Programme of study for Applied Science Extended Certificate Year 13 2024-2025

Autumn (1st and 2nd term) Spring (1st and 2nd term) Teacher 1	Autumn (1st and 2nd term) Spring (1st and 2nd term) Teacher 2	Autumn (1st and 2nd term) Spring (1st and 2nd term) Teacher 3
Other timescale: From: September 2024 To: May 2025	**Other timescale:** From: September 2024 To: May 2025	**Other timescale:** From: September 2024 To: May 2025
Topic: **Unit 8:** Physiology of human body systems. Coursework based. **Skills (students should be able to do):** • Reading, revising, essay writing, exam practice. Personal learning thinking skills including • independent enquirers, • creative thinkers, • reflective learners, • team workers, • self-managers, effective participants.	**Topic:** **Unit 3:** Scientific Investigative skills. Exam based. **Skills (students should be able to do):** • Researching, reading, essay writing, exam practice. Personal learning thinking skills including: • independent enquirers, • creative thinkers, • reflective learners, • team workers, • self-managers, effective participants	**Topic:** **Unit 2:** Practical Scientific Procedure and Techniques. Coursework based. **Skills (students should be able to do):** • Researching, reading, essay writing, exam practice. Personal learning thinking skills including: • independent enquirers, • creative thinkers, • reflective learners, • team workers, • self-managers, • effective participants. The fundamental knowledge, practical skills, transferable skills – for example, organisation, self-assessment and problem-solving, and the ability to interpret data – all developed in this unit will give students confidence when they undertake the more complex practical techniques involved in higher education science courses such as biochemistry, chemistry, forensic science and environmental science.
Key Learning Outcomes (students should know): **Assignment A:** Students to understand the impact of disorders of the musculoskeletal system and their associated corrective treatments.	**Key Learning Outcomes (students should know):** **AO1:** Students should be able to demonstrate knowledge and understanding of scientific concepts, procedures, processes and techniques and their application in a practical investigative context.	**Key Learning Outcomes (students should know):** **Assignment A:** Students to undertake titration and colorimetry to determine the concentration of solutions.

Assignment B: Students to understand the impact of disorders on the physiology of the lymphatic system and the associated corrective treatments. **Assignment C:** Students to explore the physiology of the digestive system and the use of corrective treatments for dietary-related diseases	**AO2:** Students should be able to interpret and analyse qualitative and quantitative scientific information to make reasoned judgements and draw conclusions based on evidence in a practical investigative context. **AO3:** Students should be able to evaluate practical investigative procedures used and their effect on the qualitative and quantitative scientific information obtained to make reasoned judgements. **AO4:** Students should be able to make connections between different scientific concepts, procedures, processes, and techniques to make a hypothesis and write a plan for a practical investigation.	**Assignment B:** Students to undertake calorimetry to study cooling curves. **Assignment C:** Students to undertake chromatographic techniques to identify components in mixtures. **Assignment D:** Students to review personal development of scientific skills for laboratory work.
No end of term assessment for this unit as coursework based.	**End of term 1 assessment to cover:** • Unit 3 only: various practical exams and then practical write-ups will be assessed	**No end of term assessment for this unit as coursework based.**
Building understanding: Rationale for your sequence of lessons: **Assignment A:** The sequence of lessons for the structure, function, and health of the musculoskeletal system is designed to gradually build students' understanding from basic identification of structures to the complexities of musculoskeletal disorders and treatments. The rationale for this sequence prioritizes foundational knowledge before delving into more advanced concepts, ensuring students can fully grasp the system's function and how it can be affected by disease or injury. **1. Introduction to the Skeletal System: Axial and Appendicular Skeleton** **Objective:** To help students identify and understand the structure of the major bones in the	**Building understanding: Rationale for your sequence of lessons:** The sequence of lessons designed to address Assessment Objectives (AOs) AO1 through AO4 is structured to build progressively upon students' knowledge and skills. The lessons aim to ensure a thorough understanding of scientific concepts, procedures, and processes, while also developing students' analytical and evaluative abilities. By following a logical progression, students will be able to confidently apply their knowledge in a practical investigative context. Below is the rationale for this sequence of lessons: **1. Introduction to Scientific Concepts and Terminology (AO1)** **Objective:** To establish a solid foundation of the essential scientific concepts, procedures, and processes that will be explored throughout the sequence.	**Building understanding: Rationale for your sequence of lessons:** **Assignment A**: The sequence of lessons outlined here is designed to progressively build students' competence in laboratory techniques, from basic equipment handling to advanced analytical methods such as titration and colorimetry. Here's the rationale behind the structure: **1. Laboratory Equipment and Calibration** **Objective:** To introduce students to essential laboratory equipment and ensure they understand the importance of proper calibration. **Why first?** Correct usage and calibration of equipment is fundamental to any lab work. Starting with this topic ensures that students can confidently and accurately

human body, focusing on both the axial and appendicular skeleton. **Why first?** This foundational knowledge is crucial as students need to recognize key bones before understanding how muscles, joints, and other structures interact. Starting with the skeletal framework provides the basis for all subsequent lessons. **Key skills/knowledge:** Students will learn the names, locations, and functions of bones, such as the cranium, vertebrae, ribs, and limb bones, laying the groundwork for more complex structures. **2. Bone Types and Composition** **Objective:** To explore the different types of bones (long, short, flat, irregular, sesamoid) and their composition. **Why here?** After understanding the locations and names of bones, students must learn the internal structure of bones and the significance of various types. This lesson builds an appreciation for how bones are tailored for specific functions, like support, protection, and movement. **Key skills/knowledge:** Students will study the composition of bones, including periosteum, compact and spongy bone, bone marrow, and the role of minerals like calcium in bone strength and health. **3. Identification and Classification of Joints** **Objective:** To introduce the major joint types (gliding, condyloid, hinge, ball and socket, etc.) and classify them as fibrous, cartilaginous, or synovial.	**Why first?** Students need to have a clear understanding of the basic scientific terminology and concepts before they can apply them in practical investigative work. This lesson sets the stage for deeper learning by providing the theoretical knowledge needed for the rest of the course. **Skills/knowledge:** Students will become familiar with key scientific concepts, such as experimental design, data collection, and the role of controls, giving them a framework for applying this knowledge in later investigations. **2. Introduction to Practical Investigative Techniques (AO1, AO4)** **Objective:** To demonstrate practical investigative techniques and introduce students to the concept of hypothesis formation and experimental planning. **Why here?** Once students have a theoretical understanding of scientific procedures, they need to begin applying these concepts practically. This lesson introduces basic investigative techniques and encourages students to think critically about how to design experiments based on a hypothesis. **Skills/knowledge:** Students will learn how to make connections between different scientific procedures, interpret practical setups, and begin planning their own investigations. **3. Collecting Qualitative and Quantitative Data (AO2)** **Objective:** To introduce students to methods for collecting and recording both qualitative and quantitative data in a scientific investigation. **Why now?** After students have a basic understanding of investigative techniques, they need to learn how to effectively collect and interpret data. This lesson provides	measure quantities before performing more complex experiments. **Key skills/knowledge:** Proper use of pH meters, balances, and volumetric glassware establishes good laboratory practice (GLP). Calibration processes are crucial for obtaining accurate and reliable results. **2. Use of pH Meters and Probes** **Objective:** To teach students how to use and calibrate pH meters effectively. **Why now?** After general calibration, focusing on specific equipment like pH meters ensures students can accurately measure pH levels, which is crucial in many chemical processes. **Key skills/knowledge:** Calibration according to manufacturer instructions introduces students to real-world operational procedures, fostering precision in their experimental work. **3. Use of Balances and Weighing** **Objective:** To train students in using electronic balances, with a focus on accuracy and calibration using certified weights. **Why here?** Balancing is a core skill in all chemistry labs, and it's vital students can differentiate between types of balances (rough and analytical) and their uses. Accurate weighing is critical for making solutions and for quantitative analysis. **Key skills/knowledge:** Handling different balances and understanding their precision prepares students for tasks requiring high accuracy, such as titration and preparation of standards.

Why now? Once students are familiar with bones, understanding the types of joints and their locations becomes essential for grasping how the skeletal system enables movement. Joints are the points of articulation that allow mobility, making this a natural next step after learning about the skeleton.

Key skills/knowledge: Students will learn to classify joints and identify them on diagrams or models, linking joint structure to specific types of movement, like flexion or rotation.

4. Ligaments, Tendons, and Muscle Structure

Objective: To understand the composition and function of ligaments, tendons, and muscle fibres, as well as major muscle groups.

Why here? After understanding bones and joints, students need to know how muscles attach to the skeleton and facilitate movement. This lesson explains the connective tissues (ligaments and tendons) and muscles, enabling students to visualize how the skeletal system and muscular system work together.

Key skills/knowledge: Students will identify major muscle groups, learn about muscle fibers, and understand the interaction between muscles and bones via ligaments and tendons.

5. Functions of the Musculoskeletal System

Objective: To explain how each part of the musculoskeletal system contributes to overall functioning, including skeletal support, protection, movement, mineral storage, and blood cell production.

practical guidance on recording data in ways that allow for meaningful analysis later.

Skills/knowledge: Students will learn the differences between qualitative and quantitative data, as well as methods for collecting each. They will be introduced to equipment and techniques relevant to their investigative tasks.

4. Analysis of Qualitative and Quantitative Data (AO2)

Objective: To teach students how to interpret and analyse the data collected during investigations, focusing on drawing reasonable conclusions based on evidence.

Why here? Once students have learned how to collect data, they need to be able to analyse it to make informed judgments. This lesson provides students with the tools to critically examine their data, ensuring that their conclusions are evidence-based.

Skills/knowledge: Students will be able to apply mathematical and statistical techniques to analyse quantitative data, as well as interpret qualitative results in a scientific context. This lesson emphasizes critical thinking and making reasoned judgments based on collected evidence.

5. Evaluation of Practical Investigative Procedures (AO3)

Objective: To introduce students to the concept of evaluating their practical investigative procedures, focusing on assessing the reliability, accuracy, and validity of their methods and results.

Why now? After students have collected and analysed data, it is important for them to reflect on the strengths and limitations of their investigative procedures. This skill

4. Safe Use of Volumetric Glassware

Objective: To teach the safe and precise use of volumetric glassware, including pipettes, burettes, and volumetric flasks.

Why here? Once students understand calibration and weighing, they need to handle volumetric glassware correctly to ensure accurate measurements for solution preparation and titrations.

Key skills/knowledge: This topic introduces techniques like accurate dilution and the calibration of volumetric glassware using water, preparing students for titration and standardization tasks.

5. Preparation and Standardization of Solutions Using Titration

Objective: To introduce titration techniques and the process of standardizing solutions.

Why now? After mastering calibration, pH, and accurate weighing, students are ready for more complex processes like titration. This activity integrates several previous skills (accurate weighing, pH measurement, and using volumetric glassware).

Key skills/knowledge: Titration involves determining concentrations from end-point detection, and students will learn how to standardize solutions using primary and secondary titrimetric standards. This process is key to chemical analysis and precise quantitative work.

6. Accurate Determination of Titration Endpoint

Objective: To ensure students can accurately detect titration endpoints using indicators or pH plots.

Why now? After focusing on structure, students are now ready to understand the physiological functions of the entire musculoskeletal system. This lesson ties together earlier content on bones, joints, muscles, and connective tissues by showing how they contribute to movement, protection, and other vital functions.

Key skills/knowledge: Students will explore the role of bones in mineral homeostasis and blood cell production, as well as how muscles contract to cause movement through various interactions with bones and joints.

6. Muscle Contraction and Movement

Objective: To explore how muscle contraction works, including the role of fast- and slow-twitch fibres, and how movement occurs through muscle-bone interaction.

Why here? With a solid understanding of the skeletal and muscular structures, students can now dive deeper into the mechanisms of movement. This lesson focuses on muscle physiology, enabling students to understand how movements like flexion, extension, and rotation occur.

Key skills/knowledge: Students will learn about the process of muscle contraction at the cellular level and how specific muscle types contribute to different types of movement, including internal/external rotation and circumduction.

7. Common Musculoskeletal Disorders

Objective: To introduce common disorders of the musculoskeletal system, such as arthritis, fractures, is essential for refining future experiments and improving the quality of their results.

Skills/knowledge: Students will evaluate the effectiveness of their investigative methods, identifying any potential sources of error or bias. They will learn to assess the impact of these factors on their data and draw conclusions about the overall reliability of their investigation.

6. Hypothesis Formation and Experimental Design (AO4)

Objective: To further develop students' abilities to make connections between scientific concepts and design their own practical investigations, starting with hypothesis formation.

Why now? Having learned the basics of scientific investigation, students are now ready to apply this knowledge in designing their own experiments. This lesson encourages them to synthesize different scientific ideas and concepts to create a well-structured experimental plan.

Skills/knowledge: Students will be guided in making connections between scientific theories and practical investigation techniques, leading to the formation of a hypothesis. They will then draft a detailed experimental plan, outlining their method, variables, and how they intend to collect and analyse data.

7. Applying Scientific Knowledge to Real-World Investigations (AO4)

Objective: To guide students in making connections between scientific theories and real-world investigations, helping them apply their practical skills in a broader context.

Why here? Students will be trained in interpreting visual changes (colour change of indicators) and graphical methods (pH vs. volume) to enhance precision in determining when titrations are complete.

Key skills/knowledge: These skills are crucial in achieving reproducible results and accurate calculations of concentration during titration, improving the accuracy of the analysis.

7. Calculation of Concentrations

Objective: To enable students to calculate solution concentrations from titration results.

Why here? After performing titrations, students need to process their data by calculating concentrations using molecular masses. This introduces more quantitative aspects of laboratory work.

Key skills/knowledge: Using molecular mass from the periodic table, students will apply their measurements to solve problems involving solution concentrations, fostering their analytical thinking.

8. Introduction to Colorimetry (A3)

Objective: To introduce colorimetry techniques, including how to use colorimeters and spectrometers.

Why now? Colorimetry builds on the previous lessons about measurement, calibration, and concentration determination. It introduces another technique for analysing chemical solutions, particularly those involving coloured substances.

Key skills/knowledge: Understanding how to select filters or wavelengths for specific analyses enhances students' capability to perform quantitative analysis in the lab.

and tendon injuries, along with their causes and symptoms. **Why now?** After fully understanding the healthy functioning of the musculoskeletal system, students are ready to explore what happens when the system is compromised. This lesson builds awareness of how injuries and diseases affect movement and function. **Key skills/knowledge:** Students will learn to identify symptoms of disorders like arthritis or fractures and understand the physiological reasons behind conditions like hypermobility or repetitive strain injury (RSI). **8. Treatments for Musculoskeletal Disorders** **Objective:** To explore treatments for common musculoskeletal disorders, including physiotherapy, joint replacement therapy, and RICE (Rest, Ice, Compression, Elevation). **Why here?** With knowledge of musculoskeletal disorders, students are now prepared to learn about the various treatments. This lesson connects the physiological impact of treatments to the specific musculoskeletal issues they address. **Key skills/knowledge:** Students will understand how different treatments, such as arthroscopy or casting, help restore musculoskeletal function, and the scientific reasoning behind them, such as reducing inflammation or promoting healing. **9. Physiological Reasoning Behind Treatments**	**Why now?** Once students have developed the skills needed to form hypotheses and design experiments, it is important to give them opportunities to apply these skills in more complex, real-world scenarios. This lesson expands their understanding of how scientific investigations can be used to solve practical problems. **Skills/knowledge:** Students will apply their theoretical and practical knowledge to design investigations that address real-world scientific questions or challenges. This lesson encourages critical thinking and problem-solving in contexts beyond the classroom. **8. Evaluation and Refinement of Experimental Designs (AO3)** **Objective:** To further develop students' evaluative skills by having them review and refine their experimental designs based on feedback and potential issues encountered during the investigation process. **Why now?** As students gain experience designing experiments, it is essential that they also learn how to refine and improve their plans. This lesson helps them develop resilience and adaptability by encouraging iterative improvement of their investigative procedures. **Skills/knowledge:** Students will critically review their experimental designs, identify areas for improvement, and adjust enhance the reliability and accuracy of their investigations. They will also learn to incorporate feedback from peers and instructors into their revised plans. **9. Synthesizing Learning: Final Practical Investigation (AO1, AO2, AO3, AO4)** **Objective:** To give students the opportunity to design, conduct, analyse, and evaluate a full practical	**9. Measurement of Absorbance and Use of the Beer-Lambert Law** **Objective:** To teach students how to measure absorbance and apply the Beer-Lambert law to determine concentrations. **Why here?** With the basics of colorimetry in place, students are now ready to quantify the absorbance of solutions and apply this data to concentration calculations using the Beer-Lambert law. **Key skills/knowledge:** Using absorbance data to find unknown concentrations reinforces students' understanding of the relationship between light absorption and concentration, a key principle in many types of chemical analysis. **10. Preparation of Calibration Standards and Accurate Dilution** **Objective:** To guide students through preparing a range of calibration standards and ensuring accurate dilution of stock solutions. **Why here?** Building on dilution skills and calibration introduced earlier, this step ensures students understand how to create calibration curves, a critical part of quantitative analysis in colorimetry. **Key skills/knowledge:** Preparing solutions with precise concentrations for calibration plots is essential for accurately measuring unknowns in experiments. **11. Use of Calibration Plot to Determine Unknown Concentrations**

Objective: To explain the physiological mechanisms that make treatments effective for specific musculoskeletal issues. **Why now?** This final lesson ties everything together by explaining the physiological principles underlying various treatments. By understanding why treatments work, students will gain a deeper insight into how the musculoskeletal system heals and adapts after injury or disease. **Key skills/knowledge:** Students will learn how therapies like physiotherapy strengthen muscles and improve joint function, as well as how surgical interventions like joint replacement help restore mobility. **Overall Structure and Flow:** **Foundational Knowledge First:** The lessons begin with the basics of identifying and understanding skeletal and muscular structures, ensuring that students have a solid understanding of anatomy before moving on to more complex topics. **Gradual Build to Function and Disorders:** After establishing a foundation, the sequence moves to explaining how these systems work and interact to produce movement and maintain homeostasis. This provides the basis for understanding what happens when the system malfunctions due to injury or disease. **Final Focus on Treatments:** The final lessons focus on disorders and their treatments, allowing students to appreciate the medical interventions used to restore musculoskeletal function. Ending with treatment provides a sense of real-world	investigation, applying all the skills and knowledge gained in previous lessons. **Why now?** This lesson serves as a culminating experience, where students bring together all the knowledge and skills they have learned throughout the sequence. It ensures that they are prepared for both assessments and real-world scientific challenges. **Skills/knowledge:** Students will complete a comprehensive investigation, from hypothesis formation to analysis and evaluation. They will demonstrate their ability to apply scientific concepts, analyse data, make evidence-based conclusions, and refine their methods based on evaluative feedback. **Overall Structure and Flow:** **Building Foundational Knowledge:** The sequence starts with foundational lessons that establish core scientific concepts, ensuring that students have the theoretical understanding necessary for practical investigations. **Gradual Progression:** The lessons build progressively, starting with simple investigative techniques and moving toward more complex analysis and evaluation, ensuring students develop practical and analytical skills simultaneously. **Emphasis on Evaluation and Refinement:** Throughout the sequence, there is a strong focus on developing students' evaluative skills, encouraging them to critically assess their methods and results to improve their investigative work. **Real-World Application:** The lessons culminate in the application of scientific knowledge to real-world problems, preparing students to tackle complex scientific investigations in both academic and professional settings.	**Objective:** To teach students how to use a calibration plot or trend line to determine the concentration of an unknown solution. **Why here?** This final step integrates all previous knowledge—accurate measurement, dilution, and absorbance readings—allowing students to apply these concepts in determining unknowns. **Key skills/knowledge:** Creating and interpreting calibration plots (using graph paper or Excel) helps students analyse data in a scientific way, applying mathematics to experimental results. **Overall Structure and Flow:** **Foundation First:** The sequence begins with the basics of equipment calibration, followed by safe and precise use of balances and volumetric glassware. These foundational skills are critical for accurate experimental results. **Progressive Complexity:** The lessons gradually increase in complexity, from simple pH measurements to titration, concentration calculations, and finally, colorimetry. **Hands-On Application:** The sequence is practical, ensuring that students gain experience with essential lab techniques while understanding the underlying theory and principles. **Real-World Relevance:** Concepts like standardization, accurate dilution, and calibration of solutions and equipment are crucial in both industrial and research settings, preparing students for future laboratory work. This structure ensures a logical, progressive development of skills and knowledge, moving from foundational techniques to advanced analytical methods, equipping students with the tools necessary for accurate and reliable scientific analysis.

application and helps connect the academic content to healthcare practices. This sequence ensures that students' progress logically from basic anatomy to complex physiological processes and disorders, developing both theoretical knowledge and practical understanding of the musculoskeletal system. **Assignment B** The sequence of lessons for Learning Aim B on the lymphatic system is structured to build a comprehensive understanding of the system's structure, function, and how disorders can impact its physiology. By starting with foundational knowledge and progressing to the understanding of disorders and treatments, students can fully grasp the importance of the lymphatic system in maintaining overall health. **1. Introduction to the Structure of the Lymphatic System (B1)** **Objective:** To help students identify and understand the structure and location of the components of the lymphatic system, including the spleen, thymus, tonsils, lymph glands, lymph vessels, and major lymph nodes. **Why first?** Knowledge of the structure of the lymphatic system is fundamental. By recognizing the locations of lymphatic organs and nodes, students can later understand how these components function and interact with the rest of the body. **Key skills/knowledge:** Students will learn the names and functions of the major lymphatic organs and vessels and understand their anatomical		Lessons before **assignment B** given to help prepare students. The sequence of lessons outlined here is designed to progressively build students' competence in laboratory techniques, from basic equipment handling to advanced analytical methods such as titration and colorimetry. Here's the rationale behind the structure: **1. Laboratory Equipment and Calibration** **Objective:** To introduce students to essential laboratory equipment and ensure they understand the importance of proper calibration. **Why first?** Correct usage and calibration of equipment is fundamental to any lab work. Starting with this topic ensures that students can confidently and accurately measure quantities before performing more complex experiments. **Key skills/knowledge:** Proper use of pH meters, balances, and volumetric glassware establishes good laboratory practice (GLP). Calibration processes are crucial for obtaining accurate and reliable results. **2. Use of pH Meters and Probes** **Objective:** To teach students how to use and calibrate pH meters effectively. **Why now?** After general calibration, focusing on specific equipment like pH meters ensures students can accurately measure pH levels, which is crucial in many chemical processes. **Key skills/knowledge:** Calibration according to manufacturer instructions introduces students to real-world operational procedures, fostering precision in their experimental work.

locations, providing a basis for understanding how they contribute to lymphatic function. **2. Understanding the Composition and Function of Lymph (B2)** **Objective:** To explore the formation, composition, and role of lymph and lymphocytes, including the transport mechanisms and importance of valves in lymphatic vessels. **Why here?** Once students know the structure of the lymphatic system, they need to understand how lymph, the system's main fluid, is produced and transported. This lesson provides essential knowledge for understanding the role of the lymphatic system in immune response and fluid balance. **Key skills/knowledge:** Students will study the composition of lymph, the formation of lymphocytes, and the role of lymphatic valves in ensuring unidirectional flow. This knowledge is critical for later lessons on the system's role in maintaining homeostasis. **3. Lymphatic Functions: Fluid Removal and Pressure Regulation** **Objective:** To explain the processes by which the lymphatic system removes interstitial fluid from tissues and maintains hydrostatic pressure. **Why now?** After learning about the formation of lymph, students will now focus on one of the key roles of the lymphatic system: fluid balance. This lesson builds on the previous one by explaining how lymph helps remove excess tissue fluid,		**3. Use of Balances and Weighing** **Objective:** To train students in using electronic balances, with a focus on accuracy and calibration using certified weights. **Why here?** Balancing is a core skill in all chemistry labs, and it's vital students can differentiate between types of balances (rough and analytical) and their uses. Accurate weighing is critical for making solutions and for quantitative analysis. **Key skills/knowledge:** Handling different balances and understanding their precision prepares students for tasks requiring high accuracy, such as titration and preparation of standards. **4. Safe Use of Volumetric Glassware** **Objective:** To teach the safe and precise use of volumetric glassware, including pipettes, burettes, and volumetric flasks. **Why here?** Once students understand calibration and weighing, they need to handle volumetric glassware correctly to ensure accurate measurements for solution preparation and titrations. **Key skills/knowledge:** This topic introduces techniques like accurate dilution and the calibration of volumetric glassware using water, preparing students for titration and standardization tasks. **5. Preparation and Standardization of Solutions Using Titration (A2)** **Objective:** To introduce titration techniques and the process of standardizing solutions.

preventing oedema and maintaining normal pressure. **Key skills/knowledge:** Students will understand the movement of interstitial fluid into lymphatic vessels and how this system contributes to maintaining fluid balance and pressure throughout the body. **4. Absorption of Fats in the Lymphatic System** **Objective:** To explain the role of the lymphatic system in absorbing fats from the digestive system, specifically through structures like lacteals in the small intestine. **Why here?** Having established the lymphatic system's role in fluid removal and pressure regulation, students are now prepared to understand its role in fat absorption. This lesson expands the students' understanding of how the lymphatic system supports other body systems, such as digestion. **Key skills/knowledge:** Students will explore the process by which fats are absorbed from the digestive system, particularly through lymphatic capillaries, and how they are transported to the bloodstream. **5. Disorders of the Lymphatic System: Lymphadenitis, Lymphedema, and Hodgkin's Lymphoma (B3)** **Objective:** To introduce common lymphatic disorders such as lymphadenitis, lymphedema, and Hodgkin's lymphoma, including their symptoms and physiological impact on the lymphatic system.		**Why now?** After mastering calibration, pH, and accurate weighing, students are ready for more complex processes like titration. This activity integrates several previous skills (accurate weighing, pH measurement, and using volumetric glassware). **Key skills/knowledge:** Titration involves determining concentrations from end-point detection, and students will learn how to standardize solutions using primary and secondary titrimetric standards. This process is key to chemical analysis and precise quantitative work. **6. Accurate Determination of Titration Endpoint** **Objective:** To ensure students can accurately detect titration endpoints using indicators or pH plots. **Why here?** Students will be trained in interpreting visual changes (colour change of indicators) and graphical methods (pH vs. volume) to enhance precision in determining when titrations are complete. **Key skills/knowledge:** These skills are crucial in achieving reproducible results and accurate calculations of concentration during titration, improving the accuracy of the analysis. **7. Calculation of Concentrations** **Objective:** To enable students to calculate solution concentrations from titration results. **Why here?** After performing titrations, students need to process their data by calculating concentrations using molecular masses. This introduces more quantitative aspects of laboratory work. **Key skills/knowledge:** Using molecular mass from the periodic table, students will apply their measurements to

Why now? After understanding normal lymphatic function, it is essential to explore what happens when the system becomes dysfunctional. This lesson focuses on diseases that disrupt normal lymphatic processes, laying the groundwork for the subsequent exploration of treatments. **Key skills/knowledge:** Students will learn to recognize the symptoms and physiological changes caused by lymphatic disorders. This helps build an understanding of how the system can fail and the implications for overall health. **6. Treatments for Lymphatic Disorders** **Objective:** To explore treatments for lymphatic system disorders, including the physiological reasoning behind treatments like compression therapy, surgery, chemotherapy, and radiation therapy. **Why here?** Once students have learned about lymphatic disorders, it is logical to introduce the treatments that can address these conditions. Understanding the medical interventions used for lymphatic disorders will give students insight into how the system can be restored or managed after disease. **Key skills/knowledge:** Students will study different treatments for conditions such as lymphedema and Hodgkin's lymphoma, with a focus on how these treatments correct the underlying physiological issues, such as blocked lymph flow or malignant growths. **7. Case Studies: Impact of Disorders on the Lymphatic System**		solve problems involving solution concentrations, fostering their analytical thinking. **8. Introduction to Colorimetry (A3)** **Objective:** To introduce colorimetry techniques, including how to use colorimeters and spectrometers. **Why now?** Colorimetry builds on the previous lessons about measurement, calibration, and concentration determination. It introduces another technique for analysing chemical solutions, particularly those involving coloured substances. **Key skills/knowledge:** Understanding how to select filters or wavelengths for specific analyses enhances students' capability to perform quantitative analysis in the lab. **9. Measurement of Absorbance and Use of the Beer-Lambert Law** **Objective:** To teach students how to measure absorbance and apply the Beer-Lambert law to determine concentrations. **Why here?** With the basics of colorimetry in place, students are now ready to quantify the absorbance of solutions and apply this data to concentration calculations using the Beer-Lambert law. **Key skills/knowledge:** Using absorbance data to find unknown concentrations reinforces students' understanding of the relationship between light absorption and concentration, a key principle in many types of chemical analysis. **10. Preparation of Calibration Standards and Accurate Dilution**

Objective: To analyse case studies that highlight the impact of lymphatic disorders on a patient's physiology and the effectiveness of treatments. **Why now?** This lesson gives students the opportunity to apply their theoretical knowledge to real-world scenarios. By studying specific cases, students can better understand the progression of lymphatic disorders and the outcomes of various treatments. **Key skills/knowledge:** Students will critically evaluate case studies, looking at the progression of disorders, diagnostic methods, and treatment outcomes, and applying their understanding of lymphatic function and pathology. **8. Review and Synthesis: The Role of the Lymphatic System in Maintaining Health** **Objective:** To review the structure, function, and disorders of the lymphatic system and synthesize how this system contributes to overall health. **Why now?** This lesson consolidates all the learning from previous lessons. It allows students to reflect on the importance of the lymphatic system in immune function, fluid balance, and fat absorption, as well as the potential consequences of system failure. **Key skills/knowledge:** Students will integrate their knowledge of lymphatic structure, function, and disorders, and review how the system's functions are interrelated with other physiological systems in maintaining health. **Overall Structure and Flow:**		**Objective:** To guide students through preparing a range of calibration standards and ensuring accurate dilution of stock solutions. **Why here?** Building on dilution skills and calibration introduced earlier, this step ensures students understand how to create calibration curves, a critical part of quantitative analysis in colorimetry. **Key skills/knowledge:** Preparing solutions with precise concentrations for calibration plots is essential for accurately measuring unknowns in experiments. **11. Use of Calibration Plot to Determine Unknown Concentrations** **Objective:** To teach students how to use a calibration plot or trend line to determine the concentration of an unknown solution. **Why here?** This final step integrates all previous knowledge—accurate measurement, dilution, and absorbance readings—allowing students to apply these concepts in determining unknowns. **Key skills/knowledge:** Creating and interpreting calibration plots (using graph paper or Excel) helps students analyze data in a scientific way, applying mathematics to experimental results. **Overall Structure and Flow:** **Foundation First:** The sequence begins with the basics of equipment calibration, followed by safe and precise use of balances and volumetric glassware. These foundational skills are critical for accurate experimental results.

Foundational Knowledge First: The lessons begin with basic anatomical and physiological knowledge, ensuring that students have a firm understanding of the lymphatic system's components and their functions. **Gradual Progression to Disorders and Treatments:** After establishing how the lymphatic system works under normal conditions, students will explore how disorders impact the system and how medical interventions can correct dysfunctions. **Integration of Practical Application:** By the end of the sequence, students will engage with real-world case studies and review sessions that help them synthesize and apply their knowledge, preparing them to understand lymphatic health in both academic and clinical contexts. This sequence ensures that students build a comprehensive understanding of the lymphatic system, progressing from basic anatomy to advanced concepts of disorders and treatments, while maintaining a logical flow that enhances learning outcomes. **Assignment C** The sequence of lessons for Learning Aim C on the digestive system is structured to help students explore the system's structure and function, understand how nutrients are absorbed, and address how digestive disorders can be treated. The flow is logical and progressive, starting from fundamental anatomical knowledge and advancing towards the physiological processes and health implications. This ensures students gain a comprehensive understanding of the digestive		**Progressive Complexity:** The lessons gradually increase in complexity, from simple pH measurements to titration, concentration calculations, and finally, colorimetry. **Hands-On Application:** The sequence is practical, ensuring that students gain experience with essential lab techniques while understanding the underlying theory and principles. **Real-World Relevance:** Concepts like standardization, accurate dilution, and calibration of solutions and equipment are crucial in both industrial and research settings, preparing students for future laboratory work. This structure ensures a logical, progressive development of skills and knowledge, moving from foundational techniques to advanced analytical methods, equipping students with the tools necessary for accurate and reliable scientific analysis. The sequence of lessons for Learning Aim B, "Undertake calorimetry to study cooling curves," is designed to gradually introduce students to the principles of calorimetry, focusing on the use of thermometers and the interpretation of cooling curves. Here's the rationale behind this structure: **1. Introduction to Thermometers** **Objective:** To familiarize students with the types of thermometers, how they work, and their role in measuring temperature accurately. **Why first?** Accurate temperature measurement is fundamental to calorimetry and cooling curve studies. Students must understand how to use and calibrate thermometers before moving on to analyze cooling curves. **Key skills/knowledge:** Differentiating between electronic and liquid-filled thermometers ensures students know

system's role in maintaining health and treating diseases related to digestion. **1. Introduction to the Structure of the Digestive System (C1)** **Objective:** To familiarize students with the anatomy of the digestive system, including the mouth, stomach, intestines, and associated organs like the pancreas, liver, and gallbladder. **Why first?** Understanding the structure of the digestive system is foundational. Students need to know the locations and roles of various organs to comprehend how digestion and nutrient absorption occur. **Key skills/knowledge:** Students will learn to identify the key parts of the digestive system and associated organs, providing the foundation for understanding how these structures contribute to the system's overall function. **2. Mechanical and Chemical Digestion (C2)** **Objective:** To explore the processes of mechanical and chemical digestion, focusing on how food is broken down into absorbable components. **Why here?** After students understand the structure, they are ready to learn how these structures facilitate the breakdown of food. This lesson will cover the digestive processes that occur in various parts of the system. **Key skills/knowledge:** Students will learn the roles of mechanical digestion (e.g., chewing, stomach churning) and chemical digestion (e.g., enzyme		which thermometer to use for different situations and how to gain accurate readings. **2. Relationship Between Temperature and Heat Energy** **Objective:** To introduce students to the theoretical relationship between temperature and heat energy. **Why here?** Understanding this relationship is critical for calorimetry and interpreting cooling curves. Before students work with actual data, they need to know how temperature correlates with heat energy transfer. **Key skills/knowledge:** This foundational knowledge helps students understand the concepts of heat capacity, energy transfer, and how thermometers reflect changes in energy. **3. Types of Thermometers and Their Applications** **Objective:** To explore different types of thermometers and their appropriate use in various practical scenarios. **Why now?** After understanding the heat-energy relationship, students are ready to learn how different thermometers work and which are best suited for specific experiments. **Key skills/knowledge:** Students will learn to select the appropriate thermometer (e.g., electronic probes for fast readings, liquid-filled thermometers for traditional measurements) and the conditions under which each performs best. **4. Calibration of Thermometers Using Ice and Boiling Water** **Objective:** To teach students how to check the calibration of thermometers.

action), setting the stage for understanding nutrient absorption. **3. Enzymatic Action and Nutrient Absorption** **Objective:** To understand the role of digestive enzymes (protease, amylase, lipase) in breaking down proteins, carbohydrates, and fats, and the process of nutrient absorption. **Why now?** This lesson builds directly on the previous one by delving into how specific enzymes act on different macronutrients and how these nutrients are absorbed through processes like active transport and diffusion. **Key skills/knowledge:** Students will explore the action of enzymes, the chemical processes of hydrolysis, and where in the digestive tract nutrients are absorbed, making connections between structure and function. **4. Chemical Tests for Nutrients** **Objective:** To perform chemical tests for the presence of macronutrients such as starch, proteins, lipids, and sugars in food. **Why here?** After learning about nutrient absorption, students can now apply this knowledge practically by testing for these nutrients in food samples. This reinforces their understanding of macronutrients and prepares them for discussions on dietary deficiencies. **Key skills/knowledge:** Students will gain hands-on experience with biochemical tests, which reinforces theoretical knowledge and provides practical skills in identifying nutrients.		**Why here?** Calibration ensures that students' future measurements are accurate and reliable. Without this step, the data collected in calorimetry experiments could be flawed. **Key skills/knowledge:** Using fixed reference points (ice at 0°C and boiling water at 100°C) helps students understand how to check for measurement accuracy and how to adjust or account for calibration discrepancies. **5. Accuracy of Thermometers at Different Temperatures** **Objective:** To explain how thermometer accuracy can vary across temperature ranges and how to handle this variability. **Why here?** As students prepare to undertake calorimetry, they need to understand that thermometer accuracy is not uniform across all temperatures. This helps them better interpret results in the context of their tools' limitations. **Key skills/knowledge:** Recognizing these accuracy differences allows students to assess the precision of their measurements and consider error margins in their analyses. **6. Introduction to Cooling Curves** **Objective:** To introduce cooling curves and explain how they represent temperature change over time. **Why now?** With a solid understanding of temperature measurement, students are ready to visualize how temperature changes over time and how this data can be used to study heat transfer and cooling processes. **Key skills/knowledge:** Learning how to plot and interpret temperature as a function of time introduces students to

5. Nutrient Deficiencies and their Impact **Objective:** To introduce the concept of macronutrient and micronutrient deficiencies and explore the physiological symptoms of these deficiencies. **Why now?** Following the lessons on digestion and absorption, students will now learn about the consequences of inadequate nutrient intake, which ties into the practical understanding of how the digestive system affects overall health. **Key skills/knowledge:** Students will examine the importance of nutrients such as proteins, vitamins, minerals, and fibres, and learn to recognize the symptoms and effects of deficiencies (e.g., scurvy, anaemia, rickets). **6. Dietary-Related Digestive Disorders (C3)** **Objective:** To introduce digestive diseases such as coeliac disease, irritable bowel syndrome (IBS), and colitis, explaining the physiological reasons behind these disorders. **Why here?** After understanding the normal functioning of the digestive system, this lesson introduces what happens when the system malfunctions. It focuses on diseases that affect digestion and absorption and how they alter normal digestive processes. **Key skills/knowledge:** Students will explore the causes, symptoms, and physiological impact of common digestive disorders, linking this knowledge to the digestive processes they have already studied.		the concept of cooling curves and prepares them for more complex analysis. **7. Rate of Cooling from the Gradient of the Cooling Curve** **Objective:** To teach students how to calculate the rate of cooling using the gradient of the tangent to the cooling curve. **Why here?** Once students can construct cooling curves, they can begin analyzing the rate of cooling, a key component in calorimetry experiments. **Key skills/knowledge:** Calculating the gradient (rate of cooling) gives students insight into how quickly heat is lost, which they can later relate to factors like material properties or environmental conditions. **8. Determination of Melting Point and Freezing Point from Cooling Curves** **Objective:** To explore how cooling curves can reveal the melting and freezing points of a substance. **Why now?** This is a natural extension of interpreting cooling curves. After understanding how to construct and analyze the rate of cooling, students can identify phase changes in substances, which are crucial in calorimetric studies. **Key skills/knowledge:** Interpreting flat regions or inflections in the curve helps students recognize phase transitions (such as freezing or melting), allowing them to gather key physical data from their experiments. **9. Supercooling and Its Representation in Cooling Curves** **Objective:** To introduce the concept of supercooling and its appearance on cooling curves.

7. Corrective Treatments for Digestive Disorders **Objective:** To study the treatments for digestive diseases such as dietary changes, medication, and surgery, explaining how these treatments work to correct digestive dysfunctions. **Why here?** Having understood the nature of digestive disorders, this lesson focuses on how these conditions can be treated, providing insight into medical and dietary interventions. **Key skills/knowledge:** Students will study various treatments (e.g., gluten-free diets for coeliac disease, anti-inflammatory drugs for colitis) and understand the physiological reasoning behind each intervention, preparing them for future healthcare-related studies or careers. **8. Case Studies: Managing Digestive System Disorders** **Objective:** To apply theoretical knowledge through analysis of case studies of patients with dietary-related digestive disorders. **Why now?** This lesson allows students to apply their learning in a real-world context. By analyzing specific patient cases, students can consolidate their knowledge of digestive diseases and treatments. **Key skills/knowledge:** Students will critically analyze case studies, making connections between symptoms, diagnoses, and treatment plans, and applying their theoretical knowledge to practical scenarios.		**Why here?** Supercooling is an important phenomenon in cooling curves that students must understand to accurately interpret deviations from the expected curve shape. **Key skills/knowledge:** Recognizing supercooling, where the substance temporarily stays below its freezing point without solidifying, helps students appreciate the complexities of cooling behaviour and material properties. **10. Shape of Cooling Curves and Intermolecular Forces** **Objective:** To explain how the shape of a cooling curve relates to intermolecular forces and the state of the substance (solid or liquid). **Why now?** This is the culmination of the cooling curve analysis, where students connect experimental data to theoretical knowledge about molecular interactions. **Key skills/knowledge:** Understanding how the cooling curve reflects the strength of intermolecular forces and how these forces influence the cooling process provides students with a deeper understanding of phase changes and energy transfer. **Overall Structure and Flow:** **Foundation of Temperature Measurement First:** The lessons start with the basics of thermometry and calibration, ensuring students can accurately measure temperature and understand the underlying concepts of heat and energy. **Progressive Learning in Cooling Curve Analysis:** After mastering the use of thermometers, students progressively build up to constructing, analyzing, and interpreting cooling curves, which are key in calorimetry. **Linking Theory to Practice:** Students are gradually introduced to more complex phenomena, such as

9. Review and Synthesis: Digestive System and Health **Objective:** To review all the content covered, synthesizing how the structure, function, and diseases of the digestive system are interconnected. **Why now?** This final review lesson consolidates all the learning, helping students see how the various components of the digestive system contribute to overall health and how disorders disrupt this balance. **Key skills/knowledge:** Students will integrate their knowledge of the digestive system, its diseases, and treatments, reinforcing their understanding of how proper functioning is vital for maintaining health. **Overall Structure and Flow:** **Building a Foundation:** The sequence begins with the fundamental anatomy and physiology of the digestive system, ensuring students have the necessary background to understand the more complex processes of digestion and disease. **Progressive Complexity:** The lessons gradually build from the basic structure and processes of digestion to a deeper understanding of nutrient absorption, disorders, and treatments, allowing for logical progression in learning. **Application of Knowledge:** Case studies and practical testing of food samples provide students with opportunities to apply theoretical knowledge in practical and clinical contexts, reinforcing		supercooling and intermolecular forces, as they gain practical experience in handling real data and understanding the factors that influence cooling rates. This structured sequence allows students to move from basic temperature measurement to sophisticated analysis of heat transfer and cooling behaviour, building confidence and competence in both practical and theoretical aspects of calorimetry. **Assignment C** The sequence of lessons for Learning Aim C, "Undertake chromatographic techniques to identify components in mixtures," is designed to help students build a comprehensive understanding of chromatography, from its theoretical foundations to practical applications. Here's the rationale for the structure: **1. Introduction to Chromatographic Techniques (C1)** **Objective:** To introduce students to the fundamental concepts and terminology in chromatography. **Why first?** A foundational understanding of chromatography terminology (e.g., mobile and stationary phases, adsorption) is essential for students to grasp how the techniques work before they engage in practical applications. **Key skills/knowledge:** Familiarity with key terms and principles like the role of mobile and stationary phases ensures students can follow later lessons on specific techniques like paper and thin-layer chromatography. **2. Principles of Paper Chromatography** **Objective:** To explain the theory behind paper chromatography and its practical application. **Why here?** Paper chromatography is a relatively simple technique and provides a good entry point into

learning outcomes and preparing them for further studies or careers in healthcare or science. This structure ensures that students develop a comprehensive and applicable understanding of the digestive system, preparing them for both academic and real-world applications of this knowledge.		chromatographic methods. It also introduces the role of capillary action and separation based on solubility. **Key skills/knowledge:** Understanding the basic principles of paper chromatography helps students see how mixtures can be separated based on their movement through the stationary phase, preparing them for more complex methods like TLC. **3. Principles of Thin-Layer Chromatography (TLC)** **Objective:** To teach students how TLC works, including the structure of TLC plates and the nature of the solid adsorbent layer. **Why now?** Building on the understanding of paper chromatography, students can explore TLC, a more versatile technique that allows finer separations and is widely used in labs. **Key skills/knowledge:** Students will learn the differences between TLC and paper chromatography, including the types of plates used (glass, metal, plastic) and the importance of the adsorbent layer. **4. Use of Capillary Tubes for Sample Application** **Objective:** To provide hands-on training in applying mixtures to paper or TLC plates using capillary tubes. **Why here?** Accurate sample application is crucial to successful chromatography. After learning about paper and TLC theory, students need practical skills to ensure their samples are applied correctly and consistently. **Key skills/knowledge:** This step focuses on proper sample application, ensuring students avoid common issues such as overloading or improper placement, which can affect results.

		5. Choice of Developing Solvent and Vessel **Objective:** To teach students how to select the appropriate solvent and developing vessel for their chromatography experiments. **Why now?** After mastering sample application, students need to learn how to choose a suitable solvent for developing their chromatogram, as the solvent determines how well different components of the mixture separate. **Key skills/knowledge:** Understanding solvent properties and their compatibility with different samples is crucial for successful chromatographic separation. This prepares students for optimizing their experiments based on the nature of the mixtures they are analyzing. **6. Preparative Methods for Samples (Solvent Extraction, Filtration, Evaporation)** **Objective:** To introduce students to preparative methods for obtaining pure samples before chromatographic analysis. **Why here?** Proper sample preparation is key to ensuring reliable chromatographic results. Students need to understand how to extract, filter, and concentrate samples before applying them to a chromatography plate. **Key skills/knowledge:** These methods (solvent extraction, filtration, evaporation) ensure that the samples are in the right form for analysis, preventing contamination or incomplete separation during chromatography. **7. Use of Locating Agents** **Objective:** To teach students how locating agents are used to make components visible on chromatograms.

		Why now? Once students understand how to run chromatography experiments, they need to visualize the results. Locating agents are essential for making invisible substances (like colorless compounds) visible on the chromatogram. **Key skills/knowledge:** Using locating agents like iodine or ninhydrin helps students detect the presence of various substances on their chromatograms, which is critical for identifying components in mixtures. **8. Application of Chromatography to Separate Components (C2)** **Objective:** To apply chromatography techniques to separate mixtures such as plant pigments. **Why here?** After learning the theory and procedures, students are ready to apply their knowledge to practical chromatography experiments. Separating plant pigments provides a clear and visually engaging way to demonstrate the effectiveness of chromatography. **Key skills/knowledge:** Students will extract pigments using solvents like propanone, apply them to paper or TLC plates, and use chromatography to separate and identify the components, reinforcing their understanding of the technique. **9. Interpretation of Chromatograms** **Objective:** To teach students how to interpret chromatograms, focusing on the polarity of molecules, solubility, and retention in the stationary phase. **Why now?** After running chromatograms, students need to analyze the results. Understanding how molecule polarity and size affect solubility and mobility in the mobile phase is crucial for interpreting separation patterns.

		Key skills/knowledge: Students will connect chromatographic separation to the molecular properties of the substances they are analyzing, enabling them to explain why certain components travel further or stay closer to the baseline. **10. Calculation of Rf Value** **Objective:** To teach students how to calculate the retention factor (Rf) and use it to quantify the mobility of components. **Why here?** After interpreting chromatograms qualitatively, students are ready to calculate Rf values, which provide a quantitative measure of how far components travel. This is essential for comparing and identifying substances. **Key skills/knowledge:** Calculating Rf values solidifies students' understanding of the relationship between molecular properties and chromatographic behavior, allowing for more precise identification of unknown components. **11. Common Problems in Chromatographic Technique** **Objective:** To make students aware of common technical issues that can affect chromatographic results. **Why now?** As students gain experience, they will inevitably encounter problems such as overloading samples or contamination. Recognizing and troubleshooting these issues will help them refine their technique. **Key skills/knowledge:** Identifying and correcting problems like poor sample application or improper solvent choice enhances students' ability to produce accurate, reproducible chromatograms.

		12. Identification of Unknown Mixtures and Pure Substances **Objective:** To apply chromatography techniques to identify unknown substances, such as amino acids, using paper chromatography. **Why now?** After mastering the interpretation of chromatograms, students can apply these skills to real-world scenarios where they identify unknowns. Amino acid analysis is a common example that integrates multiple aspects of chromatography. **Key skills/knowledge:** This exercise challenges students to use their chromatography knowledge to identify specific substances, reinforcing both their technical and analytical skills. **13. Awareness of Other Chromatographic Methods (Gas Chromatography, Ion-Exchange Chromatography)** **Objective:** To provide students with an understanding of other chromatographic techniques, such as gas chromatography and ion-exchange chromatography. **Why here?** As the final lesson, introducing advanced chromatographic methods broadens students' awareness of the wide range of chromatography techniques used in industry and research. **Key skills/knowledge:** Although these methods (e.g., gas chromatography, ion-exchange chromatography) involve different principles and equipment, knowing about them prepares students for future studies and careers in analytical chemistry. **Overall Structure and Flow:** **Theory to Practice:** The lessons begin with theoretical concepts (terminology, principles of chromatography) to

		build a strong foundation before moving to hands-on applications. **Step-by-Step Mastery:** Each lesson adds a new layer of complexity, from simple paper chromatography to more advanced techniques like TLC and identification of unknowns. This ensures students develop both technical skills and theoretical understanding. **Real-World Applications:** The practical exercises, like separating plant pigments or identifying amino acids, help students apply their learning to realistic scenarios, reinforcing the relevance of chromatography in scientific analysis. This sequence ensures that students build their knowledge and skills in chromatography gradually, from foundational theory to complex applications and real-world problem-solving. **Assignment D** The sequence of lessons for Learning Aim D, "Review personal development of scientific skills for laboratory work," is designed to help students build essential skills and professional behaviours for working effectively in scientific environments. Here's the rationale for the structure: **1. Introduction to Personal Responsibility in Laboratory Work (D1)** **Objective:** To instill an understanding of personal responsibility in maintaining quality and safety standards in the lab. **Why first?** Personal responsibility is the foundation for all scientific work. Students must first understand their role in

		upholding safety protocols and delivering high-quality results to succeed in any lab-based environment. **Key skills/knowledge:** Students will learn to take ownership of their work, follow standards and protocols, and understand the consequences of not adhering to safety and quality measures. **2. Application of Safe Working Practices** **Objective:** To develop students' understanding and application of safe laboratory practices. **Why here?** After understanding personal responsibility, students must ensure that they can maintain a safe environment by practicing proper laboratory safety. Safety is paramount in any scientific setting, and students must be well-versed in these practices early on. **Key skills/knowledge:** Mastering the use of personal protective equipment (PPE), proper handling of chemicals, and understanding hazard protocols are critical components of maintaining a safe working environment. **3. Taking Responsibility for Completing Tasks and Procedures** **Objective:** To teach students to manage tasks independently while adhering to defined parameters and protocols. **Why now?** As students begin to work independently, they must understand how to manage their responsibilities, complete tasks on time, and maintain the quality of their work. This builds their ability to work efficiently within a structured framework. **Key skills/knowledge:** Students will learn how to organize their workload, follow lab protocols, and meet deadlines,

		preparing them for the realities of working in a professional laboratory setting. **Developing Interpersonal Skills for Effective Teamwork** **Objective:** To introduce the importance of communication, collaboration, and cooperation in a lab environment. **Why now?** Scientific work often involves teamwork. After building personal responsibility, students should learn to work with others efficiently. Collaboration enhances productivity and ensures a safe and cooperative working atmosphere. **Key skills/knowledge:** Students will practice active listening, clear communication, and teamwork skills, ensuring that they can contribute effectively to group work and lab projects. **Constructive Feedback: Giving and Receiving** **Objective:** To teach students how to give and receive constructive feedback in a professional context. **Why here?** Effective feedback improves performance and ensures continuous development. After focusing on teamwork, learning how to give and accept feedback allows students to grow and refine their skills. **Key skills/knowledge:** Students will understand how to provide constructive criticism respectfully and how to accept feedback positively, which are critical skills for professional growth and maintaining a collaborative work environment. **Behaviour for Safe and Efficient Working in Science** **Objective:** To reinforce professional behaviour necessary for maintaining safety and efficiency in the lab.

		Why now? With interpersonal skills in place, students must also understand how their behaviour influences the overall lab environment. Professional behaviour is key to ensuring smooth operations, safety, and respect among colleagues. **Key skills/knowledge:** Students will develop habits of punctuality, attentiveness, and adherence to safety protocols to ensure the laboratory functions smoothly and without risk. **Introduction to Professional Practice in Science** **Objective:** To introduce students to the concept of professional practice, including the recognition of problems and the application of scientific methods to resolve them. **Why here?** Once students are comfortable with the basics of lab work and interpersonal dynamics, they are ready to explore how to approach problem-solving in a scientific manner. This builds their ability to think critically and apply scientific principles to real-world challenges. **Key skills/knowledge:** Students will learn to identify problems, troubleshoot issues using scientific methods, and develop solutions, which are essential skills for professional scientific practice. **8. Problem Recognition and Application of Scientific Methods to Solve Problems** **Objective:** To develop students' ability to recognize and analyze problems in the lab and apply appropriate scientific methods to solve them. **Why now?** After understanding the concept of professional practice, students should learn to apply problem-solving skills in real laboratory situations. Problem

		identification and solution are at the heart of scientific inquiry. **Key skills/knowledge:** This lesson focuses on how to approach unexpected results or issues in the lab, use logical reasoning, and apply scientific methods to overcome challenges. **9. Resource Management: Identifying, Organizing, and Using Resources Effectively** **Objective:** To teach students how to manage laboratory resources efficiently. **Why here?** Efficient resource management ensures smooth laboratory operations. Students need to know how to organize materials, use equipment wisely, and avoid waste, which is critical for maintaining a professional and productive environment. **Key skills/knowledge:** Students will learn to plan experiments with available resources, prioritize tasks, and ensure that lab equipment and supplies are used efficiently and sustainably. **10. Maintaining and Enhancing Competence in Professional Practice** **Objective:** To instill a habit of continuous learning and improvement in professional scientific practice. **Why now?** As students prepare for future careers in science, they need to understand the importance of lifelong learning and skill enhancement. This final lesson emphasizes self-reflection and professional growth beyond the classroom. **Key skills/knowledge:** Students will learn to assess their own performance, seek out opportunities for professional

		development, and maintain up-to-date knowledge and skills in their field. **Overall Structure and Flow:** **Building Personal Responsibility First:** The lessons begin with personal responsibility, which is foundational for both safety and quality in scientific work. This ensures that students develop an understanding of how their behavior and actions directly impact lab work. **Gradual Focus on Interpersonal and Professional Skills:** After mastering personal responsibility, the lessons shift to interpersonal skills like communication and teamwork, followed by problem-solving and professional practices. This ensures students can work both independently and collaboratively. **Ending with Professional Development:** The final lessons focus on resource management and continuous improvement, preparing students for the realities of working in a professional scientific environment where efficiency, problem-solving, and lifelong learning are key to success. This sequence of lessons ensures that students develop a well-rounded set of skills, from personal responsibility and teamwork to problem-solving and professional growth, preparing them for successful careers in the laboratory.
Home – Learning: Students to produce a report and use information gained from research, visits, dissections/videos, models and simulations to produce an illustrated report explaining and analysing the structure and function of the musculoskeletal system. An evaluation of a related disorder/dysfunction of the system and associated treatments must be included. **Assignment B:**	**Home – Learning:** • Knowledge (flipped learning) • Pupils are to read extracts prior to the lessons. • Exam Papers	**Home – Learning:** **Assignment A:** **A report containing:** Results for checking the calibration of a pipette and balance(s) and calibration of a pH meter. A report on the use of Na2CO3 to standardise HCl, used in turn to standardise NaOH. pH curve from the titration plus a differential plot. Results, calculations and calibration graph for the determination of the concentration of a coloured solution using colorimetry.

Students to research work using the internet and TV documentaries to help learners to create a report that describes and explains the structure and function of the lymphatic system in promoting a healthy body. An evaluative case study of the effect of a disorder/dysfunction of the system and possible treatments must be included. **Assignment C:** • A lab book/record of investigations modelling the functioning of the various parts of the digestive system. Photographs and information from the investigations will be used to create an information leaflet that explains the role and location of organs and evaluates dietary disorder in the system and possible treatments. Observation records of practical work undertaken to assess the nutrient content of food will be required. Evidence and conclusions from the investigations will be incorporated into the report.		Explanations of how the accuracy, precision and safety of the quantitative techniques may be optimised. Observation checklist, completed by the teacher, including safety. **Assignment B:** A report containing: Results from checking the calibration of at least two types of thermometers. A table of time/temperature data and a graph of temperature against time for a substance cooling. Calculations of the rate of cooling at points on the graph. An analysis of how the rate of cooling is related to intermolecular forces and the state of the substance. A report evaluating the accuracy of the cooling curve experiment. An observation report with a checklist, completed by the teacher, including safety **Assignment C:** A report containing: Results from the paper chromatography and TLC of extracted plant pigments from paper chromatography of amino acids. An explanation of the principles behind the chromatographic separations. Suggestions for improvements to the chromatographic procedures carried out and full justification of these suggestions. An observation report with a checklist, completed by the teacher, including safety. **Assignment D:** A report containing: that focuses on the evaluation of learners' performance and skill development across all scientific procedures and techniques carried out in learning aims A, B and C.
Reading and literacy:	**Reading and literacy:** Unit 3 revision guide students to read and make notes.	**Reading and literacy:** Unit 2 Applied science textbook 1

Students will research through the internet and Applied Science textbook 1 the human body including its complex mix of organs and organ systems. Knowledge of how they function to maintain human life is an essential part of the study of human physiology and students will research this. In this unit, student's research will focus on three body systems: musculoskeletal, lymphatic and digestive. Students will research and examine each of the systems as a functioning unit, identifying their structure and function. By exploring the anatomy of these systems, through experimentation and articles, students will develop their knowledge and understanding of the role in the human body. Students will also give attention to understanding the implications of what happens when the systems fail to work properly and the available treatments again through research and reading various articles.	Unit 3 Applied science textbook Unit 3 PowerPoints for Biology, Chemistry and Physics. **Planning a scientific investigation** Developing a hypothesis for an investigation • Be able to formulate a hypothesis or a null hypothesis based on relevant scientific ideas. Selection of appropriate equipment, techniques and standard procedures • Be able to select and justify the use of equipment/techniques/standard procedures for quantitative and/or qualitative investigations. **Health and safety associated with the investigation** • Understand risks and hazards associated with the investigation. **Variables in the investigation** • Independent. • Dependent. • Control. **Method for data collection and analysis** • Be able to produce a clear, logically ordered method to obtain results. • Be able to select relevant measurements and the range of measurements to be recorded. • Understand the importance of obtaining data accurately/reliably and to appropriate levels of precision. • Understand how variables can be controlled/measured/monitored. • Understand how the data/information can be analysed. **Evaluation** • Be able to make any recommendations for improvements to the investigation. • Be able to explain anomalous data. • Be able to determine quantitative and discuss qualitative sources of error.	Unit 2 PowerPoints Students will discuss results which will allow them to understand the progress in relation to that of others and also to gain an understanding key words such as reliability, repeatability and reproducibility of various procedures and techniques. Students will follow written scientific procedures in order to ensure accuracy by using techniques correctly and by checking that equipment – for example, pipettes, balances, pH meters and thermometers – is calibrated correctly and that appropriate standard calibration documentation has been completed.

	• Be able to discuss evidence of the reliability of the data collected during the investigation. • Be able to identify strengths and weaknesses within method/techniques/standard procedures/equipment used. • Be able to suggest improvements to an investigation.	
Numeracy: **Assignment C:** Chemical tests for the presence of macro-nutrients found in foods: starch, proteins, lipids, reducing and non-reducing sugars, vitamin C content.	**Numeracy:** **Physics:** Equations • Power = VI (voltage × current). • Power = work done time • Work done = energy supplied or transformed. • Define – joules, kJ, calories (1 g by 1 oC), kilocalories, kWh. • The heat capacity of water will be given if required. • Calculate heat energy supplied by a fuel to water using: o heat energy = mass of water × specific heat capacity of water × temperature rise of water. • Calculate heat energy released from a fuel in kJ mol-1. **Biology:** Sampling sizes • Select sample sizes for investigation with regards to practical constraints and the need to collect sufficient data to make valid conclusions. **Drawing conclusions and evaluation:** Interpretation/analysis of data • Be able to identify trends/patterns in data. • Be able to compare primary and secondary data. • Be able to use data to draw conclusions that are valid and relevant to the purpose of the investigation. • Interpretation of statistical tests using tables of critical values and a 5% significance level, with reference to the null hypothesis. **Collection of quantitative/qualitative data**	**Numeracy:** Students will have the opportunity to use problem-solving skills when they undertake calorimetry work. Students will follow written scientific procedures in order to ensure accuracy by using techniques correctly and by checking that equipment – for example, pipettes, balances, pH meters and thermometers – is calibrated correctly and that appropriate standard calibration documentation has been completed. **Assignment A:** • Use of pH meters and probes: o calibration according to the manufacturer's instructions. • Use of balances and weighing: o electronic balances – rough balances (two decimal places), analytical balances (four decimal places) o checking calibration with certified weights o measurement of mass using increasingly accurate balances o suitable containers for weighing liquids and solids o density of water at different temperatures. • Safe use of volumetric glassware: o bulb, graduated, automated and teat pipettes o burettes o glass and plastic filter funnels o volumetric flasks o accurate dilution o use of water as a standard for calibrating volumetric glassware. Preparation and standardisation of solutions using titration Processes involved in the preparation and standardisation of solutions using titration.

	• Be able to collect data accurately/reliably and to appropriate levels of precision. • Be able to tabulate data in a clear and logical format using correct headings with units where appropriate. • Be able to identify anomalous data and take appropriate action. • Be able to recognise when it is appropriate to take repeats. • Be able to make qualitative observations and draw inferences. **Processing data** • Be able to carry out relevant calculations where appropriate, involving: o mean and standard deviation o use and interpretation of error bars o use of statistical tests, including t-test, chi-squared and correlation analysis o use of formulae o transposition of formulae o conversion of units o use of standard form o percentage error of measuring equipment. • Be able to display data in an appropriate format, including: o choosing an appropriate graph/chart/tables o correct plotting/labelling/scales.	• Accurate determination of the end-point of titrations from: o the colour change of a suitable indicator o plots of pH versus volume o ΔpH/Δvolume versus volume. • Calculation of concentrations: o use of molecular mass from periodic table. • Use of primary and secondary titrimetric standards. Colorimetry • Measurement and use of absorbance readings. • Use of Beer-Lambert law to determine the concentration of a transition metal ion solution. • Accurate dilution of stock solutions to prepare a range of calibration standards with absorbance in the range 0 to 1. • Use of blank solutions. • Calibration plot. • Determination of unknown solution concentration from reading from graph (graph paper) or from the equation of a linear trend line through the origin (Microsoft Excel). **Assignment B:** • The relationship between temperature and heat energy. • Types of thermometer and how they are used to gain accurate readings: o electronic thermometers/temperature probes o liquid-filled thermometers. • Checking the calibration of thermometers by using ice and boiling water. • Accuracy of thermometers and temperature probes at different temperatures. Construction and interpretation of cooling curves: • temperature as a function of time • rate of cooling from the gradient of the tangent to the cooling curve • determination of melting point from the shape of a curve for a substance freezing • super cooling

		• shape of the curve and rate of cooling in relation to intermolecular forces and the state (solid or liquid) of the substance. **Assignment C:** Calculation of Rf value.
Enrichment / opportunities to develop cultural capital (including careers, WRL and SMSC): University sports science departments may be able to provide support and guidance and access to models of joints and a skeleton. Physiotherapy departments may be able to offer information and access to examples of replacement joints and exercises that will assist in treatment and recovery from musculoskeletal dysfunction. GP Surgeries may have specialist nurses who might be available to visit and provide information about management of digestive system disorders, such as coeliac disease, irritable bowel syndrome and colitis. This is done during Science week.	**Enrichment / opportunities to develop cultural capital (including careers, WRL and SMSC):** Centres may involve employers in the delivery of this unit if there are local opportunities. There is no specific guidance related to this unit. However we offer a chance during Science week and throughout the year for these students to go on visits to universities, companies visiting the school so that students can understand the purpose of this course and enhance practical skills. These visits and talks enable students to choose a career pathway for them too. Time management Individual working Group collaboration Verbal and electronic presentation Use of a variety of IT programs Research skills Teamwork Literacy and numeracy skills SMSC - Is health and safety still relevant in a modern laboratory? Discuss. - Why is precision vital as a scientific skill when linked to medical treatment? - How can applications of these experiments be used in forensics Science to solve crime?	**Enrichment / opportunities to develop cultural capital (including careers, WRL and SMSC):** Centres may involve employers in the delivery of this unit if there are local opportunities. It would be beneficial for an industry representative to explain the importance of the routine calibration of equipment in ensuring the reliability of results. A visit to a local laboratory would reinforce the importance of calibration of equipment and health and safety. Even if the local organisations that use science only operate on a small scale, their representatives will be able to reinforce the importance of the transferable skills this unit develops. This is usually done during Science week. The fundamental knowledge, practical skills, transferable skills – for example, organisation, self-assessment and problem-solving, and the ability to interpret data – all developed in this unit will give students confidence when they undertake the more complex practical techniques involved in higher education science courses such as biochemistry, chemistry, forensic science and environmental science