell Biology	1	P		N
5	Fundamentals of Chemistry	4 22	P P	1 2 3 4	P P P P

Unit no.	Unit title New RQF HN programme	Maps to unit number on existing QCF HN Applied Biology programme	Level of similarity between units	Maps to unit number on existing QCF HN Applied Chemistry programme	Level of similarity between units
6	Anatomy and Physiology	3	P		N
7	Inorganic Chemistry	22	P	1	P
8	Organic Chemistry	22	P	2	P
9	Physical Chemistry	22	P	3	P
10	Principles of Ecology and Their Applications	20	P		
11	Physiological Adaptions of Plants to Environmental Changes	25	P		N
12	Managing Environmental Resources	21	M	20	M
13	Human Health and Nutrition	16	P		N
14	Food Technology		N		N
15	Introduction to Polymer Materials and Properties		N	16	M
16	Polymer Manufacturing Techniques		N		N
17	Fundamentals of Biochemistry	2	F	15	F
18	Microbiological Techniques	15 17	M		N
19	Managing Food Properties and Production Systems		N		N
20	Introduction to Material Properties and Applications		N	26	P
21	Criminal Investigation		N		N
22	Theories and Causes of Crime		N		N
23	Psychology in the Forensic Setting		N		N
24	Sampling and Sample Preparation		N		N

Unit no.	Unit title New RQF HN programme	Maps to unit number on existing QCF HN Applied Biology programme	Level of similarity between units	Maps to unit number on existing QCF HN Applied Chemistry programme	Level of similarity between units
25	Personal and Professional Development for Scientists	32	P	29	P
26	Management of Scientific Projects	27	F	22	F
64	Work-based Investigation	8	F	8	F
35	Analytical Chemistry		N	12	P

HNCs in Applied Sciences: Unit Mapping Depth to HNC Applied Biology

RQF HNC Units		QCF HNC units		Mapping comments	
No	RQF unit title	No	QCF unit title	QCF LOs	RQF LOs
1	Fundamentals of Laboratory Techniques	4	Laboratory Techniques for Applied Biology	Unit 4: LO1 Unit 4: LO2 Unit 4: LO3 Unit 4: LO4 Unit 4: LO2/LO3/LO4	Unit 1: LO3 Partial match Unit 1: LO1 Partial match Unit 1: LO1 Partial match Unit 1: LO3 Partial match Unit 1: LO4 Partial match Unit 1: LO2 no match
2	Scientific Data Handling Approaches and Techniques	5	Analysis of Scientific Data and Information	Unit 5: LO1 Unit 5: LO2 Unit 5: LO3 Unit 5: LO4	Unit 2: LO1 Partial match Unit 2: LO2 Partial match Unit 2: LO4 Partial match Unit 2: LO3 Partial match No match
3	Regulation and Quality in the Applied Sciences	7 26	Laboratory Management Quality Assurance and Quality Control	Unit 7: LO1 Unit 7: LO2 Unit 7: LO3 Unit 7 LO4 Unit 26: LO1 Unit 26: LO2 Unit 26: LO3 Unit 26: LO4	Unit 3: No match Unit 3: No match Unit 3: LO1 Partial match Unit 3: LO2/LO4 Partial match Unit 3: No match Unit 3: No match Unit 3: LO3 Partial match Unit 3: No match

RQF HNC Units		QCF HNC units		Mapping comments	
No	RQF unit title	No	QCF unit title	QCF LOs	RQF LOs
4	Cell Biology	1	Cell Biology	Unit 1: LO1 Unit 1: LO2 Unit 1: LO3 Unit 1: LO4	Unit 4: LO1 Partial match Unit 4: No match Unit 4: LO3 Partial match Unit 4: No match
5	Fundamentals of Chemistry	22 4	Chemistry for Applied Biologists Laboratory Techniques for Applied Biology	Unit 22: LO1 Unit 22: LO2 Unit 22: LO3 Unit 22: LO4 Unit 4: LO2	Unit 5: LO1 Partial match Unit 5: LO2/LO3 Partial match Unit 5: LO2/LO3 Partial match Unit 5: LO4 Unit 5: LO2 Partial match
6	Anatomy and Physiology	3	Physiology of Cellular Systems in Animals	Unit 3: LO1 Unit 3: LO2 Unit 3: LO3	Unit 6: LO1 Very partial match Unit 6: LO2 Partial match Unit 6: LO3 Partial match Unit 6: LO4 No match
7	Inorganic Chemistry	22	Chemistry for Applied Biologists	Unit 22: LO1 Unit 22: LO2/LO3/LO4	Unit 7: LO2 Partial match Unit 7: No match
8	Organic Chemistry	22	Chemistry for Applied Biologists	Unit 22: LO1 Unit 22: LO2/LO3 Unit 22: LO4	Unit 8: LO1 Very partial match Unit 8: No match Unit 8: LO3 Partial match Unit 8: LO2/LO4 No match

RQF HNC Units		QCF HNC units		Mapping comments	
No	RQF unit title	No	QCF unit title	QCF LOs	RQF LOs
9	Physical Chemistry	22	Chemistry for Applied Biologists	Unit 22 LO1 Unit 22: LO2 Unit 22: LO3 Unit 22: LO4	Unit 9: No match Unit 9: LO1/LO3 Partial Match Unit 9: No match Unit 9: No match
10	Principles of Ecology and Their Applications	20	Ecological Principles and Their Applications	Unit 20: LO1 Unit 20: LO2 Unit 20: LO3	Unit 10: LO1/LO2 Partial match Unit 10: LO3 No match Unit 10: No match Unit 10: LO4 No match
11	Physiological Adaptions of Plants to Environmental Changes	25	Plant Physiology and Environmental Adaption	Unit 25: LO1 Unit 25: LO2 Unit 25: LO3 Unit 25: LO4	Unit 11: LO1 Partial match Unit 11: LO2 Partial match Unit 11: LO3 Very partial match Unit 11: LO4 No match
12	Managing Environmental Resources	21	Environmental Management and Conservation	Unit 21: LO1/2/3 Unit 21: LO4	Unit 12: No significant match Unit 12: LO4 Partial match
13	Human Health and Nutrition	16	Human Health and Nutrition	Unit 16: LO1 Unit 16: LO2 Unit 16: LO3 Unit 16: LO4	Unit 13: LO1 Partial match Unit 13: LO2 Partial match Unit 13: LO4 Partial match Unit 13: LO3 Partial match
14	Food Technology		New unit, no equivalent		

RQF HNC Units		QCF HNC units		Mapping comments	
No	RQF unit title	No	QCF unit title	QCF LOs	RQF LOs
15	Introduction to Polymer Materials and Properties		New unit, no equivalent		
16	Polymer Manufacturing Techniques		New unit, no equivalent		
17	Fundamentals of Biochemistry	2	Biochemistry of Macromolecules and Metabolic Pathways	Unit 2: LO1 Unit 2: LO2 Unit 2: LO3 Unit 2: LO4	Unit 17: LO1 Unit 17: LO2 Unit 17: LO4 Partial match Unit 17: LO3
18	Microbiological Techniques	15 17	Medical Microbiology Industrial Microbiology	Unit 15: LO1 Unit 15: LO2 Unit 15: LO3 Unit 15: LO4 Unit 17: LO1 Unit 17: LO2 Unit 17: LO3 Unit 17: LO4	Unit 18: No match Unit 18: LO2 Partial match Unit 18: No match Unit 18: No match Unit 18: LO3 Partial match Unit 18: LO4 Partial match Unit 18: No match Unit 18: No match
19	Managing Food Properties and Production Systems		New unit, no equivalent		
20	Introduction to Material Properties and Applications		New unit, no equivalent		
21	Criminal Investigation		New unit, no equivalent		

RQF HNC Units		QCF HNC units		Mapping comments	
No	RQF unit title	No	QCF unit title	QCF LOs	RQF LOs
22	Theories and Causes of Crime		New unit, no equivalent		
23	Psychology in the Forensic Setting		New unit, no equivalent		
24	Sampling and Sample Preparation		New unit, no equivalent		
25	Personal and Professional Development for Scientists	32	Personal and Professional Development	Unit 32: LO1/LO3/LO4 Unit 32: LO2	Unit 25: No match Unit 25: LO2/LO3 Partial match
26	Management of Scientific Projects	82	Management of Projects	Unit 27: LO1 Unit 27: LO2 Unit 27: LO3	Unit 26: LO1 Partial match Unit 26: LO2 Partial match Unit 26: LO3/LO4 Partial match
64	Work-based Investigation	8	Work-based Investigation	Unit 8: LO1 Unit 8: LO2 Unit 8: LO3 Unit 8: LO4	Unit 64: LO1 Unit 64: LO3 Unit 64: LO2 Unit 64: LO4
35	Analytical Chemistry		New unit, no equivalent		

HNCs in Applied Sciences: Unit Mapping Depth to HNC Applied Chemistry

RQF HNC Units		QCF HNC units		Mapping comments	
No	RQF unit title	No	QCF unit title	QCF LOs	RQF LOs
1	Fundamentals of Laboratory Techniques	4	Laboratory Techniques for Applied Chemistry	Unit 4: LO1 Unit 4: LO2 Unit 4: LO3 Unit 4: LO4 Unit 4: LO1/LO2/LO3/LO4	Unit 1: LO2 Partial match Unit 1: LO1 Partial match Unit 1: LO1 Partial match Unit 1: LO1 Partial match Unit 1: LO3 No match Unit 1: LO4 Partial match
2	Scientific Data Handling Approaches and Techniques	6	Analysis of Scientific Data and Information	Unit 6: LO1 Unit 6: LO2 Unit 6: LO3 Unit 6: LO4	Unit 2: LO1 Partial match Unit 2: LO2 Partial match Unit 2: LO4 Partial match Unit 2: LO3 Partial match No match
3	Regulation and Quality in the Applied Sciences	7 21	Laboratory Management Quality Assurance and Quality Control	Unit 7: LO1 Unit 7: LO2 Unit 7: LO3 Unit 7 LO4 Unit 21: LO1 Unit 21: LO2 Unit 21: LO3 Unit 21: LO4	Unit 3: No match Unit 3: No match Unit 3: LO1 Partial match Unit 3: LO2/LO4 Partial match Unit 3: No match Unit 3: No match Unit 3: LO3 Partial match Unit 3: No match
4	Cell Biology		No related QCF Unit		

RQF HNC Units		**QCF HNC units**		**Mapping comments**	
No	RQF unit title	No	QCF unit title	QCF LOs	RQF LOs
5	Fundamentals of Chemistry	1 2 3 4	Inorganic Chemistry Organic Chemistry Physical Chemistry Laboratory Techniques for Applied Chemistry	Unit 1: LO1 Unit 1: LO2 Unit 1: LO3 Unit 1: LO4 Unit 2: LO1/LO3/LO4 Unit 2: LO2 Unit 3: LO1/LO4 Unit 3: LO2/LO3 Unit 4: LO4	Unit 5: LO1 Partial match Unit 5: LO1 Partial match No match No match Unit 5: LO4 Unit 5:No match Unit 5: LO2/LO3 Partial Match Unit 5: No match Unit 5: LO2 Partial match
6	Anatomy and Physiology	57	No related QCF Unit		
7	Inorganic Chemistry	1	Inorganic Chemistry	Unit 1: LO1 Unit 1: LO2 Unit 1: LO3 Unit 1: LO4	Unit 7: LO1 Partial match Unit 7: LO2 Partial match Unit 7: LO3 Partial match Unit 7: LO4 No match
8	Organic Chemistry	2	Organic Chemistry	Unit 2: LO1 Unit 2: LO2 Unit 2: LO3 Unit 2: LO4	Unit 8: LO1/LO4 Partial match Unit 8: LO2 Partial match Unit 8: LO3 Partial match Unit 8: LO3 Partial match

RQF HNC Units		QCF HNC units		Mapping comments	
No	RQF unit title	No	QCF unit title	QCF LOs	RQF LOs
9	Physical Chemistry	3	Physical Chemistry	Unit 3: LO1 Unit 3: LO2 Unit 3: LO3 Unit 3: LO4	Unit 9: LO1/LO4 Partial match Unit 9: LO2/LO4 Partial match Unit 9: No match Unit 9: LO3/LO4 Partial match
10	Principles of Ecology and Their Applications		No related QCF Unit		
11	Physiological Adaptions of Plants to Environmental Changes		No related QCF Unit		
12	Managing Environmental Resources	20	Environmental Management and Conservation	Unit 21: LO1/2/3 Unit 21: LO4	Unit 12: No significant match Unit 12: LO4 Partial match
13	Human Health and Nutrition		No related QCF Unit		
14	Food Technology		No related QCF Unit		
15	Introduction to Polymer Materials and Properties	16	Polymer chemistry	Unit 16: LO2	Unit 15: LO2 Partial match
16	Polymer Manufacturing Techniques	55	New unit, no equivalent		
17	Fundamentals of Biochemistry	15	Biochemistry of Macromolecules and Metabolic Pathways	Unit 15: LO1 Unit 15: LO2 Unit 15: LO3 Unit 15: LO4	Unit 17: LO1 Unit 17: LO2 Unit 17: LO4 Partial match Unit 17: LO3
18	Microbiological Techniques		No related QCF unit		

RQF HNC Units		QCF HNC units		Mapping comments	
No	RQF unit title	No	QCF unit title	QCF LOs	RQF LOs
19	Managing Food Properties and Production Systems		New unit, no equivalent		
20	Introduction to Material Properties and Applications	26	Materials Science and Technology	Unit 26: LO1 Unit 26: LO2 Unit 26: LO3 Unit 26: LO4	Unit 20: LO1/LO2 Partial match Unit 20: LO4 Unit 20: No match Unit 20: LO3
21	Criminal Investigation		New unit, no equivalent		
22	Theories and Causes of Crime		New unit, no equivalent		
23	Psychology in the Forensic Setting		New unit, no equivalent		
24	Sampling and Sample Preparation		New unit, no equivalent		
25	Personal and Professional Development for Scientists	29	Personal and Professional Development	Unit 29: LO1/LO3/LO4 Unit 29: LO2	Unit 25: No match Unit 25: LO2/LO3
26	Management of Scientific Projects	22	Management of Projects	Unit 22: LO1 Unit 22: LO2 Unit 22: LO3	Unit 26: LO1 Partial match Unit 26: LO2 Partial match Unit 26: LO3/LO4 Partial match
64	Work-based Investigation	8	Work-based Investigation	Unit 8: LO1 Unit 8: LO2 Unit 8: LO3 Unit 8: LO4	Unit 64: LO1 Unit 64: LO3 Unit 64: LO2 Unit 64: LO4

RQF HNC Units		QCF HNC units		Mapping comments	
No	RQF unit title	No	QCF unit title	QCF LOs	RQF LOs
35	Analytical Chemistry	12	Analytical Chemistry	Unit 12: LO1 Unit 12: LO2 Unit 12: LO3 Unit 12: LO4	Unit 35: No match Unit 35: LO2 Partial match Unit 35: LO4 Partial match Unit 35: LO3 Partial match

QCF Pearson BTEC Level 4 Higher National Certificate in Biological Sciences for Industry and QCF Pearson BTEC Level 4 Higher National Certificate in Chemical Sciences for Industry unit content mapped to the Level 4 units available in the Pearson BTEC Higher National Applied Sciences programmes (RQF)

HNCs in Applied Sciences: Unit Mapping Overview

This mapping document is designed to support centres who wish to recognise student achievement in older QCF Higher Nationals within the new RQF suites. The document demonstrates where content is covered in the new suite, and where there is new content to cover to ensure full coverage of learning outcomes.

P – Partial mapping (some topics from the old unit appear in the new unit)

M – Minimal mapping (a minimal number of topics from the old unit appear in the new unit)

X – Full mapping + new (all the topics from the old unit appear in the new unit, but new unit also contains new topic(s))

F – Full mapping (no new topics)

N – New unit

Unit no.	Unit title New RQF HN programme	Maps to unit number on existing QCF HN Biological Sciences for Industry programme	Level of similarity between units	Maps to unit number on existing QCF HN Chemical Sciences for Industry programme	Level of similarity between units
1	Fundamentals of Laboratory Techniques	7	P	8	P
2	Scientific Data Handling Approaches and Techniques	8	P	9	P
3	Regulation and Quality in the Applied Sciences	14 12	P P	15 13	P P
4	Cell Biology	5	P		N
5	Fundamentals of Chemistry	5 17	P P	5 6 7 8	P P P P
6	Anatomy and Physiology	10	P		N
7	Inorganic Chemistry	17		6	P

Unit no.	Unit title New RQF HN programme	Maps to unit number on existing QCF HN Biological Sciences for Industry programme	Level of similarity between units	Maps to unit number on existing QCF HN Chemical Sciences for Industry programme	Level of similarity between units
8	Organic Chemistry	17	P	5	P
9	Physical Chemistry	17	P	7	P
10	Principles of Ecology and Their Applications	29	P		
11	Physiological Adaptions of Plants to Environmental Changes	32	P		N
12	Managing Environmental Resources	30	M		N
13	Human Health and Nutrition	24	P		N
14	Food Technology		N		N
15	Introduction to Polymer Materials and Properties		N	23	M
16	Polymer Manufacturing Techniques		N		N
17	Fundamentals of Biochemistry	9	F	22	F
18	Microbiological Techniques	6	M		N
19	Managing Food Properties and Production Systems		N		N
20	Introduction to Material Properties and Applications		N	27	P
21	Criminal Investigation		N		N
22	Theories and Causes of Crime		N		N
23	Psychology in the Forensic Setting		N		N
24	Sampling and Sample Preparation		N		N
25	Personal and Professional Development for Scientists	2	P	2	P

Unit no.	Unit title New RQF HN programme	Maps to unit number on existing QCF HN Biological Sciences for Industry programme	Level of similarity between units	Maps to unit number on existing QCF HN Chemical Sciences for Industry programme	Level of similarity between units
26	Management of Scientific Projects		N		N
64	Work-based Investigation	11	F	12	F
35	Analytical Chemistry		N	11	P

HNCs in Applied Sciences: Unit Mapping Depth to HNC Biological Sciences for Industry

RQF HNC Units		QCF HNC units		Mapping comments	
No	RQF unit title	No	QCF unit title	QCF LOs	RQF LOs
1	Fundamentals of Laboratory Techniques	7	Laboratory Techniques for Applied Biology	Unit 7: LO1 Unit 7: LO2 Unit 7: LO3 Unit 7: LO4 Unit 7: LO2/LO3/LO4	Unit 1: LO3 Partial match Unit 1: LO1 Partial match Unit 1: LO1 Partial match Unit 1: LO3 Partial match Unit 1: LO4 Partial match Unit 1: LO2 no match
2	Scientific Data Handling Approaches and Techniques	8	Analysis of Scientific Data and Information	Unit 5: LO1 Unit 5: LO2 Unit 5: LO3 Unit 5: LO4	Unit 2: LO1 Partial match Unit 2: LO2 Partial match Unit 2: LO4 Partial match Unit 2: LO3 Partial match No match

RQF HNC Units		QCF HNC units		Mapping comments	
No	RQF unit title	No	QCF unit title	QCF LOs	RQF LOs
3	Regulation and Quality in the Applied Sciences	14 12	Laboratory Management Quality Assurance and Quality Control	Unit 14: LO1 Unit 14 LO2 Unit 14: LO3 Unit 14: LO4 Unit 12: LO1 Unit 12: LO2 Unit 12: LO3 Unit 12: LO4	Unit 3: No match Unit 3: No match Unit 3: LO1 Partial match Unit 3: LO2/LO4 Partial match Unit 3: No match Unit 3: No match Unit 3: LO3 Partial match Unit 3: No match
4	Cell Biology	5	Cell Biology	Unit 5: LO1 Unit 5: LO2 Unit 5: LO3 Unit 5: LO4	Unit 4: LO1 Partial match Unit 4: No match Unit 4: LO3 Partial match Unit 4: No match
5	Fundamentals of Chemistry	17 7	Chemistry for Applied Biologists Laboratory Techniques for Applied Biology	Unit 17: LO1 Unit 17: LO2 Unit 17: LO3 Unit 17: LO4 Unit 7: LO2	Unit 5: LO1 Partial match Unit 5: LO2/LO3 Partial match Unit 5: LO2/LO3 Partial match Unit 5: LO4 Unit 5: LO2 Partial match

RQF HNC Units		QCF HNC units		Mapping comments	
No	RQF unit title	No	QCF unit title	QCF LOs	RQF LOs
6	Anatomy and Physiology	10	Physiology of Cellular Systems in Animals	Unit 10: LO1 Unit 10: LO2 Unit 10: LO3	Unit 6: LO1 Very partial match Unit 6: LO2 Partial match Unit 6: LO3 Partial match Unit 6: LO4 No match
7	Inorganic Chemistry	17	Chemistry for Applied Biologists	Unit 17: LO1 Unit 17: LO2/LO3/LO4	Unit 7: LO2 Partial match Unit 7: No match
8	Organic Chemistry	17	Chemistry for Applied Biologists	Unit 17: LO1 Unit 17: LO2/LO3 Unit 17: LO4	Unit 8: LO1 Very partial match Unit 8: No match Unit 8: LO3 Partial match Unit 8: LO2/LO4 No match
9	Physical Chemistry	17	Chemistry for Applied Biologists	Unit 17: LO1 Unit 17: LO2 Unit 17: LO3 Unit 17: LO4	Unit 9: No match Unit 9: LO1/LO3 Partial Match Unit 9: No match Unit 9: No match
10	Principles of Ecology and Their Applications	29	Ecological Principles and Their Applications	Unit 29: LO1 Unit 29: LO2 Unit 29: LO3	Unit 10: LO1/LO2 Partial match Unit 10: LO3 No match Unit 10: No match Unit 10: LO4 No match

RQF HNC Units		QCF HNC units		Mapping comments	
No	RQF unit title	No	QCF unit title	QCF LOs	RQF LOs
11	Physiological Adaptions of Plants to Environmental Changes	32	Plant Physiology and Environmental Adaption	Unit 32: LO1 Unit 32: LO2 Unit 32: LO3 Unit 32: LO4	Unit 11: LO1 Partial match Unit 11: LO2 Partial match Unit 11: LO3 Very partial match Unit 11: LO4 No match
12	Managing Environmental Resources	30	Environmental Management and Conservation	Unit 30: LO1/2/3 Unit 30: LO4	Unit 12: No significant match Unit 12: LO4 Partial match
13	Human Health and Nutrition	24	Human Health and Nutrition	Unit 24: LO1 Unit 24: LO2 Unit 24: LO3 Unit 24: LO4	Unit 13: LO1 Partial match Unit 13: LO2 Partial match Unit 13: LO4 Partial match Unit 13: LO3 Partial match
14	Food Technology		New unit, no equivalent		
15	Introduction to Polymer Materials and Properties		New unit, no equivalent		
16	Polymer Manufacturing Techniques		New unit, no equivalent		
17	Fundamentals of Biochemistry	9	Biochemistry of Macromolecules and Metabolic Pathways	Unit 9: LO1 Unit 9: LO2 Unit 9: LO3 Unit 9: LO4	Unit 17: LO1 Unit 17: LO2 Unit 17: LO4 Partial match Unit 17: LO3

RQF HNC Units		QCF HNC units		Mapping comments	
No	RQF unit title	No	QCF unit title	QCF LOs	RQF LOs
18	Microbiological Techniques	6	Industrial Microbiology	Unit 6: LO1 Unit 6: LO2 Unit 6: LO3 Unit 6: LO4	Unit 18: LO3 Partial match Unit 18: LO4 Partial match Unit 18: No match Unit 18: No match
19	Managing Food Properties and Production Systems		New unit, no equivalent		
20	Introduction to Material Properties and Applications		New unit, no equivalent		
21	Criminal Investigation		New unit, no equivalent		
22	Theories and Causes of Crime		New unit, no equivalent		
23	Psychology in the Forensic Setting		New unit, no equivalent		
24	Sampling and Sample Preparation		New unit, no equivalent		
25	Personal and Professional Development for Scientists	2	Personal and Professional Development	Unit 2: LO1/LO3/LO4 Unit 2: LO2	Unit 25: No match Unit 25: LO2/LO3 Partial match
26	Management of Scientific Projects		New unit, no equivalent		
64	Work-based Investigation	11	Work-based Investigation	Unit 11: LO1 Unit 11: LO2 Unit 11: LO3 Unit 11: LO4	Unit 64: LO1 Unit 64: LO3 Unit 64: LO2 Unit 64: LO4
35	Analytical Chemistry		New unit, no equivalent		

HNCs in Applied Sciences: Unit Mapping Depth to HNC Chemical Science for Industry

RQF HNC Units		QCF HNC units		Mapping comments	
No	RQF unit title	No	QCF unit title	QCF LOs	RQF LOs
1	Fundamentals of Laboratory Techniques	8	Laboratory Techniques for Applied Chemistry	Unit 8: LO1 Unit 8: LO2 Unit 8: LO3 Unit 8: LO4 Unit 8: LO1/LO2/LO3/LO4	Unit 1: LO2 Partial match Unit 1: LO1 Partial match Unit 1: LO1 Partial match Unit 1: LO1 Partial match Unit 1: LO3 No match Unit 1: LO4 Partial match
2	Scientific Data Handling Approaches and Techniques	9	Analysis of Scientific Data and Information	Unit 9: LO1 Unit 9: LO2 Unit 9: LO3 Unit 9: LO4	Unit 2: LO1 Partial match Unit 2: LO2 Partial match Unit 2: LO4 Partial match Unit 2: LO3 Partial match No match

RQF HNC Units		QCF HNC units		Mapping comments	
No	RQF unit title	No	QCF unit title	QCF LOs	RQF LOs
3	Regulation and Quality in the Applied Sciences	15 13	Laboratory Management Quality Assurance and Quality Control	Unit 15: LO1 Unit 15: LO2 Unit 15: LO3 Unit 15 LO4 Unit 13: LO1 Unit 13: LO2 Unit 13: LO3 Unit 13: LO4	Unit 3: No match Unit 3: No match Unit 3: LO1 Partial match Unit 3: LO2/LO4 Partial match Unit 3: No match Unit 3: No match Unit 3: LO3 Partial match Unit 3: No match
4	Cell Biology		No related QCF Unit		
5	Fundamentals of Chemistry	6 5 7 8	Inorganic Chemistry Organic Chemistry Physical Chemistry Laboratory Techniques for Applied Chemistry	Unit 6: LO1 Unit 6: LO2 Unit 6: LO3 Unit 6: LO4 Unit 5: LO1/LO3/LO4 Unit 5: LO2 Unit 7: LO1/LO4 Unit 7: LO2/LO3 Unit 8: LO4	Unit 5: LO1 Partial match Unit 5: LO1 Partial match No match No match Unit 5: LO4 Unit 5: No match Unit 5: LO2/LO3 Partial Match Unit 5: No match Unit 5: LO2 Partial match
6	Anatomy and Physiology		No related QCF Unit		

RQF HNC Units		QCF HNC units		Mapping comments	
No	RQF unit title	No	QCF unit title	QCF LOs	RQF LOs
7	Inorganic Chemistry	6	Inorganic Chemistry	Unit 6: LO1 Unit 6: LO2 Unit 6: LO3 Unit 6: LO4	Unit 7: LO1 Partial match Unit 7: LO2 Partial match Unit 7: LO3 Partial match Unit 7: LO4 No match
8	Organic Chemistry	5	Organic Chemistry	Unit 5: LO1 Unit 5: LO2 Unit 5: LO3 Unit 5: LO4	Unit 8: LO1/LO4 Partial match Unit 8: LO2 Partial match Unit 8: LO3 Partial match Unit 8: LO3 Partial match
9	Physical Chemistry	7	Physical Chemistry	Unit 7: LO1 Unit 7: LO2 Unit 7: LO3 Unit 7: LO4	Unit 9: LO1/LO4 Partial match Unit 9: LO2/LO4 Partial match Unit 9: No match Unit 9: LO3/LO4 Partial match
10	Principles of Ecology and Their Applications		No related QCF Unit		
11	Physiological Adaptions of Plants to Environmental Changes		No related QCF Unit		
12	Managing Environmental Resources		No related QCF Unit		
13	Human Health and Nutrition		No related QCF Unit		
14	Food Technology		No related QCF Unit		

RQF HNC Units		QCF HNC units		Mapping comments	
No	RQF unit title	No	QCF unit title	QCF LOs	RQF LOs
15	Introduction to Polymer Materials and Properties	23	Polymer chemistry	Unit 23: LO2	Unit 15: LO2 Partial match
16	Polymer Manufacturing Techniques	55	New unit, no equivalent		
17	Fundamentals of Biochemistry	22	Biochemistry of Macromolecules and Metabolic Pathways	Unit 22: LO1 Unit 22: LO2 Unit 22: LO3 Unit 22: LO4	Unit 17: LO1 Unit 17: LO2 Unit 17: LO4 Partial match Unit 17: LO3
18	Microbiological Techniques		No related QCF unit		
19	Managing Food Properties and Production Systems		New unit, no equivalent		
20	Introduction to Material Properties and Applications	27	Materials Science and Technology	Unit 27: LO1 Unit 27: LO2 Unit 27: LO3 Unit 27: LO4	Unit 20: LO1/LO2 Partial match Unit 20: LO4 Unit 20: No match Unit 20: LO3
21	Criminal Investigation		New unit, no equivalent		
22	Theories and Causes of Crime		New unit, no equivalent		
23	Psychology in the Forensic Setting		New unit, no equivalent		
24	Sampling and Sample Preparation		New unit, no equivalent		

RQF HNC Units		QCF HNC units		Mapping comments	
No	RQF unit title	No	QCF unit title	QCF LOs	RQF LOs
25	Personal and Professional Development for Scientists	2	Personal and Professional Development	Unit 2: LO1/LO3/LO4 Unit 2: LO2	Unit 25: No match Unit 25: LO2/LO3 Partial match
26	Management of Scientific Projects		No related QCF Unit		
64	Work-based Investigation	12	Work-based Investigation	Unit 12: LO1 Unit 12: LO2 Unit 12: LO3 Unit 12: LO4	Unit 64: LO1 Unit 64: LO3 Unit 64: LO2 Unit 64: LO4
35	Analytical Chemistry	11	Analytical Chemistry	Unit 11: LO1 Unit 11: LO2 Unit 11: LO3 Unit 11: LO4	Unit 35: No match Unit 35: LO2 Partial match Unit 35: LO4 Partial match Unit 35: LO3 Partial match

October 2022

For information about Pearson qualifications, including Pearson Edexcel and BTEC qualifications visit qualifications.pearson.com

Pearson Education Limited. Registered in England and Wales No. 872828
Registered Office: 80 Strand, London WC2R 0RL.

VAT Reg No GB 278 537121