Institute for Apprenticeships & Technical Education

Health and Science: Science

T Level outline content: Final version for inclusion in ITT

March 2019

Contents

Introduction

T Levels are new, two-year, technical study programmes, designed with employers to give young people the skills that industry needs. T Levels will provide a mixture of:

- technical knowledge and skills specific to their chosen industry or occupation
- an industry placement of at least 45 days in their chosen industry or occupation
- relevant maths, English and digital skills
- common workplace skills.

T Levels will become one of three major options for students to study at level 3, alongside apprenticeships for those who wish to study and train for a specific occupation 'on the job', and A levels for students who wish to continue academic education.

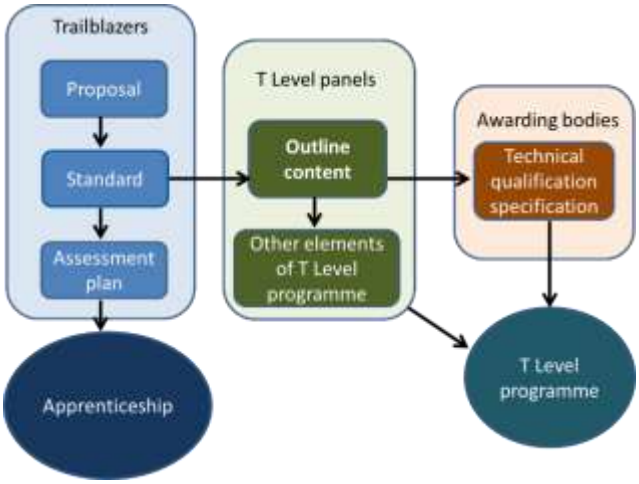
When they complete a T Level study programme, students will be able to choose between moving into a skilled occupation or further study, for example, a higher or degree level apprenticeship, or higher level technical study, including higher education.

Technical education has been categorised into fifteen different technical routes, according to occupational specialism. T Levels will be available across eleven of those routes, with occupations in the remaining four routes accessible through an apprenticeship only. Most routes have been split into a number of pathways; the T Level will broadly sit at pathway level. The occupations within scope for each T Level are set out in the Institute for Apprenticeships and Technical Education's occupational maps.

Outline content

This outline content has been produced by T Level panels of employers, professional bodies and providers, and is based on the same standards as those used for apprenticeships. The outline content will form the basis of the specifications for T Level Technical Qualifications, which will be developed by awarding organisations for approval by the Institute for Apprenticeships and Technical Education. One awarding organisation will be appointed to develop and deliver each Technical Qualification following a procurement process.

The diagram below demonstrates how the same standard created by employer-led Trailblazer groups is used for both Apprenticeships, and as the basis for this outline content. It also shows that this outline content will be used by awarding organisations to develop the full Technical Qualification (TQ) specification.

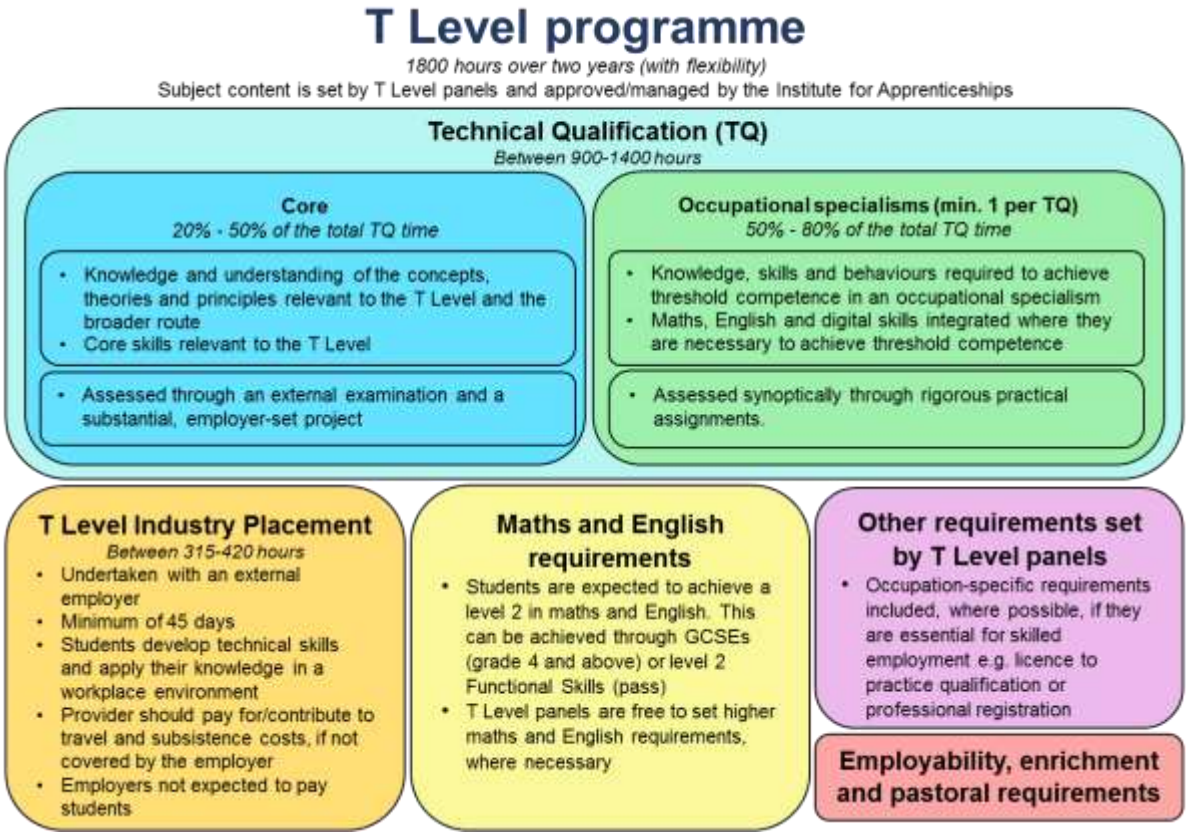


Colleges and other education and training providers will decide how to structure the T Level courses they offer, based on the qualification specifications. This will enable them to deliver the study programme's mandatory components in the most effective way for students.

T Level study programmes will include the following mandatory elements:

- a 'core' set of underpinning knowledge, concepts and skills, tailored for their chosen industry and occupation: 'core content'
- specialist content covering occupational or industry-specific skills: 'occupational specialist content'
- an industry placement with an employer, which will last for a minimum of 45 working days.

The diagram below demonstrates the different elements of a T Level programme. This outline content relates solely to the Technical Qualification part of a T Level programme.



Purpose Statement

Qualification Purpose

The purpose of the level 3 Technical Qualification (TQ) is to ensure students have the knowledge and skills needed to progress into skilled employment or higher level technical training relevant to the T Level.[1]

To achieve this, each level 3 Technical Qualification must:

- provide reliable evidence of students' attainment in relation to:
    - the core knowledge and skills relevant to the route and occupational specialisms covered by the qualification
    - the knowledge and skills required for at least one occupational specialism relevant to the qualification.

- be up-to-date, providing the knowledge and skills needed for the occupations have continued currency among employers and others.

- ensure that maths, English and digital skills are developed and applied where they are essential to achieve occupationally relevant outcomes.

- ensure that the minimum pass grade standard for occupational specialisms attests to competence, meets employer expectations, and is as close to full occupational competence as possible.

- allow the accurate identification of students' level of attainment and the effective differentiation of their performance.

- provide a clear and coherent basis for development of suitably demanding high-quality level 3 courses, which enable students to realise their potential.

- provide students with the opportunity to manage and improve their own performance.

- support fair access to attainment for all students who take the qualification, including those with special educational needs and disabilities (SEND).

[1] The Institute for Apprenticeships and Technical Education may only approve the qualification "if satisfied that by obtaining the qualification a person demonstrates that he or she has attained as many of the outcomes set out in the standards as may reasonably be expected to be attained by undertaking a course of education" (Technical and Further Education Act 2017).

Technical Qualification Design

T Level programmes will differ in length to reflect the requirements of different occupations, but are expected to last 1800 hours over two years (on average).

To accommodate legitimate differences in content across T Levels, we propose that the total time for the Technical Qualification:

- will fall within a defined range of between 900 and 1400 hours
- is no less than 50% of the time for the T Level programme as a whole and
- is no more than 75% of the total time for the programme as a whole.

Component	Content	Assessment	Grading	Planned Hours
Core Students complete one component which covers all the core content	Knowledge and understanding of contexts, concepts, theories and principles relevant to the T Level Ability to apply core knowledge and skills, through a project, to meet employer-set requirements	Assessed through an externally set test and an employer-set project	Six point scale plus ungraded (U) A* – E and U	Between 20% and 50% of the qualification time
Occupational specialisms Students must complete at least one, or more depending on the minimum requirements specific to the qualification	Knowledge and skills required to achieve a level of competence needed to enter employment	Synoptic assessment of performance outcomes, to determine whether a student meets the minimum competence requirements	Three point scale plus ungraded (U) Distinction, Merit, Pass and Ungraded	Between 50% and 80% of qualification time

Health and Science: Science

Awarding organisations will need to ensure that students have an up-to-date knowledge of the legal and regulatory obligations relating to employment in the occupations relevant to the T Level, and understand the practical implication of these on their work.

Maths, English and Digital skills are set out in the final section of this document. Awarding organisations should integrate these within the qualification so that they are applied in occupationally relevant contexts. Other core skills and behaviours important for employability are already integrated within the content and must be clearly specified in the qualification specification.

Core content

The core content relates to the whole route, and the pathway that the Technical Qualification covers. This breadth of content will help to ensure students are able to apply their skills in a variety of contexts and for a variety of different purposes. The content will vary depending on the requirements of the route and the pathway or occupations covered by the scope of the qualification.

The core knowledge and understanding is assessed through an examination and core skills through a practical employer-set project.

The core knowledge and understanding focuses on students' knowledge and understanding of contexts, concepts, theories and principles relevant to the T Level. This could include, where appropriate, assessment of knowledge and understanding relevant to the route and the pathway.

The employer-set project provides the opportunity to develop and apply a minimum range of core skills important for employability.

Awarding organisations can integrate knowledge in the employer-set project, to contextualise core skills. The allocation of content to each type of assessment will need to be approved by the Institute for Apprenticeships and Technical Education.

Core knowledge and understanding across the Health and Science route

Element	Content
Working within the Health and Science sector	• Purpose and importance of adhering to organisational policies and methods of working, including policies related to employment such as equality, diversity and inclusion, employment contracts, performance reviews, disciplinary procedures and grievance procedures • Purpose and importance of quality standards, quality management and audit processes

	• Introduction to the importance of ethics and Codes of Conduct • Awareness of employment and progression opportunities which exist within the sector, and opportunities which exist for membership and/or professional registration at a later stage in an individual's career
Health, Safety and Environmental regulations in the Health and Science sector	Regulations, legislation and procedures including: • Health and Safety at Work Act 1974 • Management of Health and Safety at Work Regulations 1999 including assessing potential hazards and risks, including specific levels of risk, minimising these risks through the use of relevant risk assessment strategies. Completing risk assessment documentation • Control of Substances Hazardous to Health (COSHH) Regulations 1994 and subsequent amendments 2002 • Mandatory use of appropriate Personal Protective Equipment (PPE), Personal Protective Equipment at Work Regulations 1992 • Reporting of Injuries, Diseases and Dangerous Occurrences Regulations 2013 (RIDDOR) • Accident or "near miss" reporting • Environmental Protection Act 1990 • Waste management and waste streams taking into consideration special waste and hazardous waste. The Special Waste Regulations 1996 & The Hazardous Waste Regulations 2005 & The Waste Electrical and Electronic Equipment Regulations (WEEE) 2012/19/EU • Fire precaution (workplace regulations) 1999 and organisational procedures for carrying out evacuations • Manual handling, including moving and positioning of equipment, and workplace ergonomics: Manual Handling Operations Regulations 1992 • Workplace ergonomics including the use of display screen equipment. Health and Safety (Display Screen Equipment) Regulations 1992 How to promote health and safety at work How to deal with situations that can occur in a health or science environment that could cause harm to self or others, e.g. spillage of hazardous material
Managing information and data within the Health and Science sector	Recording and reporting information and data • How to collect and record information and data • Importance of accuracy, attention to detail and legibility of any written information or data • Sources of information and data: how to apply relevant data and information in a range of health and science working environments

	• Application of new technology in the recording and reporting of information and data Protection of information and data • Data protection legislation, regulations and local ways of working, including the importance of confidentiality and the General Data Protection Regulation (GDPR) 2018 • Ensuring confidentiality when using screen to input or retrieve information or data • Positive use of and restrictions on the use of social media in the Health and Science sector Data storage • How and why IT systems are used to record, retrieve and store information and data • Security in relation to IT systems, including the need for back-up systems and required cyber security measures • What to do if information is not stored securely
Good Scientific and Clinical Practice	Knowledge and understanding of the principles of good scientific and clinical practice, including an understanding of the importance of adhering to the following: Standard Operating Procedures • Use and importance of following Standard Operating Procedures (SOPs), including what a SOP is, who it is applicable to and how to access SOPs for a given activity Management of equipment and work areas • Importance of regular cleaning of work areas and suitable preparation for use • Importance of maintenance, cleaning and servicing of equipment • Calibration and testing of equipment to ensure it is fit for use. Current calibration status of equipment and escalation routes if equipment is not correctly calibrated/unsuitable for intended use Stock control • Management and ordering of stock to ensure sufficient supply of required consumables and materials Storage • Appropriate storage of products, materials and equipment including storage and use of limited stability products
Core Science concepts	An understanding of fundamental scientific concepts which have application to the health, healthcare science and science pathways: **Structure and function of cells and tissues:** cell theory as an underlying concept, ultrastructure including organelles and similarities/differences between animal and plant cells, specialisation of cells

	Large molecules: proteins, carbohydrates and lipids are the three key groups of large molecules: Understanding of structures to understand function related to their properties **Exchange and transport mechanisms;** need for exchange of substances, how/where this takes place, including cellular exchange and transport, factors that affect requirements and give rise to specialised systems **Genetic information and Genetics:** including sequence of bases in DNA molecule, relationship to the mechanism of inheritance, variation and relationship between organisms **Microbiology:** including classification and characteristics of micro-organisms and microscopy techniques **Immunology:** The nature of infection and its existence in individuals and amongst populations and communities. Examples of infectious diseases and causative agents. Possible causes of infection and routes of transmission. How the body responds to invasion by foreign substances including phagocytosis and actions of T-cells and B-cells. Understanding of cell mediated immunity and antibody mediated immunity **Structure of materials and the relationship with physical and chemical properties**: including physical properties of metals-conductivity (electrical and thermal), malleability, ductility. Chemical properties such as reactivity. Relationship between the structure and properties of composite materials, such as ceramics and polymers **Acids/bases and chemical change:** concept of strong and weak acids (as distinct from dilute and concentrated solutions), properties and characteristics, reactions and resulting salts produced **Rates of reaction and energy changes:** collision theory, relationship with temperature changes on rates of reaction, role of catalysts in reactions **Chemical analysis of substances:** use of a range of tests and techniques to detect, identify chemical composition and determine amounts of substances. To include simple tests, use of instrumental techniques and determination of amounts of acids and alkalis by titration **Electricity:** current, potential difference and resistance, electrical charge and current, resistors and mains electricity

	Magnetism and electromagnetism: poles of magnets, magnetic fields, use of electromagnetism **Waves:** function in terms of carrying both energy and information, properties of waves and uses **Particles and radiation:** types of radiation, properties and interaction with matter **Units:** use of SI units and conversion between units, appropriate use of significant figures and science notation

Core knowledge and understanding across Science pathway

Element	Content
The Science sector	How route core knowledge of the Health and Science sector relates and is applied to the Science pathway, as well as specific knowledge on: • The diversity of employers, organisations and working environments within the Science sector • Different job roles within the Science sector • Application of science in non-science sectors: possible employers and job roles • Individual roles and responsibilities in line with job description and person specification; how roles fit into organisational structures • The impact of job role on others in the working environment (including colleagues within own team and others) • Good Laboratory Practice (GLP), Good Manufacturing Practice (GMP) • The key principles of continuous improvement for scientific tasks • Internal and external regulatory environment pertinent to occupations in the Science sector and how to ensure compliance with all relevant regulations, for example pharmaceutical sector and food science sector • When regulations do and don't apply to different work activities within the Science sector • Factors that impact on the commercial activities of science organisations • The importance and impact of innovation within the Science sector, examples of recent important innovations such as the increased use of Artificial Intelligence

Further science concepts	How route core Scientific knowledge relates to the Science pathway, as well as specific understanding of further science concepts: • **Cell cycle:** Meiosis and Mitosis: stages and phases, knowledge of copying of genetic information and that this is passed to daughter cells. Differences between meiosis and mitosis • **Cellular respiration**: breakdown of glucose and other respiratory substrates to make energy carrying molecules called ATP. How ATP provides source of energy for biological processes • **Enzyme and protein structure**: how the sequence of bases in the DNA molecule determines the structure of proteins, including enzymes. How enzymes catalyse a wide range of intracellular reactions. How mechanism of action and other properties of enzymes are determined by their tertiary structure • **Pathogens:** definition of, types of, examples and the diseases they can cause • **Classification of biological materials:** division into four groups according to their molecular structures and the functions they perform • **Formulae and equations:** empirical and molecular formulae, balanced equations, relative atomic mass and relative isotopic mass, mole concentrations and calculations • **Kinetic changes**: conditions that effect chemical reactions, such as temperature and pressure: ways to reduce activation energy such as use of catalysts • **Analytical techniques:** for example, chromatography, titrimetric and separation, theory and application • **Gas laws:** definitions and applications to determine behaviour of gases in particular conditions, including use of Kelvin temperature. Compression of gases • **Pressure/fluid/viscosity:** laws and relationships
Application of Safety, Health and Environmental practices in the workplace	How core knowledge of health and safety in the Health and Science Route Core relates and applies to the Science pathway, as well as specific knowledge on: • REACH guidelines • Scientific environmental specific legislation • Control of Major Accident Hazards (COMAH) • Biohazards • Controlled substances and controlled drugs • Localised extraction and ventilation • Environmental risks and regulations • Containment levels • Noise regulations, such as maximum decibel levels, and required PPE for potential noise hazards • High risk environments or substances, for example working with gases, explosive environments, lasers or ionising radiation

	• Electromagnetic regulations including use of devices such as radios and mobile phones in the proximity of specific equipment and instrumentation • Decontamination procedures for dealing with a range of common substances in the scientific environment • Use of material data sheets and associated codes
Scientific methodology	How core knowledge of Good Scientific and Clinical Practice relates to the Science pathway, as well as specific knowledge on: • Experimental design: the importance and purpose of planning • Importance of a hypothesis and/or determining the performance criteria and/or outcomes which can be tested • Planning methodologies: objective setting, critical path analysis, financial forecasting, risk management and time management • Meeting customer/client requirements • Making use of and accessing information from scientific literature and research databases • Sampling techniques for a range of common scientific subject matter and outcomes • The range of measurement techniques for a variety of common scientific subject matter and outcomes (including micro and macro scales relevant to the subject matter being measured) • Need for reliable, verifiable and accurate recording • Problem recognition and application of problem solving techniques • Evaluation of scientific methodology and making recommendations for improvements • Awareness of ISO standards
Data handling and processing	How route core knowledge of Managing Information and Data within the Health and Science Sector relates to the Science pathway, as well as specific knowledge on: • How to collect, record, interpret and analyse data in the scientific environment • Types of data: difference between Qualitative and Quantitative data • Data recording: recording requirements e.g. laboratory notebooks, data storage, and Laboratory Information Management systems (LIMs) • Data capture and software systems commonly used in scientific settings • Identification of data errors: random errors and systematic errors, how to minimise errors • Data processing and analysis, including trends in data • Appreciation of the varying statistical techniques that can be used for data analysis and data presentation in the science sector

	• Data evaluation: how to review data and make assessments based on that review • Variables to consider: preventing/reducing bias • Consideration of statistical analysis in determining sample size • Understanding and applying scale and proportion
Experimental equipment and techniques	• Knowledge of experimental equipment and techniques, including: Equipment faults and technical factors impacting on scientific results, requirements for positive and negative controls • Selection and use of appropriate equipment such as: scientific balances, glassware, centrifuges, digital and non-digital pipettes, incubators, fridge/freezers, cryogenic equipment, fume cupboards, glove boxes, temperature and humidity recorders, pH meters, microbiological equipment, autoclaves • Appropriate techniques for handling a range of different substances: i.e. solid, liquid and gases • Appropriate measurement equipment for a range of different substances and measurement scales (e.g. kilo, mili, nano scales) • Microscopy techniques including use of light microscope and haemocytometer • How to follow, and reason for using, aseptic techniques
Ethics	• Understanding of ethics in science, including: Ethical practice in all areas of science, e.g. Rigour, respect, Responsibility A Universal Ethical Code For Scientists 2007 • Intellectual property rights (IP) • Integrity • Codes of practice within organisations • Respect in the workplace

Employer-set project

The employer-set project ensures students have the opportunity to combine core knowledge and skills to develop a substantial piece of work in response to an employer-set brief.

To ensure consistency in project scope and demand, awarding organisations will develop assessment objectives, which require students to:

- plan their approach to meeting the brief
- apply core knowledge and skills as appropriate
- select relevant techniques and resources to meet the brief
- use maths, English and digital skills as appropriate
- realise a project outcome and review how well the outcome meets the brief.

The awarding organisation will work with a relevant employer or employers, to devise a set brief that:

- ensures a motivating starting point for students' projects, for example, a real-world problem to solve
- ensures students can generate evidence that covers the assessment objectives
- is manageable for providers to deliver
- is officially approved by the awarding organisations and employer.

For Science, in achieving the assessment objectives and meeting the brief, students must demonstrate the following core skills, through mostly self-directed activities to promote and develop independent learning:

- **Project management** to include independently producing a high-level project plan taking into account: timing of activities, resource and financial considerations, ethical considerations, adherence to health and safety and the maintenance of quality outcomes
- **Researching** from independently identified sources including scientific literature and other appropriate sources, prior to the project commencement and referencing these sources appropriately
- **Working with others** e.g.to ensure that any scientific techniques meet all safety, health and environmental requirements
- **Creativity and Innovation** within a science context to improve practice, processes and outcomes
- **Problem solving** within a science context and where appropriate making use of new technologies to solve problems
- **Communication** e.g. providing results and recommendations in appropriate formats to clients and/or wider stakeholders which take into consideration 'business benefits' or show commercial awareness in a variety of formats including written reports and verbal presentations
- **Reflective evaluation** to be able to make improvements to own practice e.g. having completed a task reviewing and suggesting improvements and consideration of lessons learnt for own professional development.

Occupational Specialist Content

Specialist content is structured into different occupational specialisms, which correspond to the apprenticeship standards listed on the occupational map covered by the T Level. Occupational specialisms ensure students develop the knowledge and skills necessary to achieve a level of competence needed to enter employment in the occupational specialism.

Achievement of this minimum level of competence signals that a student is well-placed to develop full occupational competence, with further support and development, once in work (including an apprenticeship). The knowledge and skills listed are required to achieve one or more ‘performance outcomes’. These indicate what the student will be able to do as a result of learning and applying the specified knowledge and skills.

In essence, each performance outcome describes, at a high level, what the student ‘can do’ to have met minimum competence requirements in an occupational specialism.

Core skills and behaviours are specified in occupational specialism(s) only where they are essential to achieving the given performance outcome. Although the behaviours maybe assessed implicitly through application of skills, they must be clearly specified in the qualification specification to support effective application of those skills.

Occupational Specialism: Technical: Laboratory Sciences

Performance Outcome 1: Perform a range of appropriate scientific techniques to collect experimental data in a laboratory setting, complying with regulations and requirements

Knowledge specific to Performance Outcome	Skills specific to Performance Outcome
Safety, health and environmental practices in laboratory science How core knowledge of health, safety and environmental practices in Science relates to Technical: Laboratory Sciences when performing scientific techniques, this includes knowledge of all legislation and regulations, use of Personal Protective Equipment (PPE), and completing risk assessments	Work safely in a laboratory, maintaining excellent housekeeping whilst following appropriate safety, environment and risk management systems Comply with all relevant legislation and regulations in the handling and disposal of solids, liquids and gases (including toxics, corrosives, irritants, sensitisers, flammables, air/water sensitive materials, explosives, compressed gases, pyrophoric, oxidisers, radioactive materials, biohazards and contaminant levels) Assess hazards and risks when performing a scientific technique including writing a risk assessment and modifying work where required Use appropriate Personal Protective Equipment when performing scientific techniques Follow all relevant legislation and risk assessments when performing scientific techniques
Ethics How core knowledge of ethics in science relates to Technical: Laboratory Sciences, this includes codes of conduct for areas such as confidentiality and intellectual property requirements	Adhere to ethical practice and codes of conduct to ensure confidentiality and intellectual property requirements are met

Core Scientific knowledge How route and pathway core knowledge of science relates to Technical: Laboratory Sciences, as well as occupationally specific knowledge, including, but not limited to: • **Atomic structure**: chemical properties of elements depends on their atomic structure. How the arrangement of electrons is linked to the way in which elements are arranged within the periodic table. Nomenclature related to atomic structure • **Amount of substrate**: definitions of relative atomic mass and relative molecular mass. The mole and Avogadro constant; using these to calculate mass and molar concentration • **Molecular structure and bonding**: different types of bonds including ionic and covalent bonds, as well as metallic bonding and the shapes of molecules. Effect of molecular structure and bonding on a range of properties including solubility and dissolution • **Organic chemistry**: nomenclature. Reactions. Important compounds including alkenes and alcohols. Principles of organic analysis • **Oxidation and reduction:** definitions in terms of oxygen transfer, hydrogen transfer and electron transfer, oxidising and reducing agents, redox reactions. Electrode potentials and electrochemical cells • **Enthalpy and Entropy:** definition of these terms. Importance of understanding stability of compounds, and why chemical reactions occur. Link between enthalpy and entropy change allowing free energy change to be calculated. How to perform calculations of enthalpy changes using Hess cycles/bon enthalpies	Apply core and occupationally specific scientific knowledge to techniques being performed in the laboratory environment

• **Materials science:** applications including polymers, alloys and composites. Definitions of terms, characteristics of addition polymerisation and condensation polymerisation • **Metabolic pathways and bioenergetics**: anabolic and catabolic pathways, differences in terms of energy change. Awareness of the most important pathways: glycolysis, Krebs cycle, Acetyl-Co A oxidation, beta-oxidation and oxidative phosphorylation. Mechanisms of pathway control • **Genotyping and Phenotyping:** genetic basis; understanding of terms. Process of determining differences through investigation of DNA sequencing using analytical techniques such as Polymerase Chain Reaction (PCR) • **Ecosystems:** definitions and terms, biomass transfer, recycling within ecosystems, primary succession, measuring the distribution and abundance of organisms in an ecosystem • **Nanoscience and nanotechnology:** general principles in terms of the manipulation of matter whose basic components are of a nanoscale size • **Electronics:** analogue and digital signals, use of electronics in technology • **Nuclear physics:** properties of stable and unstable nuclei, link between energy and mass	
Scientific tasks How scientific and maths skills are applied when completing scientific tasks The range of techniques used within laboratory sciences to complete scientific tasks	Perform a range of practical scientific techniques following multistep scientific methods and Standard Operating Procedures within a laboratory setting Perform a range of practical scientific techniques applying scientific and maths skills Use appropriate practical scientific techniques to analyse substances and environments

How core knowledge and understanding of scientific techniques relates to Technical: Laboratory Sciences, as well as occupationally specific knowledge, including, but not limited to: • Analysis of substances and environments • Titration • Micro and nanoscience • Preparation of serial dilutions Knowledge of laboratory techniques to identify, separate and analyse substances and environments • Calorimetry • Colorimetry • Chromatography • Distillation • Filtration • Electrochemistry • Spectroscopy • Thermochemistry • Characterisation Knowledge of laboratory techniques to include, but not be limited to: • Tissue culture • Cloning, protein purification, genes and enzyme classification • Microbiology techniques Knowledge of environmental laboratory techniques, such as • Biochemical Oxygen Demand (BOD) • Chemical Oxygen Demand (COD) • Total Organic Carbon (TOC) • Suspended solids • Measuring toxicology	Use appropriate practical scientific techniques to measure a range of physical properties such as polarity, temperature, pressure, conductivity and radioactivity Use appropriate practical scientific techniques to isolate materials Prepare a solution of defined molar concentration Use appropriate practical scientific techniques to separate materials Use appropriate SI units and be able to work with a range of appropriate scales when conducting scientific tasks Convert between measurement units when required Follow a scientific paper in the conducting of a scientific technique

Knowledge of laboratory techniques used in the science manufacturing environment, including but not limited to those used in the petrochemical industry and specialist and bulk manufacture of chemicals Knowledge of physics laboratory techniques in: • Electronics • Mechanics and ionising radiation • Thermal • Electricity • Magnetism Knowledge of cutting-edge techniques, particularly those related to genomics, including: • Polymerase chain reaction (PCR) • Gel electrophoresis • Flow cytometry • Nuclear magnetic resonance spectroscopy(NMR) • Next generation sequencing	
Scientific equipment, instrumentation and use of raw materials and reagents **Equipment and instrumentation** How core knowledge of scientific equipment relates to Technical: Laboratory Sciences, as well as occupationally specific equipment, including, but not limited to: • Range of equipment used to separate samples such as: column chromatography, liquid and gas chromatography, mass spectrometry, nuclear magnetic resonance • Electrical calorimeters	Use appropriate equipment to complete practical scientific techniques Calibrate scientific equipment and check it is fit for use Demonstrate practical technical competence in the use of instrumentation and equipment

• Equipment to analyse Biochemical Oxygen Demand, Chemical Oxygen Demand and Total Organic Carbon content • Cryogenic equipment • Physics laboratory equipment e.g. oscilloscopes **Raw materials and reagents** Understanding the importance of using appropriate reagents and raw materials to complete practical scientific tasks. Considering factors such as: • Sources and suppliers • Handling and storage, including shelf life to ensure integrity • Quality Assurance of raw materials and reagents	
Data Collection and Recording How core knowledge of data collection and recording relates to Technical: Laboratory Sciences including producing reliable and verifiable results, recording in a clear and accurate manner and the use of appropriate units, notation and significant figures As well as occupationally specific knowledge and understanding of: • Genomics • Computation • Big data sets • Algorithms	Produce reliable and verifiable data from scientific techniques Record data and records of work undertaken in a clear and accurate manner Use appropriate units, notation and use of significant figures when recording data
Legislation, Regulations, Standards and Guidelines How core knowledge of legislation, regulations, standards and guidelines relates to Technical: Laboratory Sciences, including all relevant regulations, regulatory bodies and standards	Adhere to all procedures to ensure compliance with all relevant regulations and quality standards when conducting scientific techniques, including GLP and GMP

Regulations including, but not limited to: • Good Laboratory Practice (GLP) • Good Manufacturing Practice (GMP) • Quality Management systems (QMS) • Good clinical Practice (GcP) Regulatory Bodies • MHRA • FDA • European Medical Agency Standards including but not limited to: • Industry specific regulations • UKAS • ASTM • Pharmacopoeia • ISO Use and importance of Standard Operating Procedures (SOP) within the Laboratory Environment	Follow Standard Operating Procedures where applicable when performing scientific techniques

Performance Outcome 2: Plan, review, implement and suggest improvements to scientific tasks relevant to a laboratory setting

Knowledge specific to Performance Outcome	**Skills specific to Performance Outcome**
Planning laboratory techniques and use of equipment How core knowledge of planning relates to Technical: Laboratory Sciences including but not limited to: • Determining the:	Design a scientific task to address a particular hypothesis including the use of controls (including positive and negative controls) Perform an appropriate literature search to help in the planning of scientific tasks

• customer requirements for laboratory analysis • laboratory sampling requirements • laboratory health, safety and environmental and regulatory requirements • resources required including laboratory equipment, reagents and consumables • scheduling of laboratory testing • scientific methods • storage of samples • format for the presentation of the data • Understanding role of others within the laboratory science environment • Developing a specific hypothesis to test using laboratory techniques • Use of positive and negative controls • Undertaking literature searches and using scientific papers As well as occupationally specific knowledge for planning laboratory techniques and equipment, including: • Laboratory method validation such as International Council of Harmonisation (ICH) requirements • Laboratory equipment validation • Awareness of concrete and abstract modelling techniques	Use information from scientific papers to plan scientific tasks Apply scientific knowledge and knowledge of scientific techniques to unfamiliar situations to plan a scientific task
Laboratory Data processing and analysis How core knowledge of laboratory data processing and analysis relates to Technical: Laboratory Sciences, including but not limited to: • Customer requirements for the processing of the results	Complete relevant calculations on data obtained in the laboratory environment Select and use appropriate statistical techniques to analyse results from scientific tasks

• Regulatory requirements e.g. validation • Relevant calculations • Conversion of units • Using the most appropriate statistical techniques • Presentation of data • The use of online databases • Use of laboratory control charts and trend charts • How to establish the validity of the results against the standards Occupationally specific knowledge for planning laboratory techniques and equipment, including: • Data processing of laboratory information to support improvements e.g. stability studies, laboratory trend charts, laboratory method validation results, and proficiency testing	Analyse, interpret and evaluate data from scientific tasks Present data in an appropriate format using appropriate statistical techniques, including the use of laboratory information management systems (LIMS) Be able to find relevant information in online databases in relation to scientific tasks, statistical techniques and laboratory information management systems (LIMS) Recognise the need for, and source, expert help in relation to laboratory data processing and analysis when required
Reviewing and improving laboratory methods and use of equipment Method: How core knowledge of reviewing and improving relates to Technical: Laboratory Sciences this occupational specialism, including but not limited to: • Laboratory reviewing strategies • How laboratory documents are created, reviewed and approved • How laboratory improvements can be implemented • Awareness of the use of computer modelling and simulation in the laboratory environment Equipment: As well as occupationally specific knowledge for reviewing and improving laboratory techniques and use of equipment, including:	Review and modify the method of a scientific task to improve the task Suggest, record and act upon improvements to a scientific task through the adoption of continuous improvement techniques

• How laboratory equipment documents are created, reviewed and approved, e.g. GLP requirements • Quality control • Laboratory method transfer	

Performance Outcome 3: Identify and resolve issues with scientific equipment or data errors

Knowledge specific to Performance Outcome	**Skills specific to Performance Outcome**

Equipment management
How core knowledge of laboratory equipment and equipment management relates to Technical: Laboratory Sciences including but not limited to:
• Maintenance, cleaning, calibration and validation of a range of laboratory equipment as outlined in the pathway core:
  • How to interpret manufacturers information
  • Employ the correct test equipment
  • Maintain records
  • Communicate the results
  • Safe disposal if equipment cannot be repaired
• Recognising equipment faults/ technical factors and their impacts on laboratory results
 	
Laboratory Equipment: Awareness of laboratory equipment to undertake scientific techniques commonly found in chemical, biological and physics laboratories as outlined in the pathway core
	Set up and calibrate a range of different types of equipment
	
	Carry out and record routine cleaning and maintenance of equipment
	
	Recognise when a piece of equipment is producing inaccurate data
	
	Recognise when equipment is likely to be being damaged or cause injury due to malfunction
	
	Recognise the need for, and source expert help when required

Laboratory Data errors How core knowledge of data errors relates to Technical: Laboratory Sciences including awareness of laboratory data errors, how they could occur and ways to minimise errors	Demonstrate an awareness of errors that can occur in scientific tasks Identify how possible data errors could occur in scientific task

Potential data errors that could occur: • Contamination of samples or equipment • Samples not stored correctly • Incorrect laboratory equipment used • Equipment not set-up correctly • Method not followed • Transcription error Ways to minimise errors: • Plan the work and workplace requirements • Read the risk assessment and COSHH sheet • Follow a validated method • Ensure equipment calibrated and set-up correctly • Store and label samples and standards correctly • Safely dispose of materials	Take steps to minimise errors in scientific tasks following continuous improvement techniques

Occupational Specialism: Technical: Food Sciences

Performance Outcome 1: Perform appropriate activities to support the food supply chain complying with regulatory requirements

Knowledge specific to Performance Outcome	Skills specific to Performance Outcome
Planning methodologies How core knowledge of planning methodologies relates to Technical: Food Sciences and the planning of procedures to support the food supply chain	Plan food safety and regulatory procedures using a range of planning methodologies
Legislation, regulations and ethics in the food and drink industry Legislation and regulations that apply to the food and drink industry including understanding of food safety and Health and Safety Use and purposes of food industry standards (e.g. British Retail Consortium, Standard Operating Processes, Quality Management Systems and internal and external specifications) Environmental legislation related to the food and drink industry UK end-to-end food supply chain, its sustainability and vulnerabilities and food fraud including Threats Analysis (TACCP) risk assessment procedure of existing suppliers Characteristics of the food and drink industry and the business workplace Ethical issues relating to the food and drink industry, for example:	Label products to show nutritional; calorific; allergen; origin of product; use by and best before dates and weights and measures Carry out a supplier assurance risk assessment for a variety of ingredients to ensure food safety Identify current supply chain and any potential areas of vulnerability using a Threats Analysis (TACCP) risk assessment Utilise horizon scanning tools to identify potential areas for food fraud

Fairtrade, use of sustainable palm oil, modern slavery, working time regulations	
Health and safety in the food and drink industry How core knowledge of health and safety relates to Technical: Food Sciences, as well as occupationally health and safety specific knowledge related to the food industry including: • Manual handling • Safe use of equipment • Standard operating procedures and personal protective equipment ergonomics	Work safely in the food environment Carry out risk assessments, identifying risks and mitigating factors
Hazard Analysis and Critical Control Points (HACCP) in the food and drink industry The importance of HACCP-based food safety management procedures The preliminary processes for HACCP-based procedures How to implement and maintain a HACCP-based food safety management system	Create a HACCP plan for a simple product
Food safety management The importance of food safety management in a Food Business Good Hygiene Practices (GHP) Risks to food safety and compliance with regulatory requirements	Maintain and implement a food safety system within a food production facility Carry out monitoring and review of food safety management

How to contribute to the maintenance of the food safety management system Monitoring and review of food safety management Methods of pest control and prevention	
Technical and quality management in the food industry Management systems, processes and industry standards used in food operations Technical and quality management procedures in food and drink operations Internal and external audit processes in food operations	Carry out an internal audit against agreed audit checklist and suggest appropriate corrective action for any issues found Review and maintain technical and quality management procedures
Microbiology How core knowledge of microbiology relates to Technical: Food Sciences, as well as occupationally specific knowledge related to the food industry including: • Awareness of pathogens and resulting toxins that can cause food borne illness • How to identify pathogens which cause food borne illness and disease • Hygiene measures used to control pathogens • How to sample an environment for contamination • Use of appropriate laboratory skills and equipment to identify pathogens	Take samples from all food surface areas in order to identify any pathogens present Use laboratory skills and equipment to identify pathogens Identify hygiene process failures and recommend system improvements
Raw Materials in the food industry	Selection of raw materials as per recipe/client requirement

Understanding of: • Sources and supply of raw materials • Specifications of raw materials • Functionality of raw materials • Systems for handling raw materials • Selection of raw materials • Quality assurance of raw materials • Storage of raw materials, in particular segregation and protection of integrity	Protection of integrity of products to ensure origin of product is maintained Follow segregation of raw materials to prevent DNA, allergen or microbial cross contamination
Food Science Understanding of: • Composition and functionality of food • Human nutritional requirements • Fermentation process • Shelf life of food	Follow all customer requirements to ensure quality of product and shelf life is maintained
Food technology Understanding of: • Energy transfer in food technology • Heat processing-based food technology • Heat removal-based food technology • Ambient temperature processing technologies • Packing and labelling of food products	Verify existing procedures are meeting food safety and quality standards
Food supply chain from end to end and relationships within it Possible adulteration within the food supply chain • Food fraud: how and where it could occur • Vulnerability, assessment and critical control points (VACCP)	Recognise when food adulteration is taking place and escalate as appropriate

How the origin of the product will confirm quality, traceability and can highlight potential concerns	

Performance Outcome 2: Develop new food and food related products to support the food supply chain

Knowledge specific to Performance Outcome	**Skills specific to Performance Outcome**
Product development process Understanding of the product development process from concept to launch Principles of New Product development (NPD) and Existing Product development (EPD) Impact of customer trends and requirements on the design of new product development; use of impact assessments to investigate such trends	Perform an impact assessment of customer trends on the design of both a NPD and EPD
Advanced recipe formulation First principles of: • Recipe balance • Ingredient substitution • Ingredient functionality Selecting correct ingredients for specific applications Raw material (RM) alternatives that can be used	Formulate a recipe from first principles using recipe balance and ingredient substitution Enhance an existing recipe selecting the correct ingredients based on their functionality Develop a food product considering raw material alternatives

Packaging innovation Awareness of new types of packaging to reduce plastic waste/increase opportunity for recycling	Develop a product considering innovations in packaging
Costing the production of products How to cost both new and existing products Cost to include ingredients, packaging, time spent, potential labour costs, electricity, transportation and viability of product	Carry out a product costing on a new product and on a modification to an existing product
Sustainability Understanding of: • Raw materials: importance of procuring from sustainable sources, for example palm oil • Packaging: reduction in use of plastic, particularly black plastic • Reuse of waste, for example biomass products • Energy usage: strategies for reduction of energy usage for example use of LED light bulbs • Transportation: consideration of 'food miles' move to 'green food miles', reduction of packaging in transportation	Carry out a sustainability analysis for a new product
Continuous Improvement (CI) Management in the food industry Key principles to include: • Workplace organisation techniques • How to maximise equipment and consider process limitations • Environmental and waste management systems and how to minimise waste • Drivers for cost and quality	Contribute to Continuous Improvement to drive down costs and drive up quality, including using IT systems to analyse and interpret data to identify trends

Selecting a suitable sampling method Considerations when selecting a suitable sampling method to include: • Sample size • Sample numbers per batch • Frequency of sampling	Collect samples as per procedural requirements
Selecting a suitable test method The test methods that can be used, when they are used and how to select a suitable test method: • Taste panels • Food allergen testing • Food contaminant testing • Nutritional analysis • Microbiological	Carry out taste panels to check for quality against quality assurance sheets as prescribed by the customer Analyse test results and provide recommendations for improvements

Performance Outcome 3: Identify and resolve issues in the food supply chain

Knowledge specific to Performance Outcome	**Skills specific to Performance Outcome**
Technical and quality problems in the food supply chain Problem solving techniques, including root cause analysis and investigation techniques, to resolve problems in food and drink operations Identifying and resolving problems relating to customer complaints and quality issues	Identify and resolve problems relating to quality issues and/or customer complaints using appropriate problem solving techniques Carry out root cause analysis of a problem and/or customer complaint and recommend suggestions for improvement
Testing and evaluation in the food supply chain	Carry out a taste panel and evaluate results

Principles of sensory evaluation in food operations and how to carry out sensory analysis Procedures for quality control testing and sensory analysis in food operations Sampling and use of sensory panels to evaluate quality in food operations Roles and maintenance of specifications and traceability in food operations	Carry out procedures for quality control testing and sensory analysis

Performance Outcome 4: Collect, analyse and interpret food production data

Knowledge specific to Performance Outcome	**Skills specific to Performance Outcome**
Food Production data How to collect, interpret and analyse food production data Using information and communication technology to support the interpretation and analysis of food production data Using management information systems (MIS) to obtain food production data Trends in food production data and relationship to continuous improvement	Create a spreadsheet and input management data to track production trends and present information in written and visual format and/or presentations

Occupational Specialism: Technical: Animal Sciences

Performance Outcome 1: Perform appropriate animal husbandry procedures on a range of laboratory animals in scientific environments

Knowledge specific to Performance Outcome	Skills specific to Performance Outcome
Animal Husbandry and Welfare: Specific husbandry and welfare considerations for all animals that are procured for the purpose of laboratory investigations Appreciation of the range of legislation including ethical requirements that allows for the procurement of animals for laboratory investigations Awareness that all animals are obtained from approved suppliers and can only be purchased by approved organisations for approved investigations Ensuring that all animals in scientific environments are given the following considerations: • Culture of care principles that all those working with animals must adhere to • Species specific requirements • Animal housing requirements: including cage types, isolators and Individually Ventilated Cage (IVC) systems • Requirements for social housing • Nutritional requirements of laboratory animals • Animal identifications options, following protocols to ensure unique identification • Animal management systems: what these are, why they are used • Animal facility cleaning procedures	Demonstrate manual dexterity in undertaking all routine animal husbandry procedures such as appropriate animal restraint, manipulation of equipment used to administer or withdraw biological samples Provide appropriate care and welfare for animals, including feeding, cleaning, handling, sexing and health checking Demonstrate consideration of the specific requirements of a particular species Follow protocols to ensure each animal is uniquely identified Observe animals to identify any clinical conditions, pain, suffering or distress and report these as appropriate Adhere to all biosecurity procedures within an animal science environment to prevent transmission of any infectious diseases, parasites or pests Use animal management systems to ensure efficient operation of an animal science environment Carry out appropriate euthanasia dissection and disposal of animals

• Biosecurity procedures • Principles of handling and sexing of laboratory animals • Principles of euthanasia and confirmation of death • Techniques available appropriate to species • Principles of microbiology • Health check procedures including the recognition of disease • Basic animal anatomy and physiology, including the importance of maintaining homeostasis for a specific species	
Laboratory management procedures How core knowledge of laboratory management procedures relates to Technical: Animals Sciences including how to ensure adequate and appropriate supplies and consumables are available	Ensure adequate and appropriate supplies and consumables are available to complete animal husbandry and welfare tasks

Performance Outcome 2: Plan the conducting of in-vivo investigations in compliance with regulatory and legal requirements

Knowledge specific to Performance Outcome	**Skills specific to Performance Outcome**
Planning methodologies for in-vivo investigations Understanding of: • Ethical practice and the importance of the 3 R's (reduction, refinement and replacement) in planning in-vivo investigations • Use of Animals in Research • Use of environmental enrichment • Use of Statistical Analysis for determining groups sizes • Blinding in-vivo studies	Support the planning of in-vivo investigations in animal science Plan the conduct of an in-vivo investigation using knowledge of methodologies, procedures and techniques

• Preventing/reducing bias during in-vivo studies • Animal models • Transgenic technologies • Randomisation techniques • Quality standards for in-vivo investigations • Standard Operating Procedures for in-vivo investigations • Importance of the study protocol in planning in-vivo Investigations • Awareness of possible toxicity of substance being tested, relationship between toxicity and dose or individual sensitivity	
Importance of health, safety and sustainability in in-vivo investigations How core knowledge of health, safety and sustainability relates to Technical: Animals Sciences, as well as occupationally specific knowledge related to animal sciences including Laboratory Animal Allergens and use of genetically modified materials and employer specific requirements including risk assessment protocols	Ensure the plan for the conduct of an in-vivo investigation adheres to all health and safety, regulatory and legal requirements to ensure health and welfare of animals Complete risk assessments for planned in-vivo investigations to comply with risk management protocols Access and follow all appropriate Standard Operating Procedures when planning in-vivo investigations Identify an appropriate euthanasia method
Regulatory, legal requirements and quality standards for in-vivo investigations Knowledge of: • Animals in Science Regulation Unit (ASRU) and the Animals (Scientific Procedures) Act 1986 (ASPA) including Schedule 1 methodology (Appropriate Methods of Humane Killing) • Animal Welfare Act 2018	Ensure adequate and appropriate supplies and consumables are available Calculate blood volumes that comply with Home Office guidelines Identify appropriate dosing routes and volumes in compliance with project licence

• EU directive 2010/63 • Personal licence conditions • Project licence conditions • Home Office codes of practice for housing and care of laboratory animals • Home Office reporting requirements Employer specific policies including Standard Operating Procedures and guidance documents	Identify an appropriate euthanasia method
Employment and types of working environments in animal science Range of working environments in animal science including pharmaceutical research and development, contract research and development and university research and development Job roles and duties of Animal Technologists, including the planning and undertaking of in-vivo investigations Range of employment and progression opportunities for Animal Technologists	Apply knowledge of employment and working environments to support the planning of in-vivo investigations

Performance Outcome 3: Perform planned in-vivo investigations, collect and analyse experimental data in scientific environments

Knowledge specific to Performance Outcome	**Skills specific to Performance Outcome**
Techniques and Procedures pertaining to in-vivo investigations An understanding of:	Use appropriate techniques to complete an in-vivo investigation, e.g. weighing and administration Demonstrate manual dexterity when conducting in-vivo investigations

• Principles of animal welfare, including recognising signs of ill health, stress or pain in accordance with product licence conditions. Including, how to conduct physical examinations, record clinical observations and perform welfare checks • Facility Hygiene requirements and procedures i.e. decontamination, sterilisation, disinfectants and why facility hygiene is important • Principles of animal handling including requirement for manual dexterity and species-specific techniques • Reason for identification of animals, the range of identification methods available and an awareness of the importance in relation to investigations and required regulations • Measurement of food and water intake against normal expected values • Weighing techniques and bodyweight ranges for specific species/ages/strains • Administration of test materials to laboratory animals including specialism of selecting dosing routes / volumes to administer • The range of sampling methods that can be used for obtaining body fluids e.g. blood, urine • Cryo-preservatives, awareness of the different methods available and their appropriate application • Breeding techniques i.e. mating, determining pregnancy, parturition, weaning, genotyping, selection of future breeding stock, speed congenics, development of breeding plans	Comply with species specific animal handling techniques Ensure all appropriate equipment is available to complete in-vivo investigation Follow risk assessments when conducting in-vivo investigations Comply with all relevant Standard Operating Procedures when conducting in-vivo investigations Comply with all relevant health and safety, regulatory and legal requirements, including complying with the Animals (Scientific Procedures) Act 1986 (ASPA), when conducting in-vivo investigations Identify any problems when conducting in-vivo investigations and respond appropriately, including recognising, reporting and recording pain, suffering or distress in animals Use appropriate techniques to complete study e.g. euthanasia of animals post study, as per protocol

• Breeding of Conventional and Genetically Modified Animals (GMA) including breeding methods and strain nomenclature used i.e. inbreeding, out breeding, co-isogenic strains. Including what a phenotype is and the potential problems that some phenotypes have. Genetic monitoring and how GMA animals are achieved e.g. CRISPR technology • Euthanasia techniques and procedures appropriate to individual species, equipment used, understanding when to euthanise, consider human aspect of staff undertaking this work • Terminal procedures e.g. perfusions, necropsy, tissue collection and preserving tissues, when are terminal procedures used and why. The importance of collecting tissue the most appropriate way and what preservatives can be used for the different end points • Principles of aseptic surgical technique. Why aseptic technique is important, methods of sterilisation (chemical vs mechanical sterilisation) understanding of bacterial control, use of bench top autoclaves, work flow within the surgery • Pre and post-operative care of animals. What is the importance of pre/post-operative care, how this is done, and equipment required. Understanding of body temps, how to maintain species related requirements, what to look for when animals recover from anaesthesia • Anaesthesia. What type of agent to use and why, species relevant. Understanding of long or short acting and when these agents should be used and the requirement to consult veterinarians • Analgesia. What are these chemicals, why, when and the frequency they are used	

• Surgical procedure animal preparation, incisions (requires a good understanding of species anatomy) suturing	
Equipment used in animal sciences How core knowledge of scientific equipment relates to Technical: Animals Sciences, as well as occupationally specific knowledge related to animal sciences including: • Balances (animal and analytical) • Use of blood collection pots: types and requirements for centrifuging • Animal facility equipment i.e. cage/rack washers, bottle washers, mechanical cleaning equipment • Decontamination equipment i.e. Vaporised Hydrogen Peroxide (VHP) and fogging equipment • Sample rollers • Syringes and hypodermic needles: appropriate sizes for use • Blood analysers • Cell counters • Use of callipers • Use of fixatives	Demonstrate practical technical competence in the use of instrumentation and equipment
Data recording collecting and analysis How core knowledge of data collecting, recording and analysis relates to Technical: Animals Sciences, as well as occupationally specific knowledge related to animal sciences including: • Home Office reporting of severities • Project Licence Standard Condition 18 (PPL SC18) and Project Licence Standard Condition 20 (PIL SC20)	Maintain accurate experimental records e.g. observation of clinical signs, including severity and humane end points Recognise when signs of suffering and distress require further action and act appropriately seeking advice from senior colleagues as required Collect accurate and reliable data from in-vivo investigations

As well as occupationally specific knowledge and understanding of: • Genomics • Computation • Big data sets • Algorithms	Use data capture and software systems when appropriate to collect reliable and accurate data Analyse, interpret and evaluate data from in-vivo investigations, identifying results requiring further investigation and notify senior colleagues as appropriate Review study outcomes and learnings, including data evaluation and condition of animals to inform future studies

Occupational Specialism: Technical: Metrology Sciences

Performance Outcome 1: Plan appropriate scientific measurement for any measurand to comply with regulatory requirements

Knowledge specific to Performance Outcome	Skills specific to Performance Outcome
Fundamentals of metrology Context in which scientific measurement is undertaken • Understanding of the context and purpose of "the Science of measurement", i.e. metrology and its importance to society • The role of measurement standards in the planning of appropriate scientific measurement • The need for measurement and how this relates to cost, tolerance and timescales Sources of uncertainty in scientific measurement • Measurement uncertainty, repeatability and reproducibility, and conformity assessment • Traceability, calibration, testing and accreditation • Measurement instrumentation • How to calculate simple uncertainty budgets and understanding of why they are used • Selecting an appropriate sample size • Best practice for specific systems Terminology and units which are used within metrology • Difference between validation and verification of scientific measurement equipment • The correct nomenclature for scientific measurement terms and the impact of using incorrect terminology	Apply the knowledge of fundamentals of metrology in order to: • Identify measurement needs and make informed decisions about the measurement process cost, tolerance and timescales required • Determine the design of the measurement; taking into account all sources of uncertainty, including: correct sample size for the measurements which will be taken, number of repeats, operators, components, features to be inspected to obtain viable results Read and apply a simple uncertainty budget to measurement task Use different unit systems, and be able to convert between units Use the correct terminology for scientific measurement in metrology

• Understand how the Maximum Permissible error of a system is devised • Knowledge of the seven SI units used in measurement tasks and how to convert between units	
Operating principles, equipment and tools Measurement operating principles, the equipment and tools used in each principle and how to select the most appropriate Most common operating principles used for measurement Typical equipment and software programs within each operating principle, their use, and how to use them including but not limited to: • Atomic Clock • Capacitance • Chemical properties: pH scale, Density, Geiger Muller • Contact probe: Atomic Force, Co-Ordinate Measurement Machine, Skidded and Skidless surface probes • Electromagnetic: Scanning Electron Microscope, Capacitance, Resistance • Frequency Modulated: Laser Rader • Focal Plane: Focus Variation, Confocal Microscopy • Laser Tracker: Interferometer Laser Tracker, Absolute Distance Measurement Laser Tracker • Mechanical: Young Modulus, Stress Testing, Hardness Testing, Weighing Scales • Phase Shift: Interferometry • Thermal • Time: Stopwatch, Atomic Clock • Time of flight: 3D laser scanner	Select and use appropriate tools, equipment, instrumentation and software programs for a measurement task e.g. phase shift for optical testing, time of flight for momentum

• Triangulation: iGPS, Photogrammetry, Structured Light, Laser Line Scanner	
Measurement systems How to identify the most appropriate system to use for a measurement task • Advantages and limitations of each system • Examples of commercially available systems within each operating principle • Systems, equipment and tools used with each operating principle and knowledge of the advantages, limitations and typical applications of each	Apply underpinning knowledge of measurement systems to select the most appropriate measurement system to plan a measurement task
Different sample preparation methods Why different sample preparation methods are required, what these methods are and when these would be used, including but not limited to: • Cleaning: To ensure the sample is adequately prepared for the inspection • Sectioning: To ensure the appropriate section of the sample is accessible for the inspection • Mounting: Setting the sample in the correct orientation so all the required features can be inspected • Polishing: Certain scientific measurements require specific surface conditions for the sample, knowing which systems need this special treatment and how it is achieved • Coating: Certain scientific measurements need the sample to be coated to allow inspection, knowing which systems need this special treatment and how it is achieved • Soaking: Scientific measurements are affected by the temperature of the sample, soaking is ensuring the sample	Plan the specific preparation tasks which will be needed on the item to be measured

has enough time to settle at the ambient temperature where the inspection will take place • Solutions: Ensuring all liquids or other materials required for the scientific measurement are the correct quantities and have the correct properties for the measurement to occur	
Extracting measurement requirements How to identify potential and most relevant sources from which to extract measurement requirements, for example: • Manuals • Specification sheets • Catalogues • Calibration certificates • Computer-generated information • ISO standards • Accrediting bodies • Technical drawings • Design models • Product labels • Historical data	Access and interpret information and documentation to confirm measurement requirements for the item to be measured using appropriate sources of information e.g. Manuals, ISO standards and product labels
Measurement plans What these are and how they are created Information that is relevant to the plan, including, but not limited to: • Repeat count • Sample size • Measurement system to be used	Create a measurement plan with relevant information on aspects such as the system to be used and sample size for the item to be measured

Environmental effects How environmental conditions can affect both the measuring equipment and the item to be measured, and hence on the data collected Conditions such as: Temperature, vibration, humidity and lighting	Record the effect of environmental conditions on the item to be measured e.g. temperature and vibration
Application of metrology Application of the principles of metrology to industry, law, business, science, as well as areas such as business, forensics, finance and architecture	Apply principles of metrology to industry, law, business, science, as well as areas such as business, forensics, finance and architecture
Customer requirements Customer requirements in metrology, including: • Tolerances: Knowing what the scientific measurement needs to achieve based upon the functionality of the component being inspected, and what the acceptable limits of error are for the component • Timescales: More accurate measurements typically require more time to complete, so understanding the tolerance requirements will dictate what inspection times are required to achieve the tolerances • Costs: The inspection of a component is typically at the end of a process, so scientific measurement must add sufficient value to the quality to the component to offset the cost of the measurement • Methodology and techniques required: selecting the correct methodology and technique for the scientific measurement is key to obtaining good quality results. This is the main task for a metrologist in ensuring the correct approach is adopted for each measurement they undertake	Extract customer requirements from customer brief e.g. tolerances, timescales, costs, methodology and techniques required

Health and safety in metrology How core knowledge of health and safety relates to Technical: Metrology Sciences including risk assessments, and use of correct Personal Protective Equipment	Complete and/or follow risk assessments in metrology, including those for handling possible hazardous samples Select appropriate Personal Protective Equipment
Regulations and standards in metrology National and international regulations and standards, industry and organisational procedures and requirements relating to metrology codes of conduct and the importance of their application Use of Standard Operating Procedures in metrology	Follow Standard Operating Procedures in metrology Identify and follow relevant regulatory procedures and standards from a range of sources when undertaking measurement tasks Comply with all relevant legislation, statutory regulations, standards, policies, procedures and requirements relating to codes of conduct and safe working practice relating to the preparation, storage, standards, control and handling of samples, tools, equipment, instrumentation and software programs when carrying out measurement tasks
Quality requirements in Metrology Importance of quality requirements, assurance, verification, inspection, accreditation, audit systems and processes	Identify and adhere to the correct regulations, ISO standards and quality accreditations required for the type of industry
Employment and working environments in metrology Need for further professional development, undertaking CPD, and knowledge of the state-of-the-art technology in metrology and future developments including: • Automation • Metrology and big data • Industry 4.0	Maintain a record of personal development and training from undertaking CPD and knowledge of the state-of-the-art technology and future developments in metrology Use feedback to develop and improve

Performance Outcome 2: Perform scientific measurement tasks using the most appropriate measurement for a measurand to ensure accuracy

Knowledge specific to Performance Outcome	Skills specific to Performance Outcome
Accuracy in Metrology Validation and verification techniques for a range of measuring instruments Calibration and testing methods for a range of metrology equipment, current calibration status and escalation route if machine isn't correctly calibrated	Perform a measurement task using developed plan including appropriate equipment Prepare the work environment in order to perform measurement tasks Set up the measuring system and the item to be measured Prepare the correct standard for the measurement Read and follow a calibration procedure Determine the current calibration status of a system from a calibration certificate or calibration label Follow best practice for the specific system being used

Performance Outcome 3: Collect, analyse and interpret data from measurement tasks

Knowledge specific to Performance Outcome	Skills specific to Performance Outcome
Processing data from measurement tasks How to process raw data from measurement systems to retrieve, analyse, interpret, validate and record measurement results in line with specifications, identify patterns and assess repeatability and reproducibility	Retrieve, analyse, interpret, validate and record measurement results and data in line with specifications Identify patterns in collected data Assess repeatability and reproducibility of measurements

How to process data such that the target measurands can be extracted for subsequent data processing. This includes but is not limited to: • Image processing • Filtration • Alignments • Corrections • Data recording	
Analysing data from measurement tasks How core knowledge of analysing data relates to Technical: Metrology Sciences as well as occupationally specific knowledge related to measurement tasks including: • Statistics • Measurement Systems Analysis • Algebraic formulae • Calculations on measurement data	Identify any anomalous results and re-run investigations to assess invalid data Sentencing the sample using the measurement data against the original customer requirements Contribute to the production of reports and other measurement documentation Present data in most appropriate format to meet customer requirements
Reviewing data obtained How to review the measurement data obtained against measurement requirements	

Performance Outcome 4: Identify and resolve issues with measurement tools and equipment

Knowledge specific to Performance Outcome	**Skills specific to Performance Outcome**
Identifying and resolving issues in metrology	Carry out basic repairs on measurement systems, tools and equipment

How core knowledge of problem solving relates to Technical: Metrology Sciences as well as occupationally specific knowledge related to measurement tasks including: • Potential sources of uncertainty impact on data collection, analysis • Interpretation/understanding of the meaning of data/correlation of standard deviation and data • How to carry out basic repairs on measurement systems, tools and equipment • How and when to discuss results and issues with peers and when to escalate issues to senior metrology colleagues	Use problem solving techniques to identify and resolve issues relating to metrology tools and equipment Discuss measurement results and issues with peers and determine when issues need to be escalated When appropriate, source expert help from senior colleagues or others on metrology issues

Integrating maths, English and digital skills

Maths

The completion of a level 2 mathematics qualification (GCSE mathematics or Functional Skills) is a minimum exit requirement for all T Levels. This will ensure that all students have demonstrated fluency and competence in mathematics, and are able to recognise the importance of mathematics in their own lives, in work and to society. Achievement of a level 2 mathematics qualification will also provide the foundation to access mathematics at a higher level, if required.

Technical Qualifications should contain sufficient and appropriate maths to help students reach the minimum required competence in their chosen specialism(s). The following General Maths Competencies (GMCs) have been developed with input from the Royal Society Advisory Committee on Maths Education (ACME), and awarding organisations will need to embed these, and the underpinning maths, into the specifications and assessments being developed as part of the Technical Qualification.

The GMCs below are relevant to this particular Technical Qualification:

- Communicate using mathematics
- Cost a project
- Estimate, calculate and error-spot
- Measure with precision
- Optimise work processes
- Process data
- Represent with mathematical diagrams
- Understand data
- Use rules and formulae
- Work with proportion.

Awarding organisations that are awarded an exclusive licence will need to integrate these into the Technical Qualification specification and assessments, drawing upon a more detailed framework of maths that underpins the GMCs, currently being developed in association with the Royal Society ACME.

English

The completion of a level 2 English qualification (English language GCSE or Functional Skills) is a minimum exit requirement for all T Levels. This will ensure that all students have demonstrated that they can read fluently, communicate and write effectively, and demonstrate a confident control of Standard English.

The specification for a Technical Qualification should ensure that students acquire the technical vocabulary, and gain the practical communication skills (written and oral), needed to achieve competence in their chosen occupational specialism(s).

The assessments for Technical Qualifications should ensure that students:

- Know the correct technical vocabulary and use it appropriately

- Apply their communication skills (written and oral) appropriately, using Standard English
- Use accurate spelling, punctuation and grammar.

Digital

Technical Qualifications should contain sufficient and appropriate digital skills to help students reach competence in their chosen specialism(s).

This Technical Qualification should support students to develop the digital knowledge and skills needed in order to:

- Adopt professional approaches to using digital communications and social media
- Collate, manage, access and use digital data in spreadsheets, databases and other formats
- Design and create new digital artefacts and materials such as digital writing, digital imagine, digital audio and video, digital code, apps and interfaces and web pages
- Follow licensing guidelines, using only approved and licensed software applications
- Gather and organise information from different digital sources
- Make use of standard analytical tools in applications to better interpret information.

Awarding organisations that are awarded an exclusive licence will need to integrate these into the Technical Qualification specification and assessment.