MINISTRY OF EDUCATION

BIOMEDICAL SCIENCE

For Senior High Schools

TEACHER MANUAL

YEAR TWO

NATIONAL COUNCIL FOR CURRICULUM & ASSESSMENT OF MINISTRY OF EDUCATION

MINISTRY OF EDUCATION

REPUBLIC OF GHANA

Biomedical Science

For Senior High Schools

Teacher Manual

Year Two

NaCCA NATIONAL COUNCIL FOR CURRICULUM & ASSESSMENT OF MINISTRY OF EDUCATION

BIOMEDICAL SCIENCE TEACHER MANUAL

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Introduction

The National Council for Curriculum and Assessment (NaCCA) has developed a new Senior High School (SHS) curriculum which aims to ensure that all learners achieve their potential by equipping them with 21st Century skills, competencies, character qualities and shared Ghanaian values. This will prepare learners to live a responsible adult life, further their education and enter the world of work.

This is the first time that Ghana has developed an SHS Curriculum which focuses on national values, attempting to educate a generation of Ghanaian youth who are proud of our country and can contribute effectively to its development.

This Teacher Manual for Biomedical Science is a single reference document which covers all aspects of the content, pedagogy, teaching and learning resources and assessment required to effectively teach Year Two of the new curriculum. It contains information for all 24 weeks of Year Two including the nine key assessments required for the Student Transcript Portal (STP).

Thank you for your continued efforts in teaching our children to become responsible citizens.

It is our belief that, if implemented effectively, this new curriculum will go a long way to transforming our Senior High Schools and developing Ghana so that we become a proud, prosperous and values-driven nation where our people are our greatest national asset.

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SECTION 1: CAREERS IN BIOMEDICAL SCIENCE

STRAND: BIOMEDICAL SCIENCE IN SOCIETY

Sub-Strand: Biomedical Science in Practice

Learning Outcome: *Describe various roles of biomedical scientists in society*

Content Standard: *Explore the various roles of biomedical scientists in society*

HINT

- ***Classwork should be assigned during weeks 1–4**. The highest-scoring exercise or homework should be included in the learner's academic transcript.*
- *Learners should be given individual portfolio in week 2. The portfolio assessment will span the entire academic year, starting in the 2nd week of the first semester to the 22nd week of the second semester and it will be included in the learner's transcript. Refer to Appendix A for the required items, and discuss with learners what should be included in their individual portfolios.*
- *A group project should be assigned to learners by week 3, with a submission deadline by week 9. Teachers must explain the project's context and scope before groups start. This project will be recorded in the learner's transcript. Refer to Appendix B at the end of this section for a sample of group project task.*

INTRODUCTION AND SECTION SUMMARY

Delving more into the world of careers within biomedical science, in this section, learners explore and examine diverse roles that contribute to preventing, diagnosing, and treating diseases. A broad spectrum of professions, from research scientists developing new treatments to medical laboratory technicians analysing samples for diagnosis are discussed. Also, learners are introduced to the field of forensics. Learners uncover some methodologies and principles of other science fields used in forensic investigations as well as the crucial role of biomedical science professionals in unravelling crimes. The section concludes with a deep dive into some specific biomedical career paths, gaining a detailed understanding of the educational requirements, responsibilities, and impact these fields have on healthcare. This section also lays the groundwork for learners to appreciate the vast career landscape within biomedical science and identify potential pathways that align with their interests.

The weeks covered by this section are:

Week 1: Investigate and discuss a variety of biomedical science careers that relate to the prevention, diagnosis, and treatment of diseases.

Week 2: Discuss and describe the role of biomedical science professionals in forensics.

Week 3: Explore various biomedical career fields related to clinical or research studies.

SUMMARY OF PEDAGOGICAL EXEMPLARS

To achieve the content standard for this section, the following pedagogical exemplars are recommended: using experiential learning and digital learning, learners observe the roles of biomedical scientists in treating, preventing and diagnosing diseases as well as their roles in forensic investigations. In mixed gender/ability groups learners use activity-based learning to first role-play some of the professionals and also explore how biometrics (such as fingerprints and facial recognition) are used in forensic investigations. To promote learners' ability to research, learners use exploratory and project-based learning to explore biomedical career fields relating to clinical and research studies and their associated roles. Learners focus on the training required to take up chosen career fields in biomedical fields using project-based learning.

ASSESSMENT SUMMARY

To assess learners' ability to show an understanding of careers in biomedical science, DOK levels 2, 3 and 4 assessment strategies are recommended. Learners' conceptual understanding is assessed on the roles and importance of some biomedical science careers in healthcare and also, the role of biomedical science methodologies in forensic investigations using DOK level 2 assessment strategies. Using DOK level 3 assessment, learners' strategic reasoning abilities are assessed on how the various careers in biomedical science focus on treating, diagnosing, and preventing diseases. How forensic investigations are carried out focusing on the role of biomedical science methodologies is assessed using DOK level 3. The recommended mode of assessments for each week is as follows:

Week 1: Homework

Week 2: Presentation

Week 3: Research

WEEK 1

Learning Indicator: Investigate and discuss a variety of biomedical science careers that relate to the prevention, diagnosis, and treatment of diseases

Focal Area 1: Discussions of Careers Involved in Preventing and Diagnosing Diseases

Biomedical scientists are essential for the prevention, diagnosis and treatment of diseases. From analysing complex data to testing new medications. These careers within biomedical science are interconnected and contribute to various aspects of preventing, diagnosing, understanding and treating diseases. These careers also have several specialities whose roles involve a combination of clinical research into diagnostic tools, understanding the biological causes of diseases, and working to improve healthcare and wellbeing. In the prevention and diagnosis of diseases, the knowledge acquired is used to identify illnesses and abnormalities. Samples ranging from blood to tissue are analysed with the application of an array of technology.

Some biomedical science careers focused on preventing and diagnosing diseases include:

1. **Biomedical scientists**: mostly carry out experiments on samples to research the causes and to improve the diagnosis of common and rare diseases and disorders. They are also renowned for their significant contribution to preventative healthcare for example, by conducting health screening and vaccination.
2. **Microbiologists**: these are scientists who focus on research and investigation of the effects of microorganisms in diseases, antibodies, hormones and vaccine production.
3. **Immunologists**: focus on understanding the role of the immune system in combating diseases. They also analyse blood and body fluids to help diagnose diseases like haemolytic anaemia.
4. **Genetic Counsellors**: helping individuals and families understand genetic diseases as well as their risks is the main role of genetic counsellors. They also advise on genetic tests needed for the diagnosis of certain diseases and disorders. For example, prenatal genetic screening can help diagnose the potential for certain genetic disorders before birth (for example, Down syndrome).
5. **Epidemiologists**: study causes, patterns, and consequences of diseases in groups of people with the aim of preventing future occurrences. The nature of their studies involves conducting surveys and analysing huge data sets.

Disease prevention focuses on keeping people healthy, and the right diagnosis is a key aspect of health care, as it provides an explanation of a patient's health problems and informs subsequent healthcare decisions.

Careers Involved in Treating Diseases

Aside from prevention and diagnosis another dynamic and exciting area which is essential for the longevity of individuals, is the treatment of human diseases. Treatment is aimed at controlling health problems, and lessening or clearing up disease symptoms. It can be carried out in several ways including using medicines, therapy, or surgery.

Some of the discussed biomedical science careers in prevention and diagnosis also work in providing treatment. This could be researching to develop new treatments for some conditions or improving already existing treatments. Examples of biomedical science careers aimed at improving healthcare through treatment include:

1. **Biotechnologists**: using extensive knowledge of biology and technology, biotechnologists create innovative products or improve old ones for the treatment of diseases and disorders.
2. **Medicinal chemist**: with skills in experimental design and data analysis, they use chemistry techniques to design and synthesise chemical compounds which have a positive effect on the body or mind.
3. **Pharmaceutical scientist**: create new and more effective medicines for specific conditions or diseases. The focus is on the drug discovery process through which potential new therapeutic entities are identified, using a combination of computational, experimental, translational, and clinical models.
4. **Bioinformatician**: using computational tools (such as algorithms and statistics) to analyse biological data forms the basis of the work of bioinformatician. Real-world examples of bioinformatician's impact span being responsible for designing experiments and translating results into accessible data and visuals to enable medical teams to make informed decisions. Or they might analyse genomic data to find disease-related proteins and use this information to design new targeted drugs.
5. **Clinical scientists**: healthcare and medical experts whose work is very wide-ranging and can include laboratory work and testing, basic and applied research. They are trained to analyse various medical samples like blood, tissue or other bodily fluids to diagnose, prevent and treat diseases.

Figure 1.1: *Biomedical Science careers (Photo credit: Ho Regional Hospital, Trafalgar, 2024)*

Learning Tasks

The objective of this task is to help learners understand the role of biomedical scientists, their contributions to healthcare in terms of diagnostics, treatment and prevention.

1. Learners watch videos/images or embark on a field trip to observe selected biomedical scientists (for example, pharmacists, radiologists, community health nurses) at work. The videos should be based on their career path, daily tasks, and significant contributions to the field in the area of diagnosis, treatment and prevention.

2. After the activity, learners write a reflection on what they learned and how it has changed their perception of biomedical science.

Pedagogical Exemplars

1. **Experiential Learning:** Learners watch videos/images or embark on a field trip to observe selected biomedical scientists (those related to the prevention, diagnosis and treatment of disease) at work. Learners critically analyse and relate various careers to the prevention, diagnosis and treatment of diseases.
2. **Activity-Based Learning:** In mixed-ability/gender groups, learners role-play the various professionals and how they work in the prevention, diagnosis and treatment of diseases. Before the beginning of the role-play, a group member tells the class about the career the group has chosen, and a brief summary about the career.

Key Assessment

Level 2 (Conceptual understanding)

1. Match the following biomedical science careers (Set A) with their role descriptions (Set B) and justify your choices.

   SET A

   a. Microbiologist

   b. Immunologist

   c. Bioinformatician

   SET B

   Studies the immune system and its response to infectious agents.

   Analyses microorganisms to identify infections.

   Applies computational tools and biology for drug discovery.

2. Explain in writing or orally the importance of biomedical science professionals in promoting good health.

Level 3 (Strategic reasoning)

There is a new disease outbreak in your community. Outline which of the careers in biomedical science may be responsible for dealing with the situation and bringing it under control. How are the enumerated biomedical science careers involved in addressing the outbreak?

WEEK 2

Learning Indicator: Discuss and describe the role of biomedical science professionals in forensics

Focal Area 1: How is Biomedical Science Used in Forensics?

Discussions of Forensic Science

The world of biomedical science is growing quickly, opening doors to new and exciting jobs in many different areas. Forensics uses the methods of biology, chemistry, physics and other sciences to help with criminal investigations and legal cases (Siegel, 2024). There are many different specialisations within forensic science, each with its own unique role. Forensic science relies on several methodologies and principles of biomedical science to unravel crimes. Some interesting disciplines include:

1. **Forensic odontology**: can also be referred to as forensic dentistry. This field uses dentition to identify people. Teeth are very durable and can survive situations like fires or crashes that destroy other body parts. This makes them especially helpful in identifying victims of disasters involving fires (Siegel, 2024).
2. **Forensic toxicology**: toxicology is used for the analyses of body fluids and tissues with the aim of detecting poisons and drugs. A typical example is the measurement of blood alcohol levels to ascertain how much alcohol a person has in their system and how it might have affected their behaviour (Siegel, 2024).
3. **Forensic pathology**: Forensic pathologists are like medical detectives who determine the cause and manner of death by performing an autopsy considering forensic science. An autopsy involves carefully examining the body for injuries, diseases, or signs of poisoning that could explain the cause of death. During an autopsy, the forensic pathologist may work closely with forensic toxicologists, who analyse tissue samples to detect any substances that might have contributed to the death of the individual (Siegel, 2024).
4. **Forensic serology**: This field focuses on analysing blood serum to gather evidence for investigations and court cases. Blood is rich in unique molecules like proteins and antibodies. Forensic serologists use these molecules to identify blood type, species of origin (human vs. animal), and even perform tests to detect the presence of certain substances such as semen, saliva and blood (McNevin & Padula, 2023).

Exploring Some Other Disciplines of Forensic Science

1. **Forensic psychology**: Imagine assessing if someone is mentally fit to stand trial. That is what forensic psychology is about. Forensic psychiatrists and to some extent psychologists help understand a person's mental state to aid in their defence. Psychological profiling is also used in the reconstruction of crime scenes where applicable.
2. **Forensic anthropology**: Just like archaeologists, forensic anthropologists study bones. They can use their knowledge to examine skeletal remains from a crime scene and potentially identify the person and determine the cause of death.
3. **Forensic engineering**: involves the concepts of mechanical, chemical, civil, and electrical engineering as tools in the reconstruction of crimes and accidents and the determination of

their cause. Think of forensic engineers as accident scene detectives! They use the principles of engineering, to figure out what happened during an accident. For example, they might analyse skid marks, car damage, road conditions, and witness statements to understand a car crash.

Application of Biomedical Science in Forensics

Forensic science relies mostly on biomedical science, particularly for analysing biological evidence. This specialised field is called biomedical forensics sciences.

Biomedical forensics can be seen in action in relation to criminal investigations, where DNA analysis, for example, can be used to identify suspects or clear suspicion. Biomedical forensics can also examine hair follicles, body fluids, and drugs at crime scenes. However, beyond crime, biomedical forensics applies methods in the medical field to diagnose and treat diseases as well as injuries.

Biomedical forensic scientists can analyse a wide range of evidence, including:

- **Biological evidence:** this can include hair follicles, which can reveal DNA or other bodily fluids.
- **Chemical evidence:** drugs and other substances found at a crime scene can be analysed to understand what happened.
- **Physical evidence:** fibres from clothing and fingerprints can also be examined using biomedical techniques.

So far, the key role Biomedical Science plays in forensic investigations have been established. It provides some powerful techniques to analyse evidence.

Here are three examples of how biomedical science helps in forensics.

1. **Analysing DNA evidence**

   A fingerprint - A fingerprint is the unique pattern of ridges and valleys on the surface of a person's finger. These patterns are formed during foetal development and remain unchanged throughout a person's life, making them an ideal tool for identification. It is made of unique instructions inside your cells called deoxyribonucleic acid (DNA). DNA is like a personal code that is different for almost everyone. In forensics, scientists can analyse DNA found at crime scenes, like hair follicles or blood drops. By comparing this DNA code to a suspect or missing person's code, it can help link biological evidence to individuals and explore genetic relationships or even rule them out entirely. It is a powerful tool for solving crimes.

2. **Identifying toxins and poisons**

   Not all dangers are visible. Sometimes, harmful substances called toxins or poisons can be hidden in food, drinks, or even medicine. Biomedical forensic scientists use special biomedical science techniques to analyse body fluids and tissues to see if any toxins or poisons are present. This can help investigators understand how someone got sick or even died.

3. **Using blood spatter analysis to reconstruct crime scenes**

   Bloodstains at a crime scene can tell a story, and its pattern can be analysed. The analysis involves a technique where scientists examine the size, shape, and location of bloodstains. Using knowledge of physics and biology, forensic scientists can recreate how the blood spatter happened. This can help investigators understand the sequence of events at a crime scene, like the position of the victim and the perpetrator during the crime.

Learning Task

In mixed ability/gender groups, guide learners in implementing at least one of the following learning tasks to reinforce understanding of the role of biomedical science in forensic investigations.

1. Begin this activity by providing learners with a brief overview of the various methodologies and principles of biomedical science used in forensic investigation of a crime scene.
   a. Assign each group with either crime scene A or B (**See Figures 3 and 4**).
   b. Guide learners to first use the word box (**Scan QR Code 4 and 5 in Addition reading for crime scene A and B respectively**) to find words representing the images from a crime scene.
   c. After finding the images in the crime scene, guide learners to analyse the scene and identify what must have happened at the crime scene and suggest ways of solving the mystery. Each group presents their findings after investigating their assigned crime scene using any preferred presentation mode (example oral, visual, written report or audio). Learners during the presentation should be open to questions and criticism of their work from their peers.

Note

For answers to Wordsearch puzzles, scan QR codes 4a (Crime scene A) and 5a (Crime scene B)

2. Create a crime scene using locally sourced materials, say red dye, to create blood spatter. Ask learners in pairs, to role-play as detectives at a crime scene to observe the scene and take down Notes. Learners should take into consideration the types of evidence collected at the scene and describe the biomedical science techniques that can be used in analysing the evidence. Learners then present their findings to the class in different modes (for example, orally, in writing or PowerPoint presentation).

Figure 2.1: *Crime Scene A. (Images generated using the prompt "3D images of a bloody crime scene with a shoe print, towel, stained gloves, dish washing liquid, blood spatter, stained sink, blood streak in the doorway, socks, knife and kitchen cabinets", 2024)*

Figure 2.2: *Crime Scene B. (Images generated using the prompt "image of burnt car crime scene with skeleton, skull, yellow can, burnt newspaper piece, diesel, shovel, broken on a road with forest environment" by Freepik, 2024* https://www.freepik.com)

Pedagogical Exemplars

1. **Activity Based-Learning:** Using coloured dye and a piece of paper/cardboards, guide learners in a fingerprinting activity. After stamping finger prints on the paper, instruct learners to label their fingerprints with their names and paste their prints on a gallery wall. Guide learners in mixed-gender/ability groups to discuss some differences they observe in the fingerprints of their colleagues.
2. **Digital Learning:** Learners watch videos (Scan **QR Code 1** or **QR Code 2** for example videos) on how forensics is used to solve crimes using fingerprints and guide learners in summarising their observations. Using the fish-bowl strategy, learners discuss the role of biomedical science in forensics using videos watched.
3. **Experiential Learning:** Learners pay a virtual (Scan **QR Code 3** for an example of a video) or in-person visit to the workplace of forensic scientists to make observations on the roles of biomedical scientists in the field of forensics. Shy learners should be encouraged to ask questions.

Note

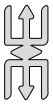
For the visually impaired get audio scenes and for the hearing impaired get videos with sign language available as an alternative for the videos used in both exemplars.

Key Assessment

Level 2 (Conceptual understanding)

1. Fill-in-the-blank question:

   A biomedical scientist working in forensics might use blood samples collected from a crime scene to analyse_____ (example DNA or blood type) to help identify suspects or link evidence to a specific person. In other cases, _____ is used to analyse blood samples, tissue and fluids collected from the crime scene to detect poisons.



Note

For the first blank, learners can use either DNA or blood type, or even another relevant answer as long as it demonstrates understanding of how these samples are used in biomedical forensic science.

2. How might a biomedical scientist working in forensics use blood samples collected from a crime scene?

Level 3 (Strategic reasoning)

A hair sample has been collected from a crime scene.

1. List and briefly describe the various disciplines of forensic science that may be involved in an investigation.
2. Describe the role of biomedical science in analysing the evidence
3. Describe the various steps involved in analysing this evidence and how it might be used in the investigation.

WEEK 3

Learning Indicator: Explore various biomedical career fields related to clinical or research studies and describe these career fields

Focal Area 1: Clinical and Research Careers in Biomedical Science

Clinical and research careers in biomedical science are just like the two sides of a coin, they go hand in hand. Clinical careers in biomedical science are aimed at diagnosing, managing and treating patients' diseases whereas research careers focus on investigating scientific questions (using the scientific method-*refer to week 3 in Year 1 for a brief recap*) and developing new therapies to treat and manage diseases. Below are discussions on the similarities and differences between these two areas of focus in biomedical science careers.

Discussion on How Clinical Professionals Directly Interact with Patients

Clinical professionals like medical doctors, and clinical scientists who carry out biomedical research, have the responsibility to interact with patients. In most cases, during the clinical trial process of researching new treatments for certain medical conditions (for example, studying a new drug for the treatment of Alzheimer's, a neurodegenerative disorder which affects memory), clinical scientists play a dual role. They are involved in the design, implementation and performance of a clinical trial study. On one hand, they perform research by tracking and recording the effect of the drug/medication being administered to patients (who have given full consent) involved in the clinical study. At the same time, they get to provide care and advice on patient care. Overall, other clinical professionals such as specialised doctors (for example, cardiologists, and oncologists) can perform research as well as interact with patients.

How Research Professionals Focus on Developing New Treatments and Knowledge

Research professionals in biomedical science play a key role in expanding scientific knowledge, and developing new diagnostic approaches as well as treatments through a systematic approach. Using the scientific process, research professionals identify and investigate the main cause of a disease or disorder focusing not just on biological processes and pathways of the disease but also on the role of environmental factors on the development and progression of some diseases and disorders (**Scan QR Code 6** for an article on the role of environmental factors on health). For example, clinical biomedical scientists focus on scientific research rather than clinical practice. They engage in research to develop new diagnostic tests with other scientists and healthcare professionals to improve existing methodologies, enhancing the diagnosis of diseases and disorders.

Focal Area 2: Explore a Chosen Clinical or Research Field

The Unique Aspects and Contributions of a Particular Field to Biomedical Science

Other fields play a vital role in bridging the gap between the theoretical and the practical parts of biomedical science. Considering the unique aspect of the different fields to biomedical science, not only biology or science learners can pick up different careers in biomedical science.

For example, a biostatistician is very important in the field of biomedical sciences because he/she is needed to analyse and interpret data collected by biological or biomedical scientists. They are also responsible for designing experiments and clinical trials, this helps them to explain the disease and draw conclusions to it.

In making assistive devices like prosthetics and orthosis for amputees, robotic engineers and manufacturing engineers are needed. Computer scientists play a crucial role in the biomedical science space in that they develop software or tools to analyse medical images, to allow for earlier and more accurate diagnoses of health conditions. Electronic health records are another contribution of computer scientists to the biomedical field, in that they create and manage the systems allowing for a more secure storage, retrieval, and analysis of patient data for improved healthcare delivery.

Daily Work, Educational Requirements and Impact of a Chosen Career in Clinical and Research Field

A neuroscientist is a biomedical scientist who researches the nervous system, to make discoveries related to it and how it functions and develop solutions for these findings. To become a neuroscientist, you should have a Bachelor's degree in Psychology or Biology, a pure research Doctor of Philosophy degree related to the nervous system, and a licence and certification to practise neuroscience in a clinical setting. Some of their daily work consists of:

- studying to remain up-to-date on the evolutionary and functional aspects of the nervous system.
- designing experiments to investigate the nature of neurological diseases/disorders (neurodevelopmental, neurodegenerative) and psychiatric disorders to develop solutions to treat patients.
- researching treatments using animal models that are genetically modified to mimic neurological disorders to test theories/hypotheses or novel therapies.

The life-long impact of the work of neuroscientists is researching neural mechanisms for diseases and disorders from a developing to an ageing brain improving the health and well-being of individuals and their quality of life.

A dietitian is a clinical scientist who educates clients on their nutrition. To become a dietitian, a bachelor's degree in dietetics is required. They perform various tasks in their field of work. Some of the daily work of a dietitian includes:

- planning nutritional therapies to address specific health issues such as diabetes and hypertension.
- preparing meals for clients with special needs.

- promoting public awareness of proper nutritional habits such as the benefits of eating a balanced meal.
- assessing clients' nutritional and health needs to support healthy living.

Dieticians provide evidence-based recommendations with the latest nutritional developments to improve the lifestyle and overall well-being of clients with or without chronic illness.

Learning Task

Individually or in groups, engage learners in an interactive game of BINGO!

1. Create Bingo cards with squares containing biomedical science clinical and research career vocabulary terms related to core duties, skills, and unique careers in biomedical science. (See **Figure 3.1** in Additional Reading for an example of the Bingo Card Game).
2. Prepare a list of relevant vocabulary terms and distribute them to learners (see **Figure 3.1** in Additional Reading for examples).
3. Let learners spend a few minutes individually reviewing the vocabulary list, and researching unfamiliar terms using textbooks or reliable online sources (provide a list beforehand). Encourage learners to take Notes on some careers that may use these terms.
4. Read out loud to the class, hints or short descriptions (see **Figure 3.1** in Additional Reading for examples) of the vocabulary without saying the actual term.
5. Learners, in turn, tick off on their bingo cards the vocabulary or term related to the hint. The first group to achieve a Bingo (filling a row, column, or diagonal with marked squares) should call out "BINGO!" and they win.
6. After the winning group calls out "BINGO!", a representative from the group stands and reads out their marked items. They can state one career either in the research or clinical field of biomedical that may be related to the terms marked.

Alternatives for Disabled Learners

Learners who have difficulty marking can use bingo chips with Braille or raised lettering. Provide learners with audiobooks or text-to-speech software for vocabulary list review.

Pedagogical Exemplars

1. **Exploratory Learning:** Before the lesson, learners research individually using available textbooks or the internet about biomedical career fields relating to clinical or research studies such as microbiologist, clinical laboratory technician, toxicologist, clinical biomedical scientist and biotechnologist, focusing on core duties, skills requirements and educational pathways.
2. **Project-Based Learning:** Learners conduct personal research and create a mind map/chart on any three biomedical career fields and associated responsibilities as well as training required to take up the chosen career. Learners present their research to the class in different modes, keeping in mind to be open to peer criticisms.

Key Assessment

Level 2 (Conceptual understanding): Choose two different biomedical career fields related to clinical or research studies. Briefly explain what each one does and why they are important in healthcare.

Level 3 (Strategic Reasoning): You are interested in a career focused on developing new cancer treatments. Research two different biomedical careers related to cancer research (for example, oncologist and biochemist). Describe how each career field contributes to the development of new cancer treatments.

SECTION 1: REVIEW

This section is a review of all the lessons taught for the last three weeks and a summary of what should have been taught.

1. What are the various careers in biomedical science that focus on diagnosing and treating diseases?
2. What are some careers in biomedical science in the prevention of diseases?
3. What is forensic science and how is biomedical science used in forensic investigation?
4. In what ways can biomedical science be applied in forensics?
5. Discuss clinical and research careers in biomedical science.
6. Discuss a unique aspect and contribution of a biomedical science field.

The field continues to evolve leading to significant advancement in healthcare delivery and quality of life. The introduction and unique impact of other fields such as physics and mathematics has expanded the scope of careers and professions taken up in the biomedical science field. Moving forward, more education on the different clinical and research careers in the biomedical field will advance our knowledge.

Additional Reading

QR Code 1

QR Code 2

QR Code 3

QR Code 4

(Crime scene A)

QR Code 5

(Crime scene B)

QR Code 4 a

(Answers to Crime scene A)

QR Code 5 a

(Answers to Crime scene B)

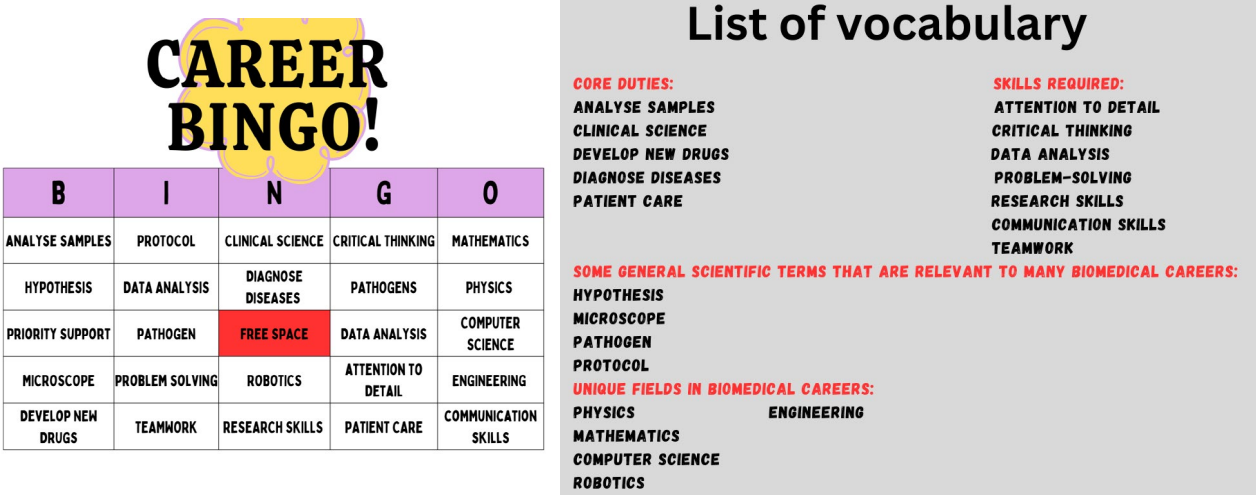


Figure 3.1: *Bingo card game*

APPENDIX A: INDIVIDUAL PORTFOLIO BUILDING

Prompt for building the portfolio should be given in week 2 and final submission date for the portfolio should be by week 22 the of academic year.

Steps to Building an Individual Portfolio

1. **Choose a format:** Decide with learners whether portfolio will be digital (like Google Slides, PowerPoint, or a dedicated portfolio website) or physical (a binder or folder).
2. **Include a title/cover page:** The portfolio should start with a title page that includes subject name, full name, class, and academic year.
3. **Table of contents:** Learners create a table of contents to organise the sections of the portfolio for easy navigation.
4. **Personal statement:** Learners write a short personal statement describing their goals, interests, and what you hope to achieve through the portfolio
5. **Artefacts:** Discuss with learners what should be included in the portfolio as well as how to organise the content. Artefacts could include:
   a. **Assignments and projects:** Include samples of best work, such as essays, reports, or creative projects.
   b. **Glossary:** Write reflections on anything learned from each assignment or project including new terminologies learned and how they contributed to their growth. Agree on the number of new terms to be added.
   c. **Tests, quizzes:** Include copies of significant tests, quizzes or examinations with their results that demonstrate understanding of key concepts.
   d. **Extracurricular activities:** Include evidence of involvement in clubs, sports, or community service (e.g., certificates, photos, descriptions).
   e. **Skill demonstrations:** Include any presentations, speeches, or performances that showcase skills.
   f. **Feedback and evaluations:** Feedback from teachers or peers that highlights strengths and areas needing improvement.
   g. **Future goals:** A section about future academic and career goals, along with steps to take to achieve them.
6. **Design and creativity:** Encourage learners to ensure their portfolios are well-organised and visually appealing by using headings, bullet points, and images where appropriate.
7. **Review and revise:** Remind them to go through the portfolio to check for clarity, organisation, and completeness before submission.
8. **Assessment criteria:** Share the rubric or criteria you will use to assess the portfolio with learners.
9. **Reflection:** Have learners complete a reflection on their experience, discussing what they learned, and the challenges faced, etc.

Sample Task

1. **Building Individual Portfolio**

   Build a portfolio that contain the following artefacts:
   a. Exercises
      i. Case study
      ii. Homework
      iii. Presentation/Poster
   b. Project works
      i. Group project- submitted in week 9
      ii. Individual project work- submitted in week 20
   c. Reports on
      i. practical work (*if any*).
      ii. research.
   d. Results for
      i. end-of-first semester examination.
      ii. mid-semester examinations for semester 1 and 2.
   e. Awards (if any)

2. **Organisation of the portfolio**

   A file with all collected items should have the following components:
   a. Cover page: Subject name, Full name, Class, and Academic Year (for example 2024/2025 Academic Year).
   b. A brief 50-word introduction to what the portfolio is about (summary of portfolio).
   c. A glossary on the last page with at least 20 new terminologies learnt throughout the year. *(All items may be placed in a clear file bag).*

Administration

1. Give clear instructions on the purpose of the portfolio and the items to be included.
2. Provide and discuss the marking scheme/ rubrics with learners.
3. Remind and prompt learners throughout the academic year which exercises should be included in the portfolio (*reminders have been provided at various sessions in the PLC handbook, so help prompt learners as well*).

Rubrics

Criteria	Excellent (5 marks)	Good (4 marks)	Satisfactory (3 marks)	Needs improvement (2 mark)	Unsatisfactory (1 mark)
Content Completeness	All required items included (e.g., exercises, projects, reports)	Most items included; only one document missing	Two items missing (e.g., project and mid-semester examination)	Three items missing (e.g., project, report, and examination)	Four or more items missing (e.g., no projects or examination)
Organisation of Portfolio and Creativity	Portfolio is exceptionally organised, with a professional cover page, a clear introduction, and a well-structured glossary.	Portfolio is well-organised with most required components present and arranged.	Organisation is adequate but has inconsistencies (e.g., headings in one style, body text in another)	Items not well-organised e.g., skipping from conclusion back to introduction.	No clear organization; items are presented randomly without any structure.
Introduction and glossary	Clear summary outlining the portfolio's purpose and content; glossary includes all relevant new terms learned as agreed on	Clear introduction that outlines the content; glossary includes most terms but misses a few (up to 20% fewer).	Introduction lacks clarity on the portfolio's goals; glossary is incomplete, missing 40% of terms.	Introduction does not explain goals; glossary is poorly developed, missing 60% of terms.	No introduction provided; glossary contains very few terms (80% fewer than required).

Submission of portfolio on the due date: 5 marks. Total marks = 20 marks

Feedback

Appreciate all learners for significant effort in presenting their portfolio and commend those with exceptionally organised portfolios while encouraging those whose overall organisation needs improvement; Entreat learners to continue keeping portfolios even outside class due to its importance, etc.

APPENDIX B: GROUP PROJECT

Prompt for the group project should be given to learners in week 3. Final submission of the group project should be by the 9th week of the academic year. The goal is to promote collaboration, critical thinking, and awareness of cross-cutting issues such as technology, innovation, health and well-being through a group project.

Steps To Assign Group Project

Define the project topic: Clearly state the topic or question the project will address. Ensure it aligns with your learning outcomes and incorporates relevant cross-cutting issues.

Set clear objectives: Outline what you expect learners to learn or achieve through the project. Include objectives related to research skills, teamwork and understanding of the impact of the topic.

Group formation: Decide how groups will be formed either assigning groups randomly or guiding learners to choose their own groups. Consider groups based on diverse skills, interests, and perspectives related to the cross-cutting issue.

Project guidelines: Provide clear guidelines to learners, including

1. project scope (what should be covered)
2. length or format (how long should the final presentation be? Should it include visual aids?)
3. deadlines (specify milestones and the final due date within week 9).

Roles and responsibilities: Encourage learners to assign roles to every member of their groups to ensure everyone contributes.

Incorporating cross-cutting issues: Require that each group addresses a specific cross-cutting issue related to their topic. For example, discuss how their project impacts or is impacted by sustainability, equity, or health**.**

Resources: Suggest resources for research or project, such as books, articles, or websites that include perspectives on cross-cutting issues. Provide access to any necessary materials or tools.

Checkpoints: Schedule periodic checkpoints to monitor progress. This could include: progress reports, group meetings with you for guidance, and peer feedback sessions.

Final presentation: Specify how the final project will be presented (e.g., oral presentation, poster, digital presentation). Outline the criteria for evaluation, ensuring that attention to cross-cutting issues is included.

Assessment criteria: Share the rubric or criteria you will use to assess the project with the groups. This should include:

- content accuracy and depth.
- integration of cross-cutting issues.
- creativity and originality.
- teamwork and collaboration.
- presentation skills.

Reflection: After the project, have learners complete a reflection on their experience, discussing what they learned, challenges faced, and how they worked together, particularly in relation to the cross-cutting issues addressed.

Sample Task

Project Topic: The Importance of Technological Tools in Biomedical Sciences

Submission Requirements and Project Outline

1. **Research Phase:** Research different technological tools used in biomedical sciences, such as: Electrocardiograms (ECGs)**,** Electromyography (EMG)**,** Imaging technologies (MRI, CT scans)**,** Pulse oximeters**,** Blood pressure monitors, etc.
    a. Look for credible sources to learn about each technological tool and how it helps in measuring communication within the body.
    b. Include issues that can be addressed with your research as well as challenges of the existing devices. How can such issues be addressed?
    c. Visit nearby clinic or hospital to interact with healthcare professionals on any of the tools present in their facility and prepare a report on it.
    d. Discuss the role of technology in your topic. How can innovation address health challenges?
2. **Presentation phase:** Create a presentation summarising your findings, including; the purpose of each tool**,** how it measures communication parameters in the body**,** and its importance in clinical settings.

    Ensure your presentation is engaging and practice as a group to ensure everyone knows their part.
3. **Report Writing:** Each group will submit a written or printed report (2-3 pages) detailing their research findings and the impact of their project. Add the report from the facility visited.

Administration

1. Put learners into small mixed ability/gender groups of about 5-6 members each
2. Share a list of reliable sources for research.
3. Explain the project components: research, presentation, and written report. Distribute the rubric for assessment criteria.
4. Establish clear deadlines for research, presentation preparation, and report submission.
5. Check in with groups regularly to discuss their progress and address any questions.
6. Organise the classroom for presentations. Allow each group to present (5-7 minutes each) followed by a Q&A session.
7. Use the rubric to evaluate each group's work and provide feedback.
8. Collect the written or printed reports and provide scores based on the rubric.

Rubric (Total marks = 20 marks)

Criteria	*Excellent (4 marks)*	*Good (3 marks)*	*Satisfactory (2 marks)*	*Needs Improvement (1 mark)*
Description of the function(s) of tools	*Covers the uses of 4 tools:* *E.g.,* *Electrocardiogram (ECG): used to diagnose heart conditions and monitor heart health;* *Electroencephalogram (EEG): used to diagnose and monitor neurological conditions, such as epilepsy, sleep disorders, and brain injuries;* *Electromyogram (EMG): used to diagnose neuromuscular disorders, assess muscle function, and evaluate nerve damage;* *Pulse oximeter: used to measure oxygen saturation levels in the blood, helping to assess respiratory function, etc.*	*Covers the uses of 3 tools:* *E.g.,* *Electrocardiogram (ECG): used to diagnose heart conditions and monitor heart health* *Electroencephalogram (EEG): used to diagnose and monitor neurological conditions, such as epilepsy, sleep disorders, and brain injuries.* *Electromyogram (EMG): used to diagnose neuromuscular disorders, assess muscle function, and evaluate nerve damage, etc.*	*Covers the uses of 2 tools:* *E.g.,* *Electrocardiogram (ECG): used to diagnose heart conditions and* *monitor heart health* *Electroencephalogram (EEG): used to diagnose and monitor neurological conditions, such as epilepsy, sleep disorders, and brain injuries, etc.*	*Covers the uses of 1 tool:* *E.g.,* *Electrocardiogram (ECG): used to diagnose heart conditions and monitor heart health* *Electroencephalogram (EEG): used to diagnose and monitor neurological conditions, such as epilepsy, sleep disorders, and brain injuries, etc.*
How each tool interacts with the body	*Covers how 4 tools interact with the body* *E.g.,* *Electrocardiogram (ECG): measures the heart's electrical activity to assess heart rate and rhythm.* *Electroencephalogram (EEG): records electrical activity in the brain to evaluate brain function and detect abnormalities.*	*Covers how 3 tools interact with the body* *E.g.,* *Electrocardiogram (ECG): measures the heart's electrical activity to assess heart rate and rhythm.* *Electroencephalogram (EEG): records electrical activity in the brain to evaluate brain function and detect abnormalities.*	*Covers how 2 tools interact with the body* *E.g.,* *Electrocardiogram (ECG): measures the heart's electrical activity to assess heart rate and rhythm.* *Electroencephalogram (EEG): records electrical activity in the brain to evaluate brain function and detect abnormalities, etc.*	*Covers how 1 tool interacts with the body* *E.g.,* *Electrocardiogram (ECG): measures the heart's electrical activity to assess heart rate and rhythm.* *Electroencephalogram (EEG): records electrical activity in the brain to evaluate brain function and detect abnormalities, etc.*

How each tool interacts with the body	*Electromyogram (EMG): measures electrical signals in muscles to assess muscle function and nerve signal transmission.* *Blood pressure monitor: measures arterial blood pressure to evaluate heart function and overall cardiovascular health, etc.*	*Electromyogram (EMG): measures electrical signals in muscles to assess muscle function and nerve signal transmission, etc.*		
Presentation skills	*Presents with 4 of the skills:* *Audible voice,* *Keeping eye contact* *Pay attention to audience* *Engaging the audience with interaction* *Use of gesture, etc.*	*Presents with 3 of the skills:* *Audible voice,* *Keeping eye contact* *Pay attention to audience* *Engaging the audience with interaction* *Use of gesture, etc.*	*Presents with 2 of the skills:* *Audible voice,* *Keeping eye contact* *Pay attention to audience* *Engaging the audience with interaction* *Use of gesture, etc.*	*Presents with 1 of the skills:* *Audible voice,* *Keeping eye contact* *Pay attention to audience* *Engaging the audience with interaction* *Use of gesture, etc.*
Written report quality	*Report shows 4 of these qualities:* *E.g.,* *Well-organised* *Clear and concise* *Free of grammatical errors* *Meets length requirement, etc.*	*Report shows 3 of these qualities:* *E.g.,* *Well-organised* *Clear and concise* *Free of grammatical errors* *Meets length requirement, etc.*	*Report shows 2 of these qualities:* *E.g.,* *Well-organised* *Clear and concise* *Free of grammatical errors, etc.*	*Report shows 1 of these qualities:* *E.g.,* *Well-organised* *Clear and concise* *Free of grammatical errors, etc.*
Use of Technical terms	*Uses 4 appropriate technical terms accurately throughout the project:* *E.g.,* *ECG: heart rhythm* *EEG: brain activity* *EMG: muscle function* *Blood pressure monitor: high blood pressure* *Pulse oximeter: oxygen level* *Electrodes: sensors (used in ECG, EEG, EMG), etc.*	*Uses 3 appropriate technical terms accurately throughout the project:* *E.g.,* *ECG: heart rhythm* *EEG: brain activity* *EMG: muscle function* *Blood pressure monitor: high blood pressure* *Pulse oximeter: oxygen level* *Electrodes: sensors (used in ECG, EEG, EMG), etc.*	*Uses 2 appropriate technical terms accurately throughout the project:* *E.g.,* *ECG: heart rhythm* *EEG: brain activity* *EMG: muscle function* *Blood pressure monitor: high blood pressure, etc.*	*Uses 1 appropriate technical term accurately throughout the project.* *E.g.,* *ECG: heart rhythm* *EEG: brain activity* *EMG: muscle function* *Blood pressure monitor: high blood pressure, etc.*

Feedback

Give specific written or oral feedback on exact areas that went well and those areas needing improvement for learners to incorporate them before final submission. After final submission, applaud those who go extra mile, encourage those who are still attaining, etc.

SECTION 2: BIOSAFETY

STRAND: BIOMEDICAL SCIENCE IN SOCIETY

Sub-Strand: Biosafety

Learning Outcome: *Explain the need for protection from biohazard exposure*

Content Standard: *Demonstrate an understanding of the essence of protection from biohazard exposure*

HINT

The scores for learners' classwork should be ready by week 4 for onward submission to the Student Transcript Portal.

INTRODUCTION AND SECTION SUMMARY

Learners explore the importance of the knowledge of biosafety levels in the laboratory and the general biosafety principles that apply in all laboratories. Learners are then made to understand the need to protect themselves from biohazardous exposure, after which they are then taken through what a Biosafety Cabinet (BSC) is and the proper procedures for setting up a BSC and its surrounding environment. The proper donning and doffing of personal protective equipment (PPE) end this section. Overall, working in a laboratory requires following standard operating procedures as well as general safety and biosafety rules to protect laboratory staff and the surrounding environment.

The weeks covered by the section are:

Week 4: Describe features of the biosafety levels and proper practice

Week 5

a. Demonstrate proper setup of the biosafety cabinet and its environment.

b. Demonstrate proper methods for donning and removal of personal protective equipment (PPE) such as gloves, lab coats, eye protection and respiratory protection.

SUMMARY OF PEDAGOGICAL EXEMPLARS

Several pedagogical exemplars are recommended in this section to enhance learners' understanding of biosafety levels and protect themselves from biohazardous exposure while following appropriate biosafety rules. Using managing talk-for-learning and think-pair and share activities, learners share their thoughts on various risk lines linked to biosafety levels (BSL) 1, 2, 3 and 4. Learners get to know the features of biosafety levels and how they correspond with proper laboratory practices using structured learning strategies. With collaborative, activity-based and digital learning strategies, learners in mixed-ability groups gain an understanding and become familiar with biosafety cabinets and the hazards associated with

them and how to avoid those risks. Learners take turns in setting up a biosafety cabinet using demonstrative learning strategies.

SUMMARY OF ASSESSMENT

To assess learners' ability to show an understanding of the four biosafety levels and the containment of pathogens, levels 1, 2 and 3 assessments are recommended. Using DOK level 1 assessment, learners' ability to recall knowledge shared on BSL-1,2 & 3. Using DOK level 2 assessment strategies, learners' conceptual understanding is assessed on the importance of biosafety levels, classes of biosafety cabinets and hand hygiene to biosafety principles. Learners' strategic reasoning abilities are also assessed using DOK levels 3 assessment. Learners determine appropriate biosafety levels and biosafety cabinets for different experiments and safely addressing biohazardous situations. The recommended mode of assessments for each week is as follows:

Week 4: Classwork

Week 5: Gamification

WEEK 4

Learning Indicator: Describe Features of the Biosafety Levels and Proper Practice

Focal Area 1: The Importance of Knowledge of Biosafety Levels in the Laboratory

Assume a laboratory microbiologist works daily with potentially harmful biological agents or toxins. Various standard operating procedures and precautions must be taken in the laboratory to ensure that he/she and others are not harmed or infected.

- *Where in the lab would you complete your work?*
- *What protective equipment and practices would you use?*
- *How would you contain the microbe to limit contamination or accidental infection?*

These are some questions a laboratory worker may consider before working in the laboratory. When handling biological agents their risk groups and precautions taken to avoid potential infections, limit contamination and protect the work environment as well as the community as a whole should be considered. This is the principle on which biological safety (Biosafety) rules are developed for the working laboratory.

Biosafety can be defined as the application of safety precautions that reduce the risk of laboratory personnel's exposure to infectious microorganisms and limit contamination within the lab environment, ultimately protecting the surrounding community (Centre for Disease Control and Prevention, CDC, 2024).

In the previous year, the routes of exposure to pathogens and laboratory-acquired infections (LAIs) were explored. Also discussed were biohazards with a brief mention of the risk groups associated with handling some biological agents where we mentioned the biosafety levels (BSL) 1, 2, 3 and 4. Below is a pictorial recap of the BSL levels previously discussed.

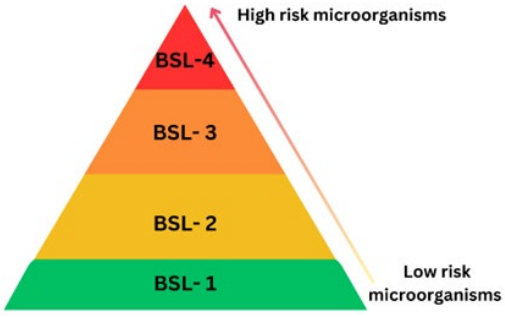


Figure 4.1: *Biological Safety Levels 1-4*

Biosafety Levels (BSL 1–4) and Their Containment Measures

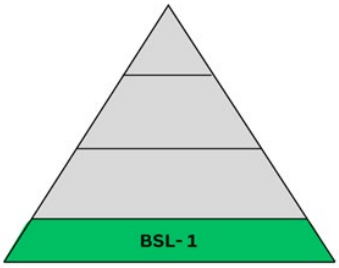
Explain the different biosafety levels (BSL 1-4) and the increasing containment measures required at each level.

A fundamental objective of any biosafety rules is the containment of potentially hazardous biological agents and toxins. The term containment refers to the use of primary and secondary barriers, facility practices and procedures, and other safety equipment, such as personal protective equipment (PPE), to manage the risks associated with handling and storing hazardous biological agents and toxins in a laboratory setting. The objective of containment is to reduce

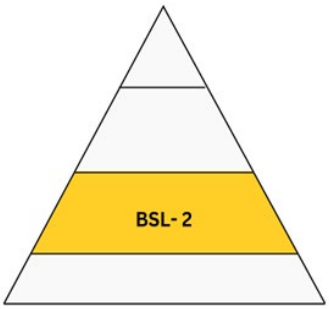
the danger of exposure to laboratory staff and the unintended release of hazardous biological agents or poisons into the surrounding environment and community (CDC & National Institute of Health, 2020).

For the four biosafety levels, microorganisms and biological agents are contained at each level using specific controls. The main risks that determine degrees of containment are infectivity, illness severity, transmissibility, and the type of work being done. The origin of the microorganism or agent, as well as the route of exposure, are important considerations. Each biosafety level requires correct containment measures for the laboratory procedures, safety equipment and facility construction.

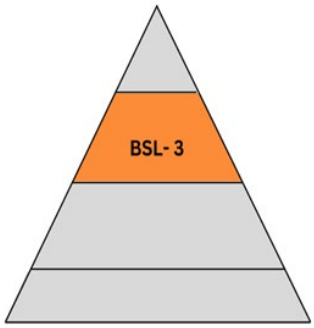
Discussion of the Four Biosafety Levels



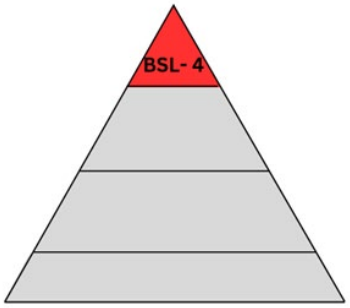
Biosafety Level 1 (BSL-1): in a laboratory labelled as BSL-1, the microorganisms and agents there represent the lowest level of risk among biohazardous materials. Examples include non-pathogenic micro-organisms that do not cause diseases in healthy individuals such as *Escherichia coli* strains used in laboratory experiments. PPE must be worn, and a sink with a water source for handwashing is essential to maintain standard laboratory practices.



Biosafety level 2 (BSL-2): This level is a build up from BSL-1, Working in a BSL-2 laboratory, involves handling biohazardous materials that pose a moderate risk of infection or disease. Common pathogens like *Staphylococcus aureus*, *Salmonella typhi*, Human immunodeficiency virus (HIV), hepatitis B and C viruses and certain strains of influenza virus are examples. Aside from the standard provision of PPEs and a functional handwashing sink, all procedures that can cause an infection are carried out in a Biosafety Cabinet (*Discussed in **Week 5***).



Biosafety Level 3 (BSL-3): in a BSL-3 laboratory, there are high-risk biohazardous materials that can cause serious diseases through inhalation. Microorganisms that can cause severe or potentially lethal diseases, such as *Mycobacterium tuberculosis*, SARS-CoV-2 (COVID-19), yellow fever, dengue fever, and Zika viruses, are at this level. Some additional containment requirements include, laboratory staff being under medical surveillance, immunised, providing respirators with PPEs. Access to such laboratories is restricted at all times.



Biosafety level 4 (BSL-4): This is the highest Biosafety level. There is a small number of BSL-4 around the world because pathogens worked with, pose the highest risk of infections/disease that are deadly and for which there are no treatments or vaccines. Examples include the Ebola and Marburg viruses. Adding on to containment requirements for BSL-3, BSL-4 has additional requirements which include, changing clothing before entering, showering after leaving the laboratory, and decontaminating all materials before exiting the laboratory. All work is performed within an appropriate BSC (usually Class III-see week five), and by wearing a full body air-supplied suit. BSL-4 laboratories are usually isolated from other buildings.

Focal Area 2: General Biosafety Principles That Apply in All Laboratories, Regardless of Level

Every biological and biomedical laboratory, regardless of biosafety level, follows standard safety practices. Strictly following these basic principles will greatly reduce the likelihood of laboratory acquired infections and spread of infections to the community.

General Biosafety Principles

1. Handwashing procedures
2. Proper waste disposal
3. Standard operating procedures in the lab, such as "No eating or drinking in the lab".

See Figure 4.2 for an overview of biosafety principles to be practised in all laboratories with the routes of exposures blocked when these principles are adhered to.

General Biosafety Practices and Principles

GENERAL BIOSAFETY PRACTICES	ROUTES OF EXPOSURE BLOCKED
Do not eat, drink, store foods, or smoke in the laboratory	Ingestion, Direct Contact with Skin, Inhalation
Use lab coats, gloves, safety eye wear, and other personal protective equipment	Inhalation, Direct Contact
Wash hands after every laboratory activity, after removing gloves and when immediately after coming into contact with an infectious biological agent or toxin	Direct Contact, Ingestion
Decontaminate work surfaces before and after use. When there are spills, immediately clean and sterilise surfaces.	Skin, Inhalation, Ingestion
Restrict use of needles, syringes, to trained personnel. Dispose of sharps in leak-and puncture-proof containers	Skin, Inhalation
Do not mouth pipette	Inhalation, Skin, Ingestion

Learning Task

This task involves a simple scenario which should build on learners' understanding of the biosafety levels and the general biosafety practices in a working laboratory.

Scenario: A new research facility is being built specifically for groundbreaking biomedical research. You are tasked with designing and carrying out a thorough biosafety training program for all laboratory staff. This program is aimed at going beyond the standard biosafety practices but also uses innovative strategies to promote a tradition of safety within the research facility.

Following the description of the project, guide learners to carry out the following tasks:

1. Learners design a complete biosafety training program that includes biosafety level considerations as well as general biosafety laboratory practices. Encourage learners to design different training methods, such as peer-to-peer learning exercises, and incorporate 21st-century skills, such as virtual reality (VR) training modules, if at all feasible.
2. Describe the measures you would take to make a research facility a safer place. This may could include:
    a. Encouraging open communication and reporting of safety concerns.
    b. Creating a system for continuous improvement of biosafety protocols.
    c. Recognising and rewarding safe work practices.
3. Explain how you would evaluate the effectiveness of your training program and how you would refine it based on feedback and ongoing safety assessments.

Pedagogical Exemplars

1. **Managing Talk for Learning:** Lead learners in a class discussion to identify pathogens and toxins that present risks to humans. Learners, using the think-pair-share activity, discuss and group the risks by aligning them to the biosafety levels (BSL-1 to 4).
2. **Collaborative Learning:** From the discussion, learners define biosafety level as a set of safety instructions guiding standard practices, safety equipment, and facility requirements that protect personnel, the environment, and the community when working with biological hazards.
3. **Activity-Based Learning:** After watching videos/images of biohazardous scenes, learners work together in mixed-ability groups to categorise risks, create diagrams to represent the various BSLs and justify the basis for the groupings. Learners then discuss the features of the BSLs and corresponding proper lab practice.

Note

Learners need to be aware of the high risk associated with BSL- 3 and BSL- 4 facilities.

Key Assessment

Level 1 (Recall)

Select the biosafety level described by the conditions of the following example. Levels are listed below.

A microbiology graduate student is working on a project under the following conditions:

1. Work is conducted on a standard laboratory table or bench.
2. A non-pathogenic laboratory strain of *E. coli* is being used.
3. Minimal PPE, such as a lab coat, gloves, and eye protection might be worn but are not necessary.
    a. BSL-1
    b. BSL-2
    c. BSL-3

Level 2 (Conceptual understanding)

1. Explain why different biosafety levels exist in laboratories.
2. List at least two examples of personal protective equipment (PPE) commonly used in a laboratory setting. Explain why proper handwashing is a crucial general biosafety principle in all laboratories.

Level 3 (Strategic reasoning)

1. You are planning a research project that involves working with a newly discovered microorganism. Based on the limited information available, describe the factors you would consider to determine the appropriate biosafety level for your experiment.
2. A student in your lab accidentally spills a culture of bacteria on their lab coat. Describe the steps they should take to address this situation safely.
3. You are designing a new laboratory space. Explain two general biosafety principles you would incorporate into the design to minimise the risk of exposure to biohazards.

WEEK 5

Learning Indicator

1. Demonstrate the proper setup of the biosafety cabinet and its environment
2. Demonstrate proper methods for donning and removing personal protective equipment (PPE) such as gloves, lab coats, eye protection, and respiratory protection

Focal Area 1: What is a Biosafety Cabinet (BSC)?

Explain the different BSC classes and their functionalities

The Biosafety Cabinet (BSC) is the main method of containment created for safely working with or handling infectious microorganisms. (Centres for Disease Control and Prevention, 2024). Biosafety levels 1–4 (discussed in week four) aimed at protection of personnel, the environment from infections, and samples being worked from contamination are means of classifying BSCs. Based on these levels of protection, biosafety cabinets have three classes. These classes and their functionalities are described below.

- **Class I Biosafety Cabinet (BSC-I):** This class is the most basic of BSCs, which provides protection for only the laboratory personnel and environment but no protection for the biological samples from contamination. BSL-2 laboratories use biosafety cabinet class I. See examples in Figure 5.1.

Figure 5.1: *Class I Biological Safety Cabinet (BIOBASE, 2024)*

- **Class II Biosafety Cabinet (BSC-II):** This BSC class provides protection for the laboratory staff and the biological samples being worked with from contamination. BSC-II is further classified into A1, A2, B1, B2 and C1, based on their working mechanisms (Scan QR code 6 at the end of this section to read more). This class of biosafety cabinets is used in BSL-2 & BSL-3 laboratories. See Figure 5.2 for examples.

(a) **(b)**

Figure 5.2: *Class II Biological Safety Cabinet (a) and Biosafety Cabinet Class II Type B2 (b) obtained from (ESCO Lifesciences, 2024) and (Bio-Clean Air Devices and Services, 2024) respectively.*

- **Class III Biosafety Cabinet (BSC-III):** BSCs in this class are leak-tight and totally enclosed but ventilated such that all the air that enters leaves through a special filter. They are also known as "glove boxes" because they have special rubber gloves attached to them which are used during operations. BSL-4 labs make use of this class of BSC. See **Figure 5.3** for examples.

Figure 5.3: *Class III Biological Safety Cabinet (BIOBASE, 2024)*

Focal Area 2: Proper Setup Procedures for the BSC And its Surrounding Environment

Before working in and around BSCs, wear appropriate personal protective equipment (PPE) such as lab coats, gloves, hairnets, goggles and nose masks. Scan **QR Code 7** to watch a video on how to set up and clean a BSC.

Discussions on Proper Setup Procedures for BSC

1. **Checking airflow and alarms**

   To check for the airflow and alarms, the BSC is installed in an area free from direct sunlight and turbulence. Also, the BSC is properly connected to an electrical power source, Ultraviolet (UV) light for sterilisation. There is the high-efficiency particulate absorbing (HEPA) filter which is free from damage and ensures effective filtration. A smoke or tissue test is usually conducted to check airflow across the work surface. Testing the visual and audible alarms to see if they are functioning correctly, is a must.

2. **Organising work within the cabinet**

   All materials needed for the procedure in the cabinet are placed in the middle of the cabinet or almost close to the back of the hood away from the air vents before starting. Frequent sterilisation and decontamination are done to keep the BSC and environment safe. Properly planning workflow is essential for minimising movement in and out of the hood. This includes arranging the work zone such that samples move from clean to dirty with materials at least 12 inches (30 cm) apart from each other ensuring that contaminated items do not pass over clean items.

3. **Maintaining a clean work surface**

   Designate specific zones within BSC for different tasks to avoid cross-contamination. Clean and disinfect before and after using the laboratory. At the workplace sterilisation processes are strictly adhered to in order to prevent introducing contaminants into the BSC. And constantly checking BSC performance indicators like airflow, velocity, and filter conditions necessary in maintaining a clean work surface.

Focal Area 3: Discuss the Sequence and Technique for Proper Donning and Appropriate Use of Personal Protective Equipment (PPE)

Properly putting on (donning) and taking off (doffing) personal protective equipment (PPE) is essential for safety in different settings, especially in healthcare and handling biohazardous materials. Following correct procedures reduces the risk of contaminating personnel, the environment and products which ensures the effectiveness of PPEs.

Steps for Proper Donning of PPE

Here is an overview of the process for properly wearing (donning) PPE

1. Thorough hand washing or sanitisation with 70% alcohol before donning PPE is an essential first step.
2. A gown is worn by first inserting arms into the sleeves and then securing the neck and waist ties firmly. The gown should adequately cover the front of the body from your neck to knees and extend around the back.
3. Select an appropriate mask size and ensure it fits tightly and securely over the nose and mouth.
4. Choose an appropriate size of goggles or face shield and properly position it over the eyes or face. This ensures a secure fit to prevent gaps between the shield and the forehead.

5. Hair is tied and hair nets are worn in some laboratories to prevent disturbances caused by untied hair (for example avoiding it falling onto your face, blocking the view of work) as well as preventing contamination of materials being worked with.
6. Gloves are the last thing worn to avoid contaminating them during the process of donning. Well- fitting gloves that extend beyond the gown cuffs are prescribed.
7. All PPE should be properly adjusted for comfort and adequate coverage without disrupting safety.

Scan **QR code 8** to watch a video on proper donning of PPE.

Focal Area 4: Discuss the Safe Removal of PPE to Minimise Contamination Risk

Steps Taken to Avoid Self-Contamination and Cross-Contamination

Proper removal (doffing) of PPE is very essential since it can either spread or prevent contamination. Correct removal procedures reduce the chance of self-contamination and guarantee that used PPE is disposed of or cleaned correctly. Each step is carefully carried out to protect both the wearer and others from potential exposure to infectious agents and biohazardous materials.

Ways of doffing some PPE

1. Begin by carefully removing gloves. Grasp the outer surface near the wrist and peel them off, turning the gloves inside out. Hold the removed gloves in the opposite gloved hand. See Figure 5.4

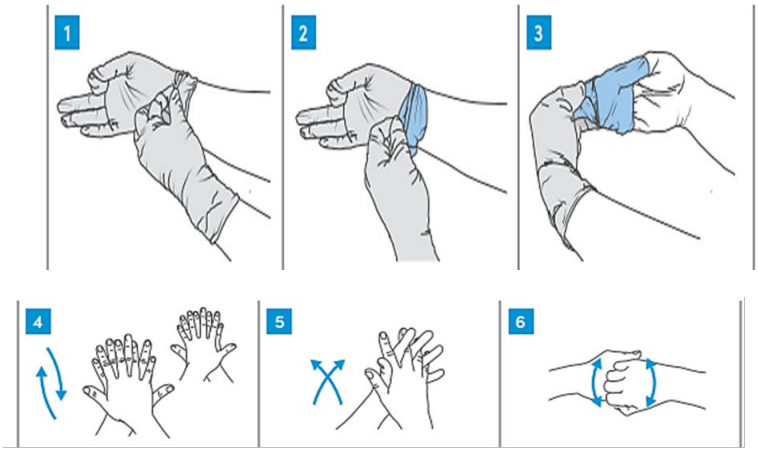


Figure 5.4: *Removal of disposable gloves (1-6)*

2. Wash hands with soap and water immediately after removing the gloves (sanitise hands with 70% alcohol if water is not available). See Figure 5.5.

Figure 5.5: *Washing of hands*

3. With the help of the headband or earpiece of the goggles or face shield, carefully remove (doff) it. Avoid touching the face of the goggle or face shield. See **Figure 5.6.**

Figure 5.6: *Removal of goggles*

4. Carefully untie the neck and waist ties of the gown. Remove it by peeling it away from your shoulders and arms, roll it inside out. See **Figure 5.7.**

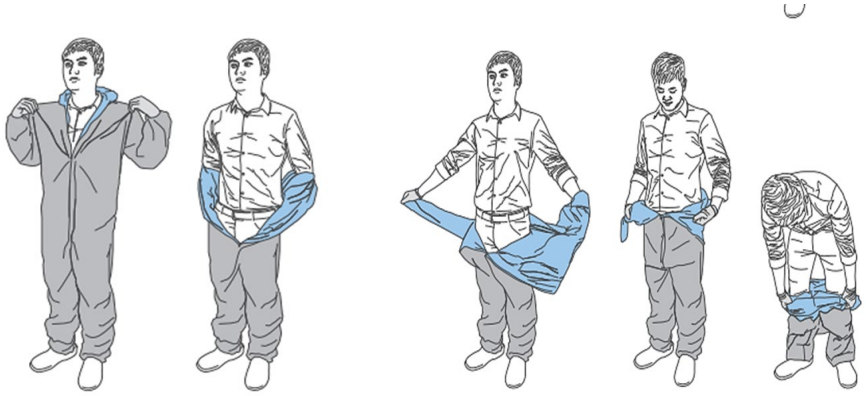


Figure 5.7: *Removal of gown*

5. With the straps or ties of the mask, remove it carefully. Make sure to avoid touching the front or surface of the mask. See **Figure 5.8.**

Figure 5.8: *Removal of nose mask*

6. The final thing to do after the doffing process is to perform hand hygiene. Washing your hand or sanitising it again to ensure it is clean from all potential contaminants.

Indicate proper disposal of used PPE

Correct disposal of PPE is crucial in reducing contamination risks and ensuring safety, especially in healthcare and in a biohazardous environment. Biohazard containers in the laboratory are set aside for disposal of biohazardous waste and one-time use PPE like gloves and nose masks. See Figure 5.9 for the various kinds of biohazard containers.

Figure 5.9: *Biohazard containers (Photo credit: Ho Regional Hospital, Trafalgar, 2024)*

These protocols include:

1. immediately separating used PPE from other wastes to prevent cross-contamination.
2. ensuring containers are tightly closed to avoid leakage.
3. placing reusable PPE into specified containers for thorough cleaning and disinfecting.
4. training personnel handling PPE on the disposal procedures.
5. disposing PPE in accordance with local and environmental guidelines to minimise cross contamination.

Learning Task

Engage learners in a series of games designed to extend and reinforce learning on biosafety cabinets and their critical role in laboratory safety. Throughout these games, learners will explore the details of biosafety cabinet classification, correct usage protocols, as well as maintenance procedures.

For example:

1. **GAME 1: MATCHING SPEED GAME**
   a. Divide learners into mixed-ability groups, give each group a list of biosafety cabinets and its related terms with corresponding descriptions (See ***Table 5.1*** for an example) to match.
   b. Since this is a speed game, a timer is started at the beginning of the matching game. The first group to finish, flips their paper and shout "EUREKA!". Note the first group to finish.
   c. The timer is kept on until the very last group is finished matching.
   d. The first group to finish shares with the class their answers. Guide a discussion on the answers provided and make corrections where appropriate.
2. **GAME 2: CROSSWORD PUZZLE**
   Guide learners in a crossword puzzle "securing the lab" game by using the clues provided to fill in the puzzle. Prompt learners that words can go across and down. Scan **QR Code 9** for an example of the crossword puzzle. **Scan QR Code 9a for answers to the puzzle.**
3. **CHARADES (PICK-AND-ACT)**
   Engage learners in a thrilling game of Charades.
   a. Write on pieces of paper, the procedures involved in donning of PPE. For example; wearing gloves, wearing a nose mask, wearing a gown, wearing goggles. Fold the papers and put them into a box.
   b. Select one learner to begin the game by picking a piece of paper from the papers with the procedures and acting out what is on the paper for the other learners to guess the procedure picked.
   c. When a learner guesses right, let the learner who picked ask a follow-up question on the doffing procedure for that particular donning procedure.
   d. The learner who guesses right will also have the opportunity to pick and act for the others to guess.
   e. The game goes on until all the pieces of paper are exhausted.

Table 1: *Biosafety protocols and their corresponding descriptions*

Biosafety	Description
Nose mask	leak tight and totally enclosed
BSC-II	provides protection for personnel and environment only
Gown	provides protection for personnel, environment and product
BSC-III	worn to protect the hands
Rubber gloves	worn to protect the nose and mouth
BSC-I	Securely attached to arm holes in the walls of the cabinet
Disposable gloves	Worn from the neck to the knee

Pedagogical Exemplars

1. **Structured Learning:** Learners visit labs or watch videos of a typical lab setting to identify hazards (pathogens, spillage, toxins, sharp objects) in a BSC and describe some potential negative outcome(s) of a given hazard.
2. **Collaborative Learning:** Learners work in pairs to suggest solutions to reduce the risk of hazards such as proper disposal, proper labelling, proper arrangement of items, and facility design that avoids moving contaminated and uncontaminated materials through the same space.
3. **Demonstrative Learning:** Learners observe an expert or an invited resource person as they set up a biosafety cabinet. Let learners take turns to demonstrate the proper setup of the biosafety cabinet as observed.
4. **Demonstrative/ Experiential Learning:** Learners fully wear their PPE (for example, lab coats, face masks, gloves, face shields, and close-toed shoes.) and cover them with Glo Germ or other dyes. Afterwards, learners remove the PPE and check for dye contamination. Demonstrate proper procedures for removing PPE so that there is no cross-contamination.

Key Assessment

Level 2 (Conceptual Assessment): Look at the image below and answer the following questions.

Figure 5.10: *A biosafety cabinet in use*

1. Which Biosafety Cabinet Class (see Figure 5.10) is the laboratory staff working in? Explain your answer.
2. Discuss the following
   a. The biosafety level laboratory you think this is.
   b. The type of microorganism (non-pathogenic or pathogenic) you suspect the laboratory worker is handling.
   c. Give some examples of the type of microorganism in your earlier response.

Level 3 (Strategic Reasoning): You are working in a laboratory that works with different biological agents including some that are highly infectious and airborne. Specify which class of biosafety cabinet you would use for this work and justify your answer.

SECTION 2 REVIEW

This section is for review of all the lessons taught for the last two weeks. A summary of what should have been taught and what each learner should have learned if differentiation has been done.

1. Define and explain biosafety levels based on the containment of microorganisms.
2. What are some of the general biosafety principles practised in every laboratory?
3. Describe the proper setup of the biosafety cabinet and its environment.
4. Define and describe the various classes of biosafety cabinets
5. Describe the processes involved in the donning and doffing processes.

Biosafety is essential in biomedical science. It involves procedures and guidelines aimed at safeguarding laboratory personnel and the environment from potential risk associated with biological agents and toxins. It also extends protection to biological samples being worked with from contamination.

Additional Reading

QR Code 6

QR Code 7

QR Code 8

QR Code 9

QR Code 9a

SECTION 3: ANATOMY AND PHYSIOLOGY-COMMUNICATION SYSTEMS

STRAND: HUMAN BODY SYSTEMS

Sub-Strand: Anatomy and Physiology

Learning Outcome: *Identify the various regions of the brain, describe their functions and their interconnectedness with some body systems for communication*

Content Standard: *Demonstrate an understanding of the interconnectedness of some body systems for communication*

HINT

- *Refer to Appendix C for table of specifications on how to develop assessment items for mid-semester examinations. Submission of group project by week 9.*
- *Remember to take the **group project** by week 9 and remind learners to keep copies in their portfolios after evaluation.*

INTRODUCTION AND SECTION SUMMARY

In this section, learners will understand that the complexity of the human brain is vital for comprehending its functions and interactions with various bodily systems. The brain has been organised into distinct regions which play a central role in regulating cognition, emotions, sensory processing and motor functions. Learners will explore these regions, their specific functions and their interconnectedness with other human body systems to ensure effective communication and coordination within the body.

The weeks covered by the section are:

Week 6 & 7: Explain the role the brain and brain mapping play in the communication system of the human body.

Week 8: Determine how communication works in the body and its effects.

Week 9: Describe the importance of technological tools in biomedical sciences to measure parameters associated with communication in the human body.

SUMMARY OF PEDAGOGICAL EXEMPLARS

This section recommends a number of pedagogical exemplars to increase learners' knowledge of the primary structure and functions of the brain and how it communicates with the rest of the human body. Using experiential learning strategies, learners in pairs discuss the various regions of the brain and their general functions. In an activity-based learning session considering mixed-ability groups, learners show their knowledge of distinct structural and functional

characteristics of regions of the brain and then focus on the parts of the brain involved in communication and information flow. Through digital learning strategies, the human body communication systems and electrical activity of the brain and heart are presented to learners for better visualisation on how they work. With collaborative learning strategies and teacher-led discussions, learners brainstorm on how specific impulses are transmitted, identifying the types of brain waves and what they represent.

SUMMARY OF ASSESSMENT

To assess learners' understanding of parts of the human brain and their functions, and the communication pathways in the human body, levels 1, 2, 3 and 4 assessments are recommended. Using DOK level 1 assessment, learners' ability to recall knowledge shared on what the human body communication system is made up of. DOK level 2 assessment strategies are used to assess learners' conceptual understanding on the specific brain regions and human body communication systems involved in processing sensory information and responding to certain stimuli, and the importance of technological tools in measuring communication within the body. Using DOK levels 3 and 4 assessment, learners' strategic reasoning abilities on the dysfunction of the frontal lobe, disorders that may occur based on the disruption of communication in a part of the human body communication systems, the use of technological tools in diagnosing problems and the benefits advancements in technological tools have in clinical settings are assessed. The recommended mode of assessments for each week is as follows:

Week 6: Mid-semester examination

Week 7: Debate

Week 8: Case study

Week 9: Quiz (oral)

WEEKS 6 & 7

Learning Indicator: Explain the role brain and brain mapping play in the communication system of the human body

Focal Area 1: What is the Role of the Brain as the Central Processing Unit of the Communication System?

Exploring Brain Anatomy and its Different Components

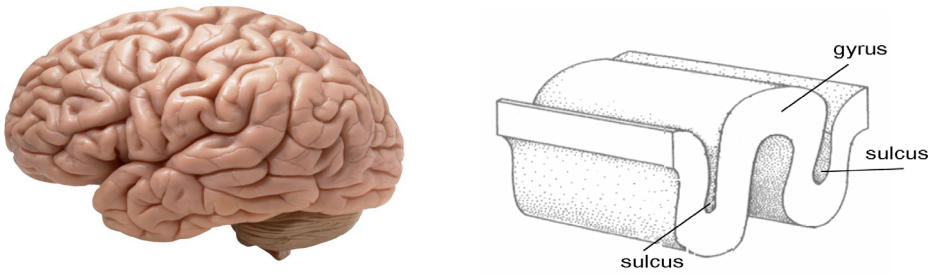
The nervous system is made up of the Central Nervous System (CNS) and the Peripheral Nervous System (PNS). The CNS is made up of the brain and the spinal cord. Generally, the human body is a giant communication network. The eyes send messages about what is seen, the ears pick up sounds, and skin feels different textures. But where does all this information go? That is where the brain comes in, which is the central processing unit (CPU) of the communication system.

The brain has three main parts; the cerebrum, cerebellum and brainstem. The cerebrum (cerebral cortex) is the largest and outermost part of the brain which gives the brain its rough wrinkly appearance. It is divided into two nearly symmetrical hemispheres, the left and right hemispheres. Each hemisphere of the brain is divided into four regions: frontal, parietal, occipital and temporal lobes. Each region is named according to the skull bones that cover them. These lobes are separated from each other by bumps known as gyrus (plural: gyri) and grooves known as sulci (grooves or fissures). The sulci and gyri give the folded appearance of the brain allowing it to fit in the skull (See Figure 6.1). These gyri and sulci form important landmarks that allow separation of the brain into functional centres. The sulci and gyri also increase the surface area of the brain to give it a broader surface area for processing more information and consequently increasing its cognitive capabilities.

Overview of the Primary Regions of the Brain

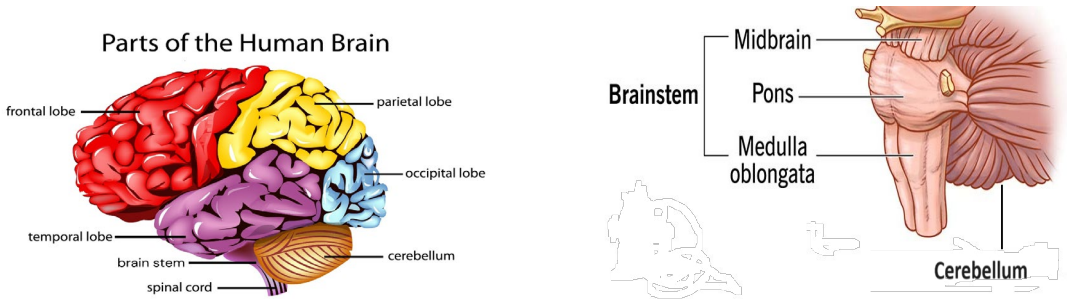
1. **Frontal lobe**: The frontal lobe is the largest lobe of the cerebral cortex. Generally, this is where higher cognitive functions including emotional regulation, planning, reasoning and problem solving occur. The frontal lobe also contains the primary motor cortex which is the major region responsible for voluntary movement.
2. **Parietal lobe**: The parietal lobe is behind the frontal lobe, separated by the central sulcus. Areas in the parietal lobe are responsible for integrating sensory information, including touch, temperature, pressure and pain.
3. **Temporal lobe**: this is located around the temple and ear regions. It is located in front of the occipital lobe. It houses several critical brain structures including the hippocampus and the amygdala. The function of the temporal lobe centres around auditory stimuli, memory, and emotion. It contains the primary auditory cortex and is the first area responsible for interpreting information in the form of sounds from the ears. It has dedicated regions for processing sensory information.
4. **Occipital lobe**: this lobe sits at the back of the head and is the smallest of the four lobes. It is the area of the brain that is responsible for interpreting information from the eyes and turning it into what a person sees.

5. **Cerebellum**: This part of the brain is also known as the "little brain". It is located at the back of the brain, underlying the occipital and temporal lobes of the cerebral cortex. Although the cerebellum accounts for approximately 10% of the brain's volume, it contains over 50% of the total number of neurons in the brain. It is responsible for coordinating movement and balance.
6. **Brainstem**: The brainstem connects the brain to the spinal cord. It sits at the bottom of the brain and includes the midbrain, pons and medulla oblongata (see Figure 6.2). It sends messages to the rest of the body to regulate balance, breathing, heart rate and also regulates many involuntary actions such as balance, blood pressure, breathing, eye movements, facial movements and sensations, sleep and wakefulness, swallowing and taste.



(a) (b)

Figure 6.1: *The human brain (a) Human brain DJ, 2005 and Gyrus and Sulci (b) Gyrus and Sulci Albert Kok, 2007*



(a) (b)

Figure 6.2: *Primary parts of the brain (a) (Kiritsis (2012)) and the brainstem and cerebellum (b)*

Discussions on the major parts of the brain and their general functions in relation to communication (for example, sensory processing, motor control, decision-making)

The brain receives information from all senses, interprets it, and then sends instructions back to the body through the spinal cord. It is like a supercomputer that controls everything we do; from simple reflexes to complex thoughts and emotions. The four lobes, cerebellum, brainstem and spinal cord all play a role in the general functions of the brain in relation to communication. The discussions on the role of the major parts of the brain related to communication may focus on the following:

Frontal lobe: this lobe is the largest of the cerebral cortex. The frontal lobe has areas responsible for higher cognitive functions, including memory, emotions, involuntary actions, problem solving, social interaction and the ability to communicate, and motor function. It is known to be the control panel of our personality. The part of the brain responsible for speech production is found in the frontal lobe. It is known as the Broca's area located on the left side of the brain.

It is a crucial region for language functions, especially speech production, articulation of words, forming sentences, and understanding grammar.

Parietal lobe: this lobe is behind the frontal lobe. The parietal lobe is involved in the processing and integration of sensory information such as touch, pressure, pain and temperature. Due to the integration of sensory information, one can tell if two objects are touching their skin instead of one (See Learning Task for an activity explaining this). This can be explained further by the fact that different brain regions have more sensory receptors than others and the parietal lobe helps us decipher this.

Occipital lobe: This is located at the posterior (back) of the brain and is primarily responsible for visual processing. Within the occipital lobe is the primary visual cortex which is the main area in the brain responsible for the initial processing of visual information. It processes information received from the eyes and relays to the secondary visual areas which interpret location and distance of what we see. It also interprets information such as colour, light and movement.

Temporal lobe: our ability to hear, understand language and form memories is controlled by certain areas of the temporal lobe. The temporal lobe is the main auditory processing centre of the brain and processes information received from the ear. The temporal lobe is involved in various roles, including visual processing, as part of the complex visual processing centre that allows one to recognize faces. Close to the middle of the brain in the temporal lobe is the hippocampus, which is an important region of the brain responsible for forming, organising, and storing new memories. It also plays a critical role in converting short-term memories into long-term ones. Also located in the medial temporal lobe is the amygdala which is involved in emotional memory and responses, particularly fear-related memories.

Cerebellum: The cerebellum is a motor structure of the hindbrain. It plays a critical role in motor control and coordination. Other functions are maintenance of balance and posture, coordination of voluntary movements, learning and refining motor skills through practice and repetition as well as allowing for precise control of fine movements, such as writing or playing a musical instrument. Although traditionally associated with motor functions, the cerebellum also contributes to certain cognitive processes, including attention, language, and executive functions.

Brain stem: the brainstem largely connects the brain to the spinal cord. It serves as a relay centre for information travelling between the brain and the rest of the body. It is also responsible for regulating many basic life functions such as breathing and heartbeats. The brainstem consists of three main parts: the midbrain, pons, and medulla oblongata. Here are the key features and functions of each part of the brainstem:

1. The midbrain plays significant roles in motor movement, particularly movements of the eye, auditory and visual processing. It is responsible for the reflexive responses to sounds. It is also involved in maintaining arousal and alertness and thereby playing a role in the sleep-wake cycle.
2. The pons is involved in the coordination of signals and communication between the left and right hemispheres as well as the spinal cord. It helps regulate the breathing rate and is also involved in facial sensation and movement, eye movement, hearing, and balancing.
3. The medulla oblongata is the lower part of the brainstem where the brain joins the spinal cord. It regulates vital functions such as heart rate, blood pressure, and breathing. It also controls reflexes such as coughing, sneezing, swallowing and vomiting. The medulla

contains nerves that allow us to make mouth and tongue movements for voice, process taste, vomit (gag reflex), and muscles involved in producing speech.

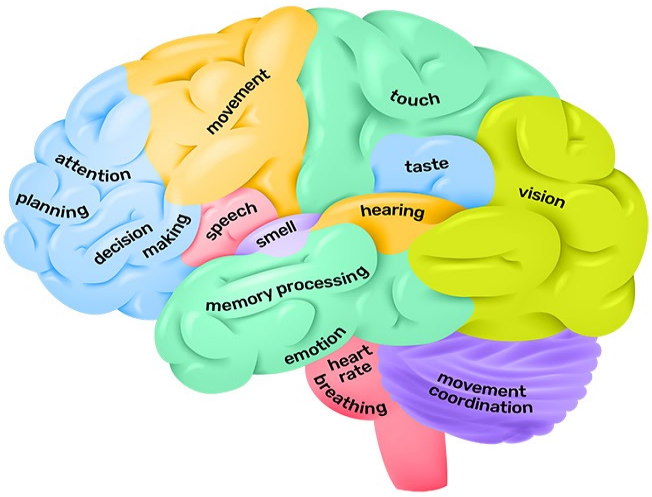


Figure 6.3: *Illustration of the functions of the four lobes, cerebellum and brainstem*

Note

Scan QR Code 10 in Additional Reading for a video on the functions of the brain regions discussed above.

Focal Area 2: The Concept of Brain Mapping and Its Role in Understanding Communication Pathways

Brain mapping is a technique that creates a detailed representation of the structure and function of the brain with the goal of mapping out specific areas that correspond to different functions, behaviours and activities. Knowledge of the structural and functional distinctions of the various brain regions, and understanding the communication pathway of processing external and internal information becomes an important tool for accessing certain brain functions. Brain mapping is a critical approach in neuroscience for understanding the intricate structure and functionality of the brain. It plays a significant role in identifying and mapping out the brain's communication pathways, which are essential for various cognitive and motor functions.

Brain mapping involves the use of various technologies to visualise and characterise the anatomical and functional organisation of the brain. This process can include mapping out the locations of different types of neurons, understanding the brain's electrical activity, and identifying the pathways through which different parts of the brain communicate. Scan **QR Code 14** for a short video to support discussions on brain mapping.

Exploring the different brain mapping imaging techniques (for example, MRI, EEG)

Brain mapping involves a variety of imaging techniques, each offering unique insights into the structure and function of the brain. Each brain mapping imaging technique has its own strengths and limitations. Structural imaging techniques like MRI provide detailed anatomical information, while functional imaging techniques like MRI (functional MRI) offer insights into brain activity and connectivity. Electrophysiological methods like EEG provide high

temporal resolution for studying brain dynamics. Here are examples of the different brain mapping imaging techniques:

1. **Magnetic Resonance Imaging (MRI)** is a medical imaging technique that uses powerful magnets and radio waves to create detailed images of the brain's structures. Magnetic fields and computer-generated radio waves are used to create detailed images of the organs and tissues in your body. (Mayo clinic, 2023). MRI provides high-resolution images of brain anatomy.

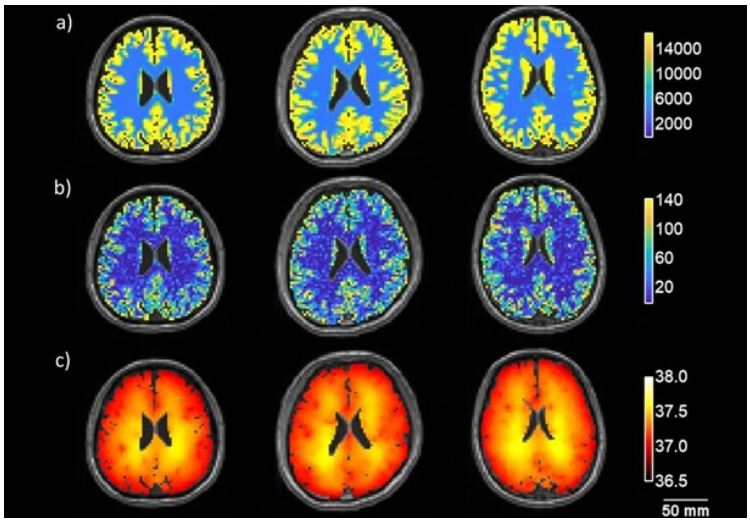


Figure 6.4: *Image of brain mapped using MRI.*

2. **Electroencephalogram (EEG)** uses electrodes placed on the scalp to measure voltage fluctuations resulting from neural activity. It is used to measure the electrical activity of the cerebral cortex by recording brain waves which are further analysed.

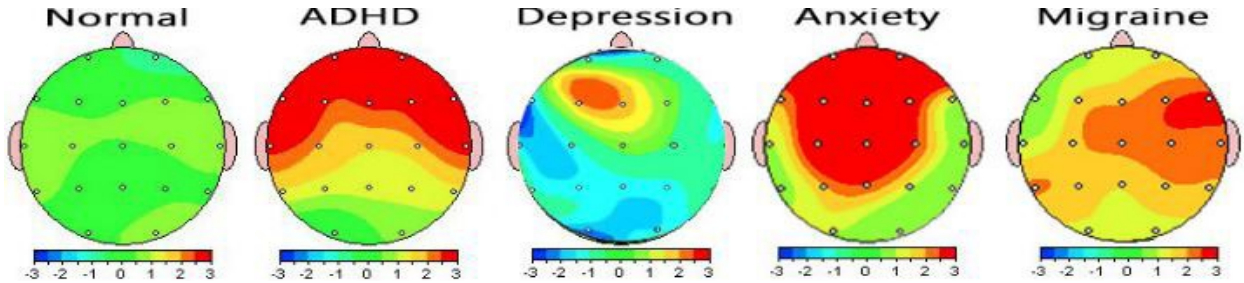


Figure 6.5: *EEG of a healthy human brain compared to common diagnoses (Behavioural Associates, 2018).*

Learning Task

To help learners understand the structure and function of the brain, including brain mapping, and to explore the role the brain plays in the communication system of the human body, guide learners to carry out the following tasks:

1. **Brain Diagram Picture Puzzle**
   This activity is designed to engage learners in a hands-on activity of the major parts of the brain and their functions.

Note

This activity should be timed.

a. Print out the brain diagram template (ensure it has the major parts outlined without labels). Scan **QR code 12** and or **13** for templates.

b. Cut the brain diagram into 6 puzzle pieces according to the patterned lines.

c. Put learners into mixed-ability groups and present them with the cut-out pieces to reassemble.

d. Once the brain is complete, guide them to observe the different sections and discuss the overall shape of the brain.

e. Ask learners to label the major parts of the brain (frontal lobe, parietal lobe, occipital lobe, temporal lobe, cerebellum and brainstem).

f. Instruct learners to provide the functions of the various parts.

2. **Feel the Touch Activity**

To understand the role of the parietal lobe in feeling touch and sensation, guide learners in performing this activity. Materials needed for this activity are a rubber stop cork and 3 pins. Prepare the touching tool as shown in Figure 6.6 below, divide learners into groups and a volunteer from the group should be selected.

a. Other groups members should have the prepared touching tool (See Figure 6.6).

b. With the volunteer's eyes closed, other group members touch him/her with the touching tool (make sure learners touch only comfortable body parts of their colleagues especially in mixed-gender groupings). The volunteer should say out loud where they feel the touch and how many pins, they feel touching them and this should be recorded. Compare various parts of the arm, hands and fingers. With care, compare various parts of the face: tongue, lips, cheeks and forehead.

c. Other groups members should be given the chance to become volunteers to ensure everyone engages in the activity if possible.

d. At the end of the activity, guide learners in a discussion on the data they recorded. Guide learners to discuss further how they think parietal lobe aided in correctly determining how many pins were touching them when their eyes were closed (that is if they were able correctly detect the touch).

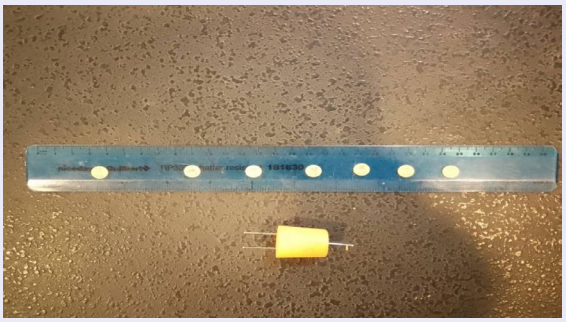


Figure 6.6: *Stop Cork and Pins*

Pedagogical Exemplars

1. **Experiential Learning:** Using charts, diagrams or 3D models, learners in pairs discuss and Note major regions of the brain, their general functions as well as sketch and colour the various regions with unique colours. With learners in pairs or groups, call out actions/ emotions, and learners respond accordingly. Learners role-play different brain regions sending messages (for example, wiggling fingers, feeling happy). Scan **QR Code 11** for a video to support this activity.
2. **Activity-Based Learning:** Provide learners with illustrations or models. Learners work in mixed-ability groups with their given illustrations/models and other literature to create a picture map of the distinct structural and functional characteristics of each region of the brain. Guide learners in their groups to brainstorm communication examples (seeing, breathing, hearing) and draw a simple model of the brain, highlighting key regions involved in communication. Learners then connect the regions with straws, thread or yarn to show information flow.

Key Assessment

Level 2 (Conceptual understanding): Identify specific brain regions involved in processing different types of sensory information like smell, taste, hearing and touch.

Level 3 (Strategic reasoning): Research on the functions of the frontal lobe and deduce how dysfunction in the frontal lobe may affect an individual's way of life.

Level 4 (Extended critical thinking and reasoning): Look at the interesting case of Phineas Gage who had an accident with an iron rod piercing his left eye through to his left frontal lobe and write a report on your findings about his case with emphasis on how different parts of the brain are responsible for different functions.

WEEK 8

Learning Indicator: Determine how communication works in the body and its effects

Focal Area 1: What Comprises the Communication System of the Human Body?

The human body has a complex communication network comprising two key systems:

1. **Nervous System:** This system functions as the central command centre, transmitting messages via nerve impulses (electrical signals) throughout the body. These signals can convey various information, such as pain sensation or movement initiation.
2. **Endocrine System:** This system regulates bodily functions through hormones, which are chemical messengers produced by glands. These hormones travel through the bloodstream to target organs, affecting growth, development, metabolism, mood, and other processes.

Together, these systems maintain homeostasis (a stable internal environment) and respond to external stimuli. The nervous system and the endocrine system regulate body processes using different pathways.

Explain The Basic Flow of Communication in the Body

The basic flow of communication in the body involves a complex network of systems working together to transmit signals and maintain homeostasis. This basic flow of communication in the body involves sensory input, processing and integration by the central nervous system, and motor output or hormone release to elicit a response. The primary systems involved in communication are the nervous system and the endocrine system. The nervous system enables rapid, precise signalling, while the endocrine system provides longer-lasting, widespread effects. Together, these systems ensure the body can respond to internal and external changes effectively, maintaining homeostasis and coordinating complex functions. To properly support learning and improve learners' understanding of the communication system of the body, introduce learners to the nervous and endocrine systems and how they contribute to communication in the body. Discussions on communication in the human body should focus on:

Nervous System Communication

The nervous system is responsible for rapid communication throughout the body using electrical and chemical signals. The nervous system is broadly divided into the central nervous system (CNS) and the peripheral nervous system (PNS) (See Figure 23). The CNS is made up of the brain (discussed in weeks 6 & 7) and the spinal cord. The basic cell unit of the CNS is the neuron. The brain and spinal cord are protected by the skull and the vertebral column respectively. The nerves and cells of the PNS unlike those of the CNS are not protected, and are susceptible to injury and trauma. The PNS nerves also contain connective tissues and blood vessels as the main transmission cables. With respect to communication, the nervous system is further divided into sensory input, processing and integration, and motor output.

1. **Sensory Input**
    a. Stimulus detection: The nervous system has sensory receptors (e.g., in the skin, eyes, ears) to detect stimuli such as touch, light, sound, taste and temperature.

b. **Signal transmission:** Sensory neurons transmit information from receptors to the CNS for processing.

2. **Processing and Integration**

Central Nervous System: The brain and spinal cord process and interpret sensory information. This involves integrating signals, making decisions, and generating responses. The brainstem also plays an important role in the regulation of cardiac and respiratory function, in maintaining consciousness and regulating the sleep cycle.

3. **Motor Output:**
   a. **Signal transmission:** The motor neurons carry signals from the CNS to effector organs that are the muscles and glands.
   b. **Response execution:** The effector organs then produce a response, such as muscle contraction or hormone secretion, and feedback loops for ongoing adjustments.

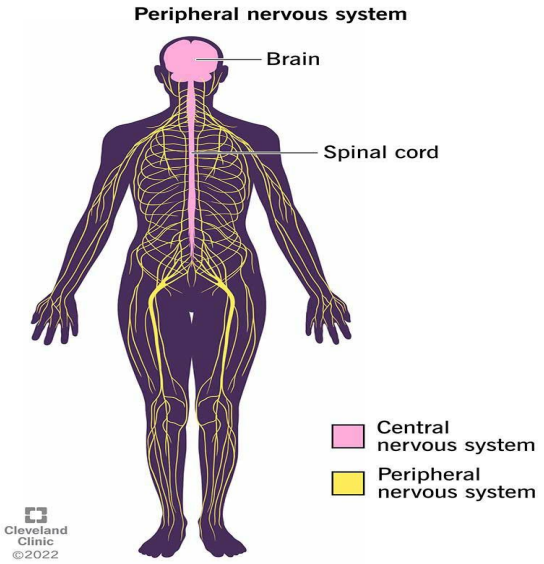


Figure 8.1: *The central and peripheral nervous system*

Endocrine System Communication

The endocrine system plays a crucial role in communication within the body by using hormones to regulate a wide range of physiological processes. Unlike the nervous system, which uses electrical impulses for rapid and precise signalling, the endocrine system relies on chemical messengers that travel through the bloodstream to reach their target cells and organs. The endocrine system communicates extra information by secreting hormones into the bloodstream, which regulate various bodily functions over longer periods. With respect to communication, the endocrine system is divided into hormone production and signal reception.

1. **Hormone production:** The endocrine system is responsible for the production and regulation of hormones, which are chemical messengers that travel through the bloodstream to target organs and tissues. Hormones regulate a variety of physiological processes, including growth, metabolism, reproduction, and homeostasis. Here's an overview of how the endocrine system functions for communication:
   a. **Glandular secretion:** Endocrine glands (e.g., pituitary, thyroid, adrenal) produce and release hormones. Hormones are synthesised in response to specific stimuli, and travel to target cells where they elicit specific responses. Feedback mechanisms, primarily negative feedback, ensure that hormone levels remain within optimal ranges to maintain

homeostasis. The coordination between different endocrine glands and hormones is essential for the proper functioning of the body.

   b. **Bloodstream transport:** Hormones enter the bloodstream and travel to target cells or organs. Hormones produced by the endocrine system are crucial for communication within the body. They are released into the bloodstream, travel to distant target cells, and bind to specific receptors to elicit a variety of physiological responses. For example, insulin is released by the pancreas in response to high blood glucose. It binds to cell surface receptors on liver, muscle, and fat cells, promoting glucose uptake and storage.

2. **Signal reception:** Signal reception in the endocrine system involves the detection and response to hormones by target cells. This process is crucial for effective communication and regulation of various physiological processes within the body.
   a. **Target cells:** Cells with specific receptors for the hormone bind the hormone, initiating a response.
   b. **Cellular response:** The binding triggers a cascade of events within the cell, leading to changes in gene expression, metabolism, or other cellular functions.

Focal Area 2: How do Disruptions in Communication Lead to Various Health Issues?

Disruptions in the body's communication systems can lead to a wide array of health issues because these systems are integral to maintaining homeostasis and coordinating bodily functions. These disruptions can result from hormonal imbalances, neurotransmitter imbalances, receptor insensitivity, neural damage, and failures in feedback mechanisms. Understanding these mechanisms is essential for diagnosing and treating various endocrine and neurological disorders effectively. Here below is an overview of how these disruptions can lead to health issues:

1. **Metabolic disorders**
   a. **Diabetes mellitus:** Both type 1 (autoimmune destruction of insulin-producing cells) and type 2 (insulin resistance) result in hyperglycaemia, which can cause complications like neuropathy, nephropathy, and cardiovascular disease.
   b. **Obesity:** Hormonal imbalances, such as those involving leptin and insulin, contribute to excessive fat accumulation and metabolic syndrome.
   c. **Muscle damage:** Muscle damage can result from direct injury, metabolic disorders, or neurological conditions that affect muscle function. Genetic mutations may also lead to the production of abnormal proteins that impair muscle function and repair. This disrupts communication between nerves and muscles causing muscular dystrophy.

2. **Neurotransmitter Imbalances**
   a. **Depression:** Imbalances in neurotransmitters like serotonin, dopamine, and norepinephrine can lead to mood disorders.
   b. **Migraines:** Disruptions in neurotransmitter balance (e.g., serotonin) and abnormal brain activity lead to migraines. Changes in the brainstem and its interactions with the trigeminal nerve, a major pain pathway, are involved.
   c. **Tension headaches:** Stress, muscle tension, and altered pain processing pathways in the central nervous system contribute to tension headaches. Neurotransmitter imbalances can also play a role.

3. **Growth and developmental disorders**
   a. **Dwarfism:** Growth hormone deficiency leads to dwarfism in children and reduced muscle mass and energy levels in adults.
   b. **Gigantism:** Excessive growth hormone production causes abnormal growth of bones and tissues.
4. **Neural Communication Disruptions**
   a. **Multiple Sclerosis:** Autoimmune attacks on the myelin sheath disrupt neural communication, leading to muscle weakness, coordination problems, and cognitive issues.
   b. **Epilepsy:** Abnormal electrical activity in the brain causes seizures, which can vary from brief lapses in attention to severe convulsions.

Learning Task

Consider implementing at least one of the following learning tasks to reinforce understanding and knowledge acquisition among learners.

1. Simulate action(s) that will stimulate the "flight or flee" response. You can employ one of the following activities for the stimulation:
   a. Pouring very cold water on the learners unawares
   b. Dropping an artificial reptile e.g. snake, lizard on the classroom floor on the blind side of learners and prompting them of its presence.
   c. Introducing a sudden loud noise or surprise event (e.g., a balloon popping, champagne popping, using loudspeakers for noise).
   d. Have learners perform a quick burst of physical activities, such as jumping jacks, or a short sprint.

   Guide learners to discuss how their bodies reacted under these circumstances. Discussions should be based on how the:
   a. special senses picked the signal of the stimuli
   b. nervous system processed the information
   c. endocrine system responded (with the secretion of adrenaline),
   d. musculoskeletal system responded by causing you to run to safety
   e. circulatory and respiratory systems responded with increased heart and breathing rates respectively
   f. body would have reacted in case of a miscommunication and the plausible consequence.
2. **Messages in the dark**

   Explain to the learners that our bodies are continuously sending and receiving messages. This activity will help learners explore how light impacts our body's communication system, especially our ability to see.

a. Turn the lights off in the classroom (or use available sources of light like a flashlight) and ask learners to blindfold or close their eyes for a few minutes.

b. Briefly shine the flashlight beam near each learner's eyes (being careful not to shine it directly into their eyes). Ask them to keep their eyes closed for a few more seconds after flashing the light.

c. Have learners open their eyes and inquire:

   i. What did you observe when the light was directed near your eyes? (Spots, flashes).

   ii. How soon did your vision become clear again?

Note that in darkness, the light-sensitive cells (rods) in our eyes are highly sensitive. However, when there is excessive or bright light, these receptors become overloaded rendering them ineffective until there is accommodation of the eye. It takes some time to adjust and send a clear signal to the brain for clear vision. Our cones are not so sensitive in poor light. Hence our inability to distinguish colour in poorly lit areas.

Pedagogical Exemplars

1. **Digital Learning:** Learners watch a short video on the human body communication systems and Note down the human body systems involved. Focusing on the nervous system, use a video, picture or a 3D model to illustrate how the neurons use electrical impulses and chemical signals to transmit information within a brain area, between the brain regions and the rest of the nervous system.
2. **Collaborative Learning:** Learners brainstorm on how specific impulses are transmitted, including reflex actions and present their findings to their colleagues for feedback.

Key Assessment

Level 1 (Recall): List the parts that form the human body communication system.

Level 2 (Conceptual understanding)

1. Identify different disruptions/disorders that can occur from communication system damage.
2. What are the conditions that may occur in the human body communication system due to the disorders identified.

Level 3 (Strategic reasoning): Using the case study, answer the following questions.

Araba, is a 17-year-old student, she accidentally touches the surface of a hot iron while ironing her uniform and immediately withdraws her hand.

1. Identify which parts of the brain are involved in processing the sensation Araba felt.
2. After conducting some research, explain how the communication system processed the pain sensation.

Level 4 (Extended critical thinking and reasoning): Based on the different disorders caused by the disruptions in the human body communication system, propose ways these disorders can be prevented or treated if there are no preventive measures.

WEEK 9

Learning Indicator: Describe the importance of technological tools in biomedical sciences to measure parameters associated with communication in the human body

Focal Area 1: Technological Tools Used in Biomedical Sciences to Assess Communication Within the Human Body

Discussions on technological tools employed in assessing communication in the human body

Technological tools for assessing communication within the human body include various imaging, and diagnostic tools. These tools enable visualisation, measurement and analysis of the signals and processes that facilitate interaction between different body parts.

These tools may include the following:

1. **Electrocardiograms (ECGs)** for measuring electrical activity of the heart. It is an imaging tool that is used to check the heartbeat and record electrical signals of the heart. The Resting ECG, Ambulatory ECG and Cardiac Stress Test are types of electrocardiograms. The ECG has various purposes and uses including
   a. diagnosing heart damage, weakness, size, position and rhythm.
   b. detecting blocked or narrowed arteries in the heart that cause chest pain or heart attack.
   c. evaluating heart related problems such as severe tiredness, shortness of breath, dizziness or fainting.
   d. monitoring the effect of drugs or devices used to control the heart.
2. **Electroencephalogram (EEG)** for measuring electrical activity of the brain. The electroencephalogram is an imaging tool used to measure and record the electrical activity of the brain. It is usually used in mammals with a developed central nervous system/brain. It comprises a cap with nodes to which electrodes have been connected. The EEG uses electrodes to measure electrical activity from neurons in the superficial skull (see Figure 24). The electrode position on the scalp for EEG recording is according to the international standard 10-20 system.

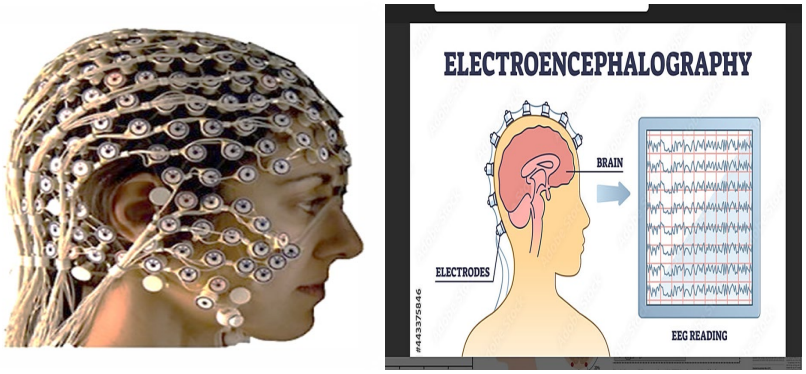


Figure 24: *Electroencephalography*

3. Electromyography (EMGs) for measuring muscle activity.

   EMG is an imaging tool that measures muscle response or electrical activity of the muscle in response to nerve stimulation of the muscle. The EMG is used to accurately diagnose neuromuscular disorders by electrodes through the skin into a muscle. Surface electrodes are sometimes used for this test. The electrodes in the muscle or on the skin pick up electrical activity and display it on a monitor in the form of waves which can be heard when an audio-amplifier is used.

Note

Refer to medical diagnostic devices in year one for images of ECG AND EMG.

Learning Task

Engage learners in a fun quiz session designed to increase learners' knowledge of technological tools used to measure parameters associated with communication in the human body. Through this quiz learners will better appreciate the roles of these tools and their importance.

QUIZ: BEST TEAM WINS

Dividing learners into mixed-ability groups of 3 or 4 teams, create a quiz session as is done in the National Science & Math Quiz with different rounds like the speed race, problem of the day, true or false and riddles. The rules of the NSMQ may apply to make the quiz more competitive and fun.

The following are samples for each round.

1. Speed race (these questions require short answers that can easily be thought of)
   E.g., What is the full meaning of EEG?
2. Problem of the day (questions in this round require learners to express their understanding of the topic in their own words)
   E.g., With focus on the different uses of the ECG, discuss its importance in a hospital.
3. True or False (questions in this round will require learners to determine whether a statement is true or false)
   E.g., The EEG, ECG and EMG all measure electrical activity in the brain. True/False
4. Riddles (In this round, the questions come as clues for groups to derive meaning and come up with the correct answer)

Clue 1: I am a technological tool with nodes.

Clue 2: I measure electrical activity by means of electrodes

Clue 3: I pick up this electrical activity from neurons in the superficial skull

What am I?

Pedagogical Exemplars

1. **Experiential / Digital Learning:** Learners visit a hospital or watch a video on how the electrical activity of the brain, electroencephalogram (EEG) or heart, electrocardiogram (ECG) can be monitored using external electrodes. Learners Note the differences in the frequency and amplitude of electrical patterns (waves) observed.

2. **Collaborative Learning**: Teacher leads a discussion on types of brain waves (alpha, beta, theta, and delta), their characteristics and the respective states of consciousness they represent. Learners discuss the EEG of clinical conditions with peculiar brain wave patterns such as seizure. Learners observe samples of EEG to identify and indicate the clinical significance of brain waves.

Key Assessment

Level 2 (Conceptual understanding): Discuss the importance of technological tools in measuring communication within the human body. Include two examples of communication parameters these tools can measure.

Level 3 (Strategic reasoning): Investigate and describe new technological advancements in ECG, EEG, and EMG. How are these advancements making the tools more accurate and easier to use in clinical settings?

Level 4 (Extended critical thinking and reasoning): Mr. Tawiah, a quarry worker, started experiencing weakness and tingling in his fingers while working, affecting his ability to crack the stones at his usual accuracy. Concerned about his situation, he decided to see his doctor. After a series of physical examinations, the doctor did not find any visible signs of injury. From the case above,

a. What could possibly be wrong with Mr. Tawiah?

b. What technological tools can the doctor use in diagnosing Mr. Tawiah's condition.

c. Explain the functions of the identified technological tools the doctor might use in arriving at this diagnosis?

HINT

*Set a date in week 9 for the submission of the **group project** and score it for onward submission to the STP*

SECTION 3 REVIEW

This section is for review of all the lessons taught for the last four weeks. A summary of what should have been taught and what each learner should have learnt if differentiation has been successful.

a. What is the brain's role in the body's communication system?

b. What is brain mapping, and how does it help scientists in determining brain function?

c. Why is understanding brain communication important?

The brain acts as the central processing unit of the human body. Together with the endocrine system, the nervous system controls the body's communication system, controlling movement, sensations, and thoughts. Brain mapping helps scientists see how messages travel through this system. This knowledge is crucial for better understanding nervous system health.

Additional Reading

QR Code 10

QR Code 11

QR Code 12

QR Code 13

APPENDIX C: STRUCTURE OF MID-SEMESTER EXAMINATION FOR SEMESTER 1

20 items (MCQs) covering focal areas 1-5 for semester 1 as in the table of specifications. Use the table of specification as a guide.

Resources: Printer, A4 sheets, answer booklets, stationary, timers; for e-Assessment, consider a stable internet, computer, or tablet as well, etc.

Duration: 30 minutes.

Marking scheme: 1 mark for each correct answer. Total marks = 20 marks

TABLE OF SPECIFICATION FOR MID SEMESTER EXAMINATION

Week	*Focal Area*	*Type of Question*	*Depth of Knowledge*			
			L1	*L2*	*L3*	*Total*
1	*Discussions of Careers Involved in Preventing and Diagnosing Diseases*	*Multiple choice*	*1*	*1*	*1*	*3*
2	*How is Biomedical Science Used in Forensics?*	*Multiple choice*	*1*	*1*	*1*	*3*
3	*Clinical and Research Careers in Biomedical Science*	*Multiple choice*		*1*	*1*	*2*
4	*The Importance of knowledge of biosafety levels in the laboratory* *General Biosafety Principles That Apply in All Laboratories, Regardless of Level*	*Multiple choice* *Multiple choice*	*1* *1*	*1* *1*	*1*	*3* *2*
5	*What is a biosafety cabinet (BSC)?* *Proper Setup Procedures for the BSC And its Surrounding Environment* *Discuss the Sequence and Technique for Proper Donning and Appropriate Use of Personal Protective Equipment (PPE)* *Discuss the safe removal of PPE to minimise contamination risk.*	*Multiple choice*	*1*	*1*	*1*	*3*
Total			***6***	***8***	***6***	***20***

SECTION 4: DISEASES AND DISORDERS

STRAND: HUMAN BODY SYSTEMS

Sub-Strand: Diseases and Disorders

Learning Outcome: *Describe how malfunctions in the nervous and endocrine systems affect other body systems and lifestyle*

Content Standard: *Apply knowledge of human body systems to indicate how damage to one system can impact function in another system*

HINT

- *The end of the first semester examination takes place in the 12th week of the academic calendar. For guidelines on developing assessment items, please refer to Appendix D at the end of this section.*
- *Give individual project by week 13 of the academic calendar which will be submitted in week 20. Inform learners to prepare for a presentation before submission. See Appendix E at the end of this section for further information on the individual project.*
- *Remind learners to include a copy of the results of the end-of-first semester examination and that of the individual project in their portfolios.*

INTRODUCTION AND SECTION SUMMARY

In this section, learners will examine how malfunctions in the nervous and endocrine systems can affect and influence other body systems which may lead to a change in a person's lifestyle. The section also explores the structural differences between bacteria and viruses, the prevalence and treatment of bacterial and viral infections in relation to the reproductive system. Learners will also be introduced to antigens and some antibiotics used to treat infections as well as the social and global impact of infectious diseases.

The weeks covered by the section are:

Week 10: Explain how major nervous system disorders impact quality of life

Week 11: Interpret the symptoms and physical characteristics of a given patient to determine an endocrine system malfunction (for example, Hyperthyroidism)

Week 12: Identify and discuss the causes, symptoms, treatments, effects and impact of diabetes on the human body and human lifestyle

Week 13: Identify the structural differences between bacteria and viruses

Week 14: Explore the systems, prevalence, and treatment of bacterial and viral infections considering infections of the reproductive system

Week 15: Explore the immune response in relation to the introduction of antigens.

Week 16: Analyse how antibiotics are used to treat infections and explain how effectiveness depends on the causative bacterium

Week 17: Discuss the global and social impact of some infectious diseases caused by bacteria and viruses

SUMMARY OF PEDAGOGICAL EXEMPLARS

The following pedagogical exemplars are recommended to achieve the learning outcomes and content standard in this section. Using talk-for-learning strategies, learners discuss the causes of nervous system dysfunction. Additionally, learners brainstorm functions of hormones in the body, sharing their thoughts on diabetes with focus on its diagnosis and effects on lifestyle. The body's immune response to foreign invasion is also discussed using talk-for-learning strategy. Project-based learning strategy in mixed ability groups, support learners in working together to identify effects of some abnormalities of the central nervous system. Again, project-based strategy is adapted to explore bacterial and viral infectious diseases, observe specimens under slides and design public health campaigns on the dangers and prevention of infectious diseases. Through digital and experiential learning, learners explore further the endocrine and digestive systems. Learners also consider the social and global impact of viral and bacterial infections. Pictures, charts and videos will support learners to brainstorm mechanisms of antibiotic action. Using activity-based learning strategy, learners explore antigens and their role in the immune system and individually create mind maps on diabetes. With collaborative learning strategy, learners identify and share thoughts on the similarities and differences between bacterial and viral infections.

SUMMARY OF ASSESSMENT

To assess learners' understanding on nervous system disorders, diabetes, bacteria and viruses, the body's immune response to antigens and the global and social impact of infectious diseases, levels 1,2,3 and 4 assessments are recommended. Using DOK level 1 assessment, learners' ability to recall knowledge shared on the symptoms of hyperthyroidism, the effects and impact of diabetes, the structural differences between bacteria and viruses, bacteria infections in the reproductive system, immune response, the functions of antibiotics and global impact of bacterial and viral diseases, Learners' conceptual understanding is assessed on nervous system disorders, symptoms of endocrine system malfunction, the development of diabetes Type 2, the role of antibiotics in treating STIs and other bacterial infections as well as the stigma surrounding HIV/AIDS, using DOK level 2 assessment strategies. Using DOK levels 3 and 4 assessments, learners' strategic reasoning abilities are assessed on nervous and endocrine system disorders, prevention and management of diabetes, effects of certain STIs on the reproductive system and enhancing access to healthcare, the role of antigens in the immune system, antibiotic resistance and the social impact of tuberculosis. The recommended mode of assessments for each week is as follows:

Week 10: questioning

Week 11: Role play

Week 12: End of First Semester Examination

Week 13: Poster presentation

Week 14: Essay type

Week 15: Demonstration

Week 16: Multiple choice

Week 17: e-Assessment

WEEK 10

Learning Indicator: Explain how major nervous system disorders impact quality of life

Focal Area 1: Explore How Various Nervous System Disorders Can Impact a Person's Quality of Life

Disorders of the nervous system can be grouped into several categories based on their nature (characteristics), and origin (underlying causes). Based on their characteristics and underlying causes, nervous system disorders can be grouped as follows:

1. **Structural disorders:** These are usually caused by injuries or damage to structures or organs of the nervous system. Examples are injuries to the brain and spinal cord, carpal tunnel syndrome and brain tumours.
2. **Neurodevelopmental disorders:** These are conditions that occur during the development of the nervous system prior to birth, leading to various functional impairments. Some well-known disorders include:
    a. **Autism Spectrum Disorder (ASD):** is a developmental disorder that affects communication, behaviour, and social interaction.
    b. **Attention-Deficit/Hyperactivity Disorder (ADHD):** Is a neurodevelopmental disorder characterised by symptoms of inattention, hyperactivity, and impulsivity. It typically appears in childhood and can continue into adulthood.
    c. **Learning disorders:** Affect specific areas of learning such as reading (dyslexia), writing, and Mathematics.
    d. **Communication disorders:** Include speech and language difficulties. For example, difficulty pronouncing specific sounds or letters correctly such as substituting "l" for "r"; "s" for "sh" and vice versa.
3. **Infections:** These are caused by infections to parts of the nervous system. Examples are meningitis, poliomyelitis and abscesses.
4. **Functional disorders:** These are conditions that affect the function of the nervous system without structural damage. Examples include
    a. epilepsy is characterised by recurrent seizures due to abnormal electrical activity in the brain;
    b. headaches including migraines and tension headaches, often due to stress or hormonal changes;
    c. sensations of spinning or imbalance (dizziness), often related to problems of the inner ear.
5. **Degenerative disorders:** Degenerative disorders of the nervous system are characterised by the progressive loss of structure or function of neurons, including death of neurons. Examples include Alzheimer's disease, Parkinson's disease, multiple sclerosis (MS), amyotrophic lateral sclerosis (ALS).
6. **Vascular disorders:** Vascular disorders of the nervous system involve issues with the blood vessels supplying the brain and spinal cord. Examples are stroke which is caused by the

disruption of blood flow to the brain, leading to brain cell death and cerebral haemorrhage that is bleeding within the brain due to vessel rupture.

7. **Autoimmune Disorders:** Autoimmune disorders of the nervous system occur when the immune system mistakenly attacks components of the nervous system. Examples are Multiple Sclerosis (MS) where the immune system attacks the protective myelin sheath covering nerve fibres, leading to communication issues between the brain and the rest of the body and Myasthenia Gravis (MG) where the antibodies attack the connections between nerves and muscles, leading to muscle weakness.

Consequently, these disorders of the nervous system can have great impact on a person's daily life from birth to adulthood. Discussions on the impact of nervous system disorders should focus on the following:

1. **Difficulty with movement and coordination:** Nervous system disorders can significantly impact movement and coordination by affecting various aspects of the brain and nervous system responsible for controlling and executing physical actions. Examples of nervous system disorders that affect movement and coordination are Parkinson's disease, stroke (depending on the affected brain part) and Multiple Sclerosis.
2. **Impaired communication and speech:** Damage to areas like the Broca's area of the frontal lobe affects our ability to not just speak but also understand language in order to communicate. Other conditions such as stroke also affects speech. Neurodevelopmental disorders such as autism can also affect communication and speech.
3. **Sensory issues:** The sensation of pain can lead to clinical conditions such as chronic pain. Damage to optic nerves, which may be caused by other medical conditions (for example diabetes-related rhinopathy) may lead to blindness. Loss of sensitivity to pain in the extremities (hand and feet) can be as a result of damage to nerve endings in the case of leprosy. These affect the senses and consequently daily life is greatly impacted.
4. **Cognitive decline:** Amnesia (temporal memory loss) and dementia (permanent, progressive memory loss) are commonly associated with cognitive decline as a result of nervous system damage. This usually happens as one ages, but also due to the death of neurons from neurodegenerative conditions. An example is Alzheimer's disease whose onset is still unclear but heavily characterised by dementia.

Focal Area 2: Real-life examples of people living with nervous system disorders

There are several diseases and disorders that greatly affect the lifestyle of the affected individuals. However, nervous system disorders which affect the brain, spinal cord and the peripheral nerves can have drastic life-changing symptoms which in some cases are not curable. Below are some real-life examples of people living with nervous system disorders.

1. Alzheimer's patients have dementia which progresses from mild to severe as the disorder progresses. Dementia is characterised by not just progressive memory loss but also, ability to speak which affects social interaction with others. Some Alzheimer's patients have their condition worsen to the point where they do not recognise their families and themselves. Scan QR Code 14 and 15 Additional reading for videos of Alzheimer's patients.
2. Aphasia is a language disorder which affects a person's ability to speak, and understand spoken and written language. It can happen suddenly after one has a stroke or a brain injury,

or it may slowly occur as a result of a growing brain tumour or a disease. The brain region usually affected is the Broca's area located in the frontal lobe. Individuals with aphasia may say something like "Drive, mom, market" when they mean to say "Mom will drive to the market today". In severe cases patients may not be able to comprehend what is being spoken to them in order to give an appropriate response. Scan **QR Code 16** for a video of a teenager who suffered aphasia after a stroke.

Other conditions that may be discussed can be autism, Parkinson's disease and chronic pain. Scan **QR Codes 17, 18** and **19** for videos of patients with these conditions to support discussions.

Learning Task

Role-Playing Activity

Put learners in groups and have them role-play a scenario of a patient visiting the hospital showing symptoms of a particular nervous system disorder (for example involuntary shaking, shuffling and slow movement in the case of Parkinson's disease). Encourage shy learners to take up the leadership role. One member of the group acts as a patient diagnosed with a major nervous system disorder (for example, Parkinson's disease and multiple sclerosis). The other group members take on roles such as family members/ caregivers and healthcare providers (for example a medical doctor, physical therapist, nurse).

At the end of the role-play, facilitate a debriefing discussion. Discuss the following questions:

1. What symptoms did the patient present?
2. What condition or disorder did the patient suffer from?
3. How will the disorder affect the quality of life of the patient as well as the family members?

Pedagogical Exemplars

1. **Managing Talk for Learning:** With the aid of pictures and videos, learners discuss conditions, diseases, and injuries that can cause nervous system problems (cerebral palsy, multiple sclerosis, stroke, vascular disorders, injuries, especially injuries to the head and spinal cord, etc.)
2. **Project-Based Learning:** Learners work in mixed ability groups to explore diseases, disorders and injuries that can affect the brain, spinal cord, or other nerves and the resulting symptoms (paralysis, muscle weakness, poor coordination, loss of sensation, seizures, confusion, pain, altered levels of consciousness, etc). They may refer to appropriate literature and engage in community interactions (experiences).

Key Assessment

Level 2 (Conceptual understanding): Answer True or False to the following questions and give short reasons for your choice.

1. Damage to the Broca's area of the frontal lobe affects our ability to communicate.
2. Autism and Alzheimer's disease are both neurodegenerative disorders.

3. A condition like stroke can be caused by some accidental damage to the central nervous system.
4. Neurological conditions such as Parkinson's disease and Multiple Sclerosis only affect aspects of the patient's life.

Level 3 (Strategic reasoning): examine a particular nervous system disorder (such as multiple sclerosis, stroke, brain and spinal injuries) and describe its effects on the physical, emotional, and social aspects of an individual's quality of life**.** Present your findings to the whole class using visual aids (charts, slides) to help the class understand your findings when you present them.

Level 4 (Extended strategic thinking and reasoning): Identify a person living with any nervous system disorder in your community, observe them for a week and write a report describing how they go about their daily activities. While comparing their life activities to that of a healthy person, determine how the nervous system disorder has impacted their life.

Note

For learners who may have difficulty in finding a person with a nervous system disorder in their community, they can surf the internet for videos or read articles to help with this assessment task.

WEEK 11

Learning Indicator: Interpret the symptoms and physical characteristics of a given patient to determine an endocrine system malfunction (example, Hyperthyroidism)

Focal Area 1: The Role of the Endocrine System in Regulating Various Bodily Functions

Briefly discuss the major glands and hormones they produce

The endocrine system is a network of glands and organs that produce, store, and release hormones. Hormones are chemical messengers that are produced and released by these glands. The hormones regulate many vital functions of the body, including metabolism, growth, reproduction, and mood. The endocrine system is made up of glands such as the hypothalamus, pancreas, pituitary, adrenal, and thyroid glands. Other organs such as the kidneys, testes and ovaries, also produce hormones. For example, there are glands in the testes and ovaries found in the reproductive system that produce hormones which support maturation and reproduction in males and females.

Discussion on the major glands, the hormones they secrete and their function(s) will focus on the following:

1. **Pituitary gland**: This is the major gland of the endocrine system. It is as small as a pea and located at the base of the brain, below the hypothalamus. It is attached to the hypothalamus by nerves and blood vessels and is controlled by the hypothalamus. The hypothalamus signals the pituitary gland if it needs to produce pituitary hormones. The pituitary gland is also called the "master gland" because it controls other endocrine glands. It releases hormones that influence growth, metabolism, and reproduction. Examples of hormones produced by the pituitary gland and their corresponding functions are as follows:
    a. Growth hormone stimulates growth of bones and muscles, promotes protein synthesis and regulates metabolism for overall development of the human body.
    b. Prolactin plays a key role in lactation (milk production) and regulation of menstrual cycle.
    c. Adrenocorticotropic hormone (ACTH) plays a crucial role in regulating the activities of the adrenal cortex, which is part of the adrenal gland. It stimulates the adrenal cortex to produce and release cortisol. Increased ACTH levels lead to elevated cortisol levels, which help the body respond to stress by increasing blood sugar, enhancing metabolism, and suppressing the immune system.
    d. Thyroid-stimulating hormone (TSH) plays a crucial role in regulating the function of the thyroid gland. It stimulates the thyroid gland to secrete hormones which regulate metabolism.
    e. Luteinizing hormone (LH) triggers ovulation and stimulates the production of oestrogen and progesterone in females, and stimulates testosterone production in males.
    f. Follicle-stimulating hormone (FSH): stimulates the growth of ovarian follicles in females and production of spermatozoa in males.

2. **Adrenal gland**: these are small triangular-shaped glands located on top of each of the kidneys. They produce and secrete various hormones that help in numerous physiological functions including the regulation of the immune system, blood pressure, metabolism and response to stress response.
3. **Thyroid gland** is located in front of the throat below the larynx. The thyroid gland is butterfly-shaped and secretes thyroid hormones which regulates metabolism. The hormones produced also regulate growth.
4. **Pancreas** is located in the abdomen and is part of the digestive system. It makes pancreatic juices containing enzymes such as amylase, proteases and lipase that help in the breakdown of food (carbohydrate, protein and fat respectively). It is mostly commonly known with regard to the regulation of blood glucose levels.
5. **Ovaries:** The ovaries produce hormones that play critical roles in the female reproductive system. The ovaries produce oestrogen which promotes the development of secondary sexual characteristics, such as breast development and the regulation of the menstrual cycle. It also produces progesterone which prepares the uterine lining for a potential pregnancy after ovulation and supports early pregnancy by maintaining the uterine lining and preventing contractions.
6. **Testes:** the testes produce hormones (example testosterone) that are essential for male reproductive functions and the development of male secondary sexual characteristics.
7. **Hypothalamus**: as established in Year 1 the hypothalamus keeps the body in a stable state-homeostasis. It is almond-shaped and located deep in the brain above the pituitary gland and below the thalamus. The hypothalamus produces hormones that regulate actions of the pituitary gland. It manages body temperature, hunger, thirst, blood pressure, sleep cycle and mood. Examples of hormones secreted by the hypothalamus and their functions are as follows:
    a. **dopamine**: inhibits the release of prolactin
    b. **somatostatin**: inhibits the release of growth hormone and thyroid-stimulating hormone
    c. **corticotropin-releasing hormone:** stimulates the pituitary gland to release adrenocorticotropic hormone
    d. **Gonadotropin-releasing hormone:** stimulates the pituitary gland to release follicle-stimulating hormone and luteinizing hormone
    e. **Growth hormone-releasing hormone:** stimulates the pituitary gland to release growth hormone and consequently promoting growth and metabolism.

Focal Area 2: Symptoms and Physical Characteristics of Endocrine System Malfunction

Analyse common symptoms of different endocrine disorders (example, fatigue, weight changes, abnormal growth) to identify potential endocrine system malfunctions

As part of the body's communication system, a malfunction in the endocrine system's production and release of hormones is accompanied by varying symptoms. Some endocrine disorders exhibit some physical changes to an individual's appearance. Below are some common endocrine system disorders and their symptoms.

1. **Hyperthyroidism**: This condition is caused by an overactive thyroid producing too much thyroid hormone. With the main function of the thyroid being the regulation of metabolism and how our body uses energy, excessive production of thyroid hormone leads to an increase in the body's metabolic rate. One clear sign is weight loss. Hand tremors and irregular heart are other signs of hyperthyroidism. The opposite with low production of thyroid hormone is known as **hypothyroidism**, with symptoms such as fatigue, weight gain, and aversion to cold conditions
2. **Gigantism**: This a very rare condition that occurs due to malfunction in the pituitary gland (usually a growth or tumour of the pituitary gland) leading to an excessive increase in the production and release of the growth hormone. This makes children grow taller and bigger faster than their peers. A large head, unusual features of the face (such as a broad nose), very large hands and feet with thick fingers and toes, more sweating than usual, a very large appetite, general weakness are some physical characteristics and symptoms associated with gigantism
3. **Dwarfism:** The endocrine disorder dwarfism, also known as growth hormone deficiency dwarfism or pituitary dwarfism, is a condition caused by insufficient production of growth hormone by the pituitary gland. Dwarfism is a condition characterised by short stature, typically defined as an adult height of 4 feet 10 inches (147 centimetres) or shorter. Other symptoms of dwarfism include delayed growth, delayed puberty and a youthful appearance.
4. **Diabetes:** is characterised by high levels of glucose in the blood. It occurs due to either insufficient insulin production by the pancreas or the body's ineffective use of insulin. Insulin is a hormone produced by the pancreas, and it plays a crucial role in regulating blood glucose levels.
5. **Adrenal gland disorders**: Cushing's syndrome and Addison's Syndrome are both disorders caused by a dysfunction in the production and release of adrenal hormones.
    a. Cushing's syndrome is caused by an overactive adrenal gland secreting high amounts of cortisol. Some signs and symptoms include weight gain or fatty deposits in certain body areas, facial hair, fatigue, muscle weakness and high blood pressure. Some Cushing's patients may develop other health issues such as diabetes.
    b. Addison syndrome is caused by adrenal insufficiency which may be due to a diseased adrenal gland. Weight loss, poor appetite, nausea and vomiting, fatigue and darkening of skin are mostly seen in individuals with this syndrome.

Cushing's and Addisons's syndromes are primary adrenal disorders while secondary disorders may also be caused due to a malfunction in the hypothalamus-pituitary axis.

Pedagogical Exemplars

1. **Digital Learning:** Learners watch a video or listen to a PowerPoint presentation on the endocrine system, its function, defects and symptoms of its malfunctioning. Learners are to Note down their observations for further discussions with shy learners encouraged to lead these discussions. Also, the learners who may have difficulty during discussions should be supported with further explanations.
2. **Talk for Learning**: Learners brainstorm on how the body makes and releases hormones that control mood, development and growth; enumerate the functions of hormones (at least two each) that control mood, development and growth. Based on the previous discourse on the functions of hormones, learners suggest and discuss possible symptoms and characteristics of a patient with specified endocrine malfunction.

Key Assessment

Level 1 (Recall): List three symptoms associated with hyperthyroidism.

Level 2 (Conceptual understanding): Match the symptoms in Column A with the right endocrine disorder in Column B. Explain your answer by explaining how each symptom relates to the chosen disorder.

Column A: Symptoms	Column B: Possible Endocrine Disorders
Unexplained weight gain	Hypothyroidism
Excessive sweating	Hyperthyroidism
Feeling cold all the time	Adrenal gland disorder
Rapid heartbeat	Dwarfism
Mood swings and irritability	
Stunted growth	

Level 3 (Strategic reasoning): For each of the following clusters of symptoms, identify the potential endocrine system disorder and, the gland involved. Give reasons for your answers.

a. Short stature and delayed growth

b. Weight gain, fatigue and cold intolerance

c. Weight loss, rapid heartbeat and heat intolerance

Learning Task

Hangman Game

To reinforce learning, learners pair up and play this word game. Scan **QR Code 20** for an instruction video on how to play the game to guide learners. Learners may also watch the video to make the instructions clearer. Notes and guidelines for playing the game are as follows:

1. The words for the game could be examples of endocrine glands, endocrine disorders like gigantism and Addison's syndrome or symptoms and physical characteristics of endocrine system disorders for example fatigue, weight loss and darkened skin.
2. Learners are to correctly identify the given word and based on the category of the given word, he/she should mention the following as applied before their partners are "hanged";
    a. signs and symptoms associated with the disorder
    b. hormones released by the gland
    c. the possible disorders exhibiting the symptom or physical characteristic observed

This game can be repeated as many times with different pairs being formed each time. During the game learners who may need further explanations for some terms should be supported.

WEEK 12

Learning Indicator: Identify and discuss the causes, symptoms, treatments, effects and impact of diabetes on the human body and human lifestyle

Focal Area 1: Understanding Diabetes – The Concept of Diabetes, and the Different Types

Introduce the concept of diabetes

Diabetes is a disorder caused by a malfunction in the endocrine system affecting glucose regulation in our bodies. There are rare types of diabetes but two main types of diabetes known globally are Type 1 diabetes and Type 2 diabetes which are different conditions but both occur when there are high levels of glucose in the blood. When you do not have diabetes, the pancreas senses an increase in blood glucose levels and releases the right amount of insulin which helps glucose in the bloodstream to move to our cells to provide energy. In both types of diabetes, insulin produced by the pancreas is a key factor in glucose regulation.

Discussions on Type 1 and Type 2 diabetes and their underlying causes should focus on the following:

Type 1 Diabetes: This is an autoimmune disorder often diagnosed in childhood. Patients with this type of diabetes cannot make sufficient insulin. When any carbohydrate is eaten, it is broken down into glucose in our bloodstream for energy production. Insulin is needed to facilitate the uptake and storage of this glucose in the body. If there is insufficient insulin this leads to high blood glucose levels, which require lifelong management. There is no cure for Type 1 diabetes, but patients can inject insulin to regulate sugar levels. The underlying cause is still unknown but a family history of diabetes 1 may make one susceptible.

Type 2 Diabetes: This is considered a lifestyle disorder in which a patient produces insulin but it is not enough or does not work effectively to regulate the blood glucose levels when it is high. Even with a family history, an individual may prevent diabetes by checking their sugar intake (diet), exercising, having regular health check-ups and having a generally healthy lifestyle.

Note

There are cases of drug-induced diabetes which even after the medication is withdrawn, diabetes may be permanent

Focal Area 2: Symptoms of Diabetes

With both types of diabetes, there are several warning signs which when followed up may help in early detection and proper management of the disorder.

Discussions on the common symptoms of diabetes may focus on the following, emphasising the importance of early detection:

1. Extreme thirst accompanied by increased drinking due to frequent urination (polydipsia).
2. Fatigue and having low energy.
3. Frequent urination with increased urine volume (polyuria): because of high levels of glucose, the kidneys are unable to reabsorb all the glucose, so excess glucose enters the urine.
4. Unintended weight loss may occur in Type 2 diabetes. Proper insulin functioning is needed for fat/lipid formation and low levels of insulin lead to reduction in fat formation.
5. Longer time for wounds to heal.
6. Blurry vision occurs due to increased glucose levels which can cause swelling of the lens of the eye. Diabetic retinopathy (damage to the blood vessels of the retina) may occur when diabetes is poorly managed.
7. Increased infections happen with diabetic individuals because diabetes can sometimes inhibit the immune system
8. Extreme hunger: there is the tendency to consume more food than we need because of decreased insulin sensitivity, insulin-sensitive cells are not able to access glucose levels, leading to increased hunger.
9. Numbness and tingling sensation in the extremities due to damage to neurons caused by high glucose levels.

Focal Area 3: Treatments and Lifestyle Adjustments in Managing Diabetes

Highlight the importance of lifestyle changes in managing diabetes

Engaging in physical activity lowers blood sugar, which aids in diabetes management. Additionally, it reduces the risk of heart disease. It can also help reduce stress. The muscles use blood sugar as an energy source when you exercise and move around. Frequent exercise also improves the way the body uses insulin. This makes exercising crucial for diabetic care as well. Your blood sugar level is lowered by the combination of these factors.

Explore various treatment options for diabetes (example medication, insulin therapy)

There are several management and treatment strategies for both types of diabetes. Type 1 diabetes is usually treated with insulin administered throughout a patient's lifetime since little or no insulin is produced by the patient's pancreas. With some medication Type 2 diabetic patients may manage the condition. See Figure 25 for examples of treatment options for type 1 and 2 diabetes.

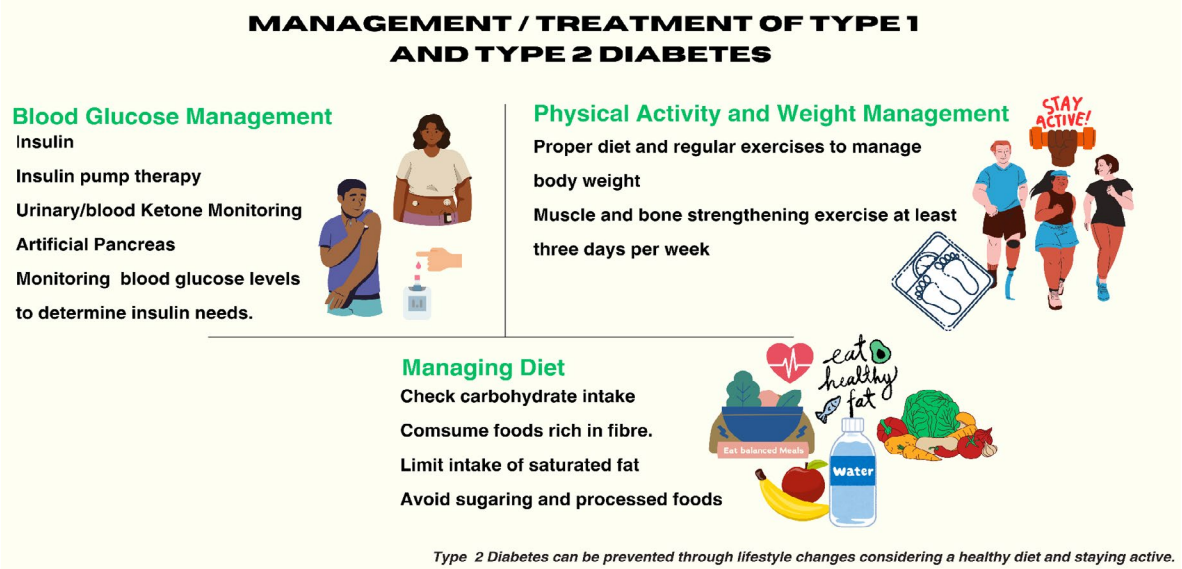


Figure 25: *Management and treatment of Type1 and Type 2 diabetes*

Focal Area 4: The Impact of Diabetes

Mention the long-term effects and complications of uncontrolled diabetes on various organs and systems in the body

Generally, individuals with diabetes suffer other health conditions if the condition is not well managed. Some of these long-term effects and complications occur even before detection and are managed with medication with patients advised to pick up healthier lifestyles to prevent further complications. Patients with diabetes either type 1 or type 2 with high levels of blood sugars, overtime, have problems with their eyes, feet, gums, heart and kidneys, and damage to blood vessels, which can lead to heart attack or, stroke. With the eyes individuals develop blurry vision, and numbness or tingling sensations in their extremities due to damage to some nerves.

Learning Task

The Sugar Maze

This activity increases learners' understanding of the impact of food choices on blood sugar levels.

1. Draw a maze on the floor or rearrange the classroom in the form of a maze.
2. Label different sections of the maze with food choices like candy, fruits, vegetables, whole grains (healthy & unhealthy foods).
3. Blindfold learners and have them navigate the maze.
4. As they go through the maze, have other learners determine and explain why the particular food choice reached is "good" or "bad" for controlling blood sugar levels.

Pedagogical Exemplars

1. **Managing Talk for Learning:** Guide learners through the diagnosis of diabetes using fasting blood sugar level values. Learners investigate the connection between insulin and blood glucose. Learners discuss and Note the causes, symptoms, treatment options and effect on lifestyle of diabetes.
2. **Experiential Learning:** Learners gather different types of vegetables, fruits, whole grains, meat and meat products. Learners apply their knowledge of the digestive system to state the digestive end-products of these foods. Guide learners in a discussion on the importance of understanding the choice of non-fat and lean meats and also limit the intake of foods that are high in sugar and fat.
3. **Activity-Based Learning:** Individually, learners create mind maps on diabetes, its causes, symptoms, prevention and treatment.

Key Assessment

Level 1 (Recall): Select the correct answer(s) for each question.

1. A significant risk factor for developing Type 2 diabetes is:
   a. genetics.
   b. lifestyle factors.
   c. taking drugs.
   d. viral infections.
2. Blurred vision can be a symptom of diabetes because of
   a. elevated blood pressure.
   b. damage to the blood vessels in the eyes.
   c. reduced insulin production.
   d. nerve damage
3. Diabetes occurs because the body does not produce enough
   a. enzymes.
   b. blood.
   c. insulin.
   e. sugar.

Level 2 (Conceptual understanding): Explain how genetics and lifestyle influence the development of Type 2 diabetes and give an example of how each factor can lead to the start of the disease.

Level 3 (Strategic reasoning): Examine the causes, symptoms, prevention, treatment of any of the two forms of diabetes and create a poster to share your findings with the class, highlighting the impact of the complication on the patient's quality of life.

Level 4 (Extended strategic thinking and reasoning): Project Work

Guide learners to form mixed gender/ability groups. In groups, learners carry out a project on creating a detailed awareness/campaign plan on diabetes. Learners should outline the following in developing the campaign:

1. Key messages about diabetes prevention, management, and complications.
2. Communication channels (for example, social media, print materials, workshops, community events).
3. Plan on implementing the campaign, including timelines, resources, and collaboration with other stakeholders.
4. Develop a presentation to communicate the campaign plan to a hypothetical audience (for example, healthcare providers, community leaders).

Each group should design visually appealing and informative (causes, symptoms and impact on lifestyle) posters on diabetes.

WEEK 13

Learning Indicator: Identify the structural differences between bacteria and viruses

Focal Area 1: Bacteria and Viruses – Microscopic Organisms That Can Cause Disease

Briefly discuss bacteria and viruses as microscopic organisms that can cause disease

Bacteria and viruses are microscopic organisms that can significantly impact health. Bacteria are single-celled living organisms, while many are beneficial, some can cause infections like tuberculosis, strep throat, pneumonia, or food poisoning. Antibiotics are typically used to combat bacterial infections. Viruses, on the other hand, are non-living infectious agents. Viruses are microscopic infectious agents that can only replicate inside the living cells of an organism. Common viral infections include the common cold, flu, HIV and hepatitis. Unlike bacteria, antibiotics are ineffective against viruses. Understanding their structure, replication, and interaction with hosts is crucial for developing effective treatments and preventive measures. The understanding of the differences between these microscopic adversaries is essential for effective diagnosis, appropriate treatment, and the prevention of infectious diseases they cause.

Compare and contrast the key structural differences between bacteria and viruses

Bacteria is a single-celled organism with a cell wall, cytoplasm, and genetic material (DNA). **See Figure 26.**

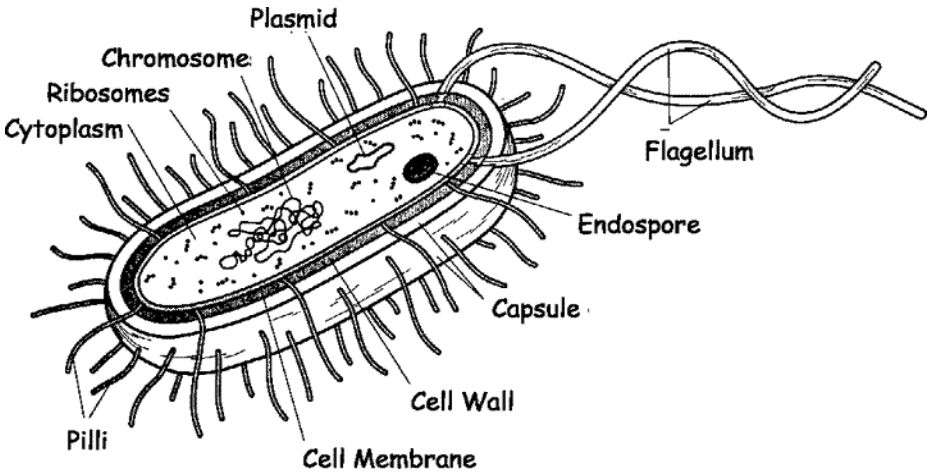


Figure 26: *Schematic Diagram of Bacterial Cell (Hiremath et al, 2012)*

Viruses are smaller than bacteria, lack a cell wall, and most of the cellular machinery. They are not considered living organisms as they cannot reproduce on their own. Instead, they invade living cells using the host's resources to multiply. Viruses can be enveloped (lentivirus) or non-enveloped (Adenovirus) (See Figure 27). See Table 2 for the summary on the differences between bacteria and viruses.

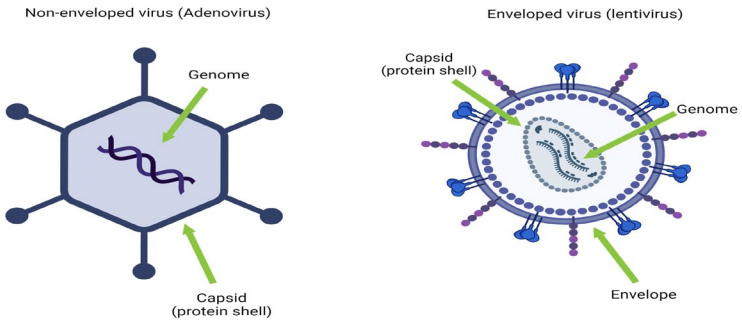


Figure 27: *Structure of Virus*

Table 2: Summary of the differences between bacteria and viruses

Feature	Bacteria	Virus
Nature and Structure	Living, single-celled, complex structure	Non-living, genetic material in a protein coat
Reproduction	Binary Fission, genetic exchange	Requires a host to replicate
Living condition	Wide range of environments	Only inside a host organism
Size	0.5 to 5 µm	20 to 30 nm
Antibiotic sensitivity	Yes	No
Examples of diseases	Tuberculosis, pneumonia, strep throat	Influenza, HIV/AIDS, COVID 19

Learning Task

1. Put learners into mixed-ability pairs and provide learners wordbox task sheets.
2. Give learners the rules of the game which may include the first team to find all words in the puzzle wins.
3. This exercise can continue till the last pair finds all the words. After the exercise, guide learners in a class discussion on what they learned about the structural differences between bacteria and viruses.

Scan **QR Codes 21 and 22** for examples of word box puzzles.

Pedagogical Exemplars

Project-Based Learning: Learners observe specimens of bacteria and viruses in pictures or a video, and document the structural differences between bacteria and virus. Learners present their findings to the class and receive feedback.

Key Assessment

Level 1 (Recall): group the following structural features under bacteria and viruses.

1. Cell wall
2. Capsid

3. Nucleus
4. Genetic material
5. Envelope
6. Ribosomes

Level 2 (Conceptual understanding): For each of the following statements, state whether they are true or false and give reason(s) for your answer.

1. Viruses are microscopic agents living in and out of a host.
2. Antibiotics can be used in the treatment of both bacterial and viral infections.

WEEK 14

Learning Indicator: Explore the symptoms, prevalence, and treatment of bacterial and viral infections considering infections of the reproductive system

Focal Area 1: Bacterial and Viral Infections of the Reproductive System

Bacterial and viral infections of the reproductive system can affect both males and females, leading to a range of symptoms and complications. These infections which are often referred to as Sexually Transmitted Infections (STIs) or Diseases (STDs) usually occur through sexual relations. An STI refers to the presence of an infectious agent in the body, such as bacteria or viruses, that can be transmitted through sexual contact whereas an STD refers to a disease that results from an STI when the infection leads to clinical symptoms or complications. For example, HIV is an STI while AIDS is the corresponding STD. Overview of some common bacterial and viral infections of the reproductive system are as follows:

Bacterial Infections of the Reproductive System

1. **Chlamydia**

   Causative agent: *Chlamydia trachomatis*

   Symptoms: Women: Often asymptomatic at the onset, abnormal vaginal discharge, burning sensation during urination and pelvic pain.

   Men: Discharge from the penis, burning sensation during urination, and testicular pain.

   Complication(s): Can lead to pelvic inflammatory disease (PID) in women, which can cause infertility. In men, it can lead to epididymitis. Epididymitis is an inflammation of the epididymis, a coiled tube at the back of the testicle that stores and carries sperm.

   Treatment: Antibiotics

2. **Gonorrhoea**

   Causative agent: *Neisseria gonorrhoeae.*
   Symptoms: Women: Often mild or asymptomatic, but can include increased vaginal discharge, painful urination, and bleeding between periods.
   Men: Burning sensation during urination, white, yellow, or green discharge from the penis, and painful or swollen testicles.

   Complication(s): Can cause PID in women, epididymitis in men, and can spread to the blood or joints.

   Treatment: Dual therapy with antibiotics

3. **Syphilis**

   Causative agent: *Treponema pallidum*

   Symptoms: Primary stage: Painless sores on the genitals, rectum, or mouth. Secondary stage: Skin rashes, mucous membrane lesions. Latent stage: No symptoms. Tertiary stage: Severe medical problems affecting the heart, brain, and other organs.

Complication(s): Can lead to serious systemic and potentially life-threatening complications if untreated.

Treatment: Antibiotics

4. **Bacterial Vaginosis**

   Causative agent: Overgrowth of normal vaginal bacteria
   Symptoms: Thin white or grey vaginal discharge with a fishy odour, itching, and burning during urination.
   Complication(s): Increased risk of acquiring STIs and complications during pregnancy.

   Treatment: Antibiotics

Viral Infections of the Reproductive System

1. **Human Papillomavirus (HPV)**

   Causative agent: Human papillomavirus.

   Symptoms: Often asymptomatic at the onset. Can cause genital warts and is associated with cervical, vulvar, vaginal, penile, anal, and oropharyngeal cancers.

   Complications: Can lead to various cancers.

   Prevention: HPV vaccine.

   Treatment: No cure for the virus itself, but treatments are available for the health problems that HPV can cause.

2. **Herpes Simplex Virus (HSV)**

   Causative agent: HSV-1 and HSV-2

   Symptoms: Painful blisters or sores on the genitals, rectum or mouth; flu-like symptoms during the initial outbreak.

   Complication(s): Recurring painful outbreaks, neonatal herpes in newborns.

   Treatment: Antiviral medications can manage symptoms and reduce outbreaks.

3. **Human Immunodeficiency Virus (HIV)**

   Causative agent: Human immunodeficiency virus

   Symptoms: Early stage (acute infection) can resemble flu-like symptoms. Chronic stage leads to weakening of the immune system.

   Complication(s): Progresses to acquired immunodeficiency syndrome (AIDS) if untreated.

   Treatment: Antiretroviral therapy (ART) to manage and control the virus.

4. **Hepatitis B and C**

   Causative agent: Hepatitis B virus (HBV) and Hepatitis C virus (HCV).
   Symptoms: Often asymptomatic. When present, symptoms include jaundice, fatigue, abdominal pain, loss of appetite, and nausea.
   Complication(s): Can lead to chronic liver disease, cirrhosis, and liver cancer.

   Treatment: Antiviral medications and, for Hepatitis B, a preventive vaccine is available.

Focal Area 2: Treatment Strategies for Bacterial and Viral Infections

Explore general treatment strategies for bacterial and viral infections

Treatment strategies for bacterial and viral infections differ significantly due to the distinct nature of bacteria and viruses. Discuss the general treatment approaches for each based on the following:

Treatment Strategies for Bacterial Infections

1. **Antibiotics**

   Mechanism: Antibiotics target specific bacterial processes such as cell wall synthesis, protein synthesis, DNA replication, or metabolic pathways. For example, Penicillin, a common antibiotic targets cell wall synthesis while tetracyclines inhibit protein synthesis.

2. **Combination therapy**

   This is used to treat infections caused by multiple bacteria or to prevent resistance. For example, combining amoxicillin with clavulanic acid for the treatment of Respiratory Tract Infection (RTI) and Urinary Tract Infection (UTI).

3. **Vaccination**

   Prevents bacterial infections such as tetanus, diphtheria, and bacterial meningitis. For example, DTaP vaccine for the prevention of diphtheria, tetanus and pertussis, and meningococcal vaccines for the prevention of meningitis.

Treatment Strategies for Viral Infections

1. **Antiviral medications**

   Mechanism: Target specific stages of the viral life cycle, such as entry, replication, assembly, or release of viral particles. For example, oseltamivir for influenza inhibits release of new viral particles.

2. **Vaccination**

   Prevents viral infections by inducing immunity. Examples include Influenza vaccine, HPV vaccine, hepatitis B vaccine, MMR vaccine (measles, mumps, rubella).

3. **Symptomatic treatment**

   Symptomatic treatment refers to medical care aimed at alleviating the symptoms of a disease or condition, rather than addressing the underlying cause. Symptomatic treatment such as analgesics and decongestants alleviates symptoms while the immune system clears the infection. For example, the use of acetaminophen for fever and pain and the use of nasal drops to clear nasal congestion provides relief from the symptoms.

4. **Combination therapy**

   Combination therapy such as the antiretroviral therapy uses multiple antiretroviral drugs to control HIV infection and prevent progression to AIDS.

Discuss the differences between bacterial and viral treatment

1. The use of antibiotics: antibiotics are effective against bacteria but not viruses. Misuse of antibiotics can lead to antibiotic resistance.
2. **Antiviral limitations:** antiviral drugs are often virus-specific and less commonly used than antibiotics due to the complexity of viral replication mechanisms.
3. **Vaccination:** both bacterial and viral infections can be prevented with vaccines, but the nature and type of vaccines differ.

Discuss prevention strategies for bacterial and viral infections based on the following

1. **Hygiene:** regular hand washing, safe food handling, and sanitising surfaces help prevent both bacterial and viral infections.
2. **Safe practices:** safe sex, avoiding sharing needles, and practising safe injection techniques.
3. **Public health measures:** quarantine, isolation, and travel restrictions during outbreaks to prevent spread.
4. **Education:** raising awareness about the importance of vaccination, proper antibiotic use, and infection prevention measures.

Learning Task

Bacteria and Virus Art Project

1. Put learners into mixed groups and let each group ballot for their specific reproduction system infection. For example, Chlamydia, HPV, HIV/AIDS. Learners research on their assigned infection(s) and create a visual representation (poster, model, digital artwork) of their assigned infection. Information on the visual representation should include the mode of transmission, symptoms and treatment options. Each group presents their work to the class followed by a whole class discussion on the presentation.

Pedagogical Exemplars

Collaborative Learning: With the aid of charts and resources, learners identify the commonalities between bacterial infections in terms of their symptoms and treatment. Learners share experiences on symptoms, prevalence and treatment of viral infections in groups. Scan QR Codes 23 in Additional Reading for a video on how antiviral medications work to support discussions.

1. **Digital Learning:** Learners research and develop a PowerPoint presentation on the treatment strategies of viral infections (for example, HPV and HIV) and bacterial infections (for example Chlamydia). If ICT tools are not available learners may use other presentation modes such as flipcharts.
2. **Project- Based Learning:** Learners in mixed-ability groups design and produce a public health campaign to educate peers about the infectious diseases considering bacteria and virus as causative agents on posters.

Key Assessment

Level 1 (Recall)

1. Mention at least two (2) examples each of bacterial and viral infections of the reproductive system.
2. What is the most common mode of transmission for bacterial and viral infections of the reproductive system?

Level 2 (Conceptual understanding): Differentiate between STIs and STDs.

Level 3 (Strategic reasoning): Describe the different ways in which chlamydia, a bacterial infection, affects the reproductive system.

Level 4 (Extended critical thinking and reasoning): Explain why antibiotics cannot be used in the treatment of viral infections.

WEEK 15

Learning Indicator: Explore the immune response in relation to the introduction of antigens

Focal Area 1: The Body's Defence System – The Immune System

Discuss the immune system as the body's natural defence against pathogens

The immune system is a complex network of cells, tissues, and organs that work together to defend the body against harmful microorganisms, such as bacteria, viruses, fungi, and their toxins. It also plays a role in identifying and destroying abnormal cells, such as cancer cells. Naturally the presence of foreign invaders activates the immune system. These foreign invaders include disease-causing pathogens such as bacteria, viruses, fungi, and their toxins. The immune system is made up of different organs, cells, and proteins that work together. The organs that are important for the proper functioning of the immune system include thymus, bone marrow, lymph nodes and vessels, spleen and the skin (See Figure 28). The immune system is highly organised and efficient in protecting the body against infections and diseases. It involves a complex interplay of various cells, tissues, and molecules that work together to recognize, respond to, and remember pathogens. A pathogen is any organism or infectious agent that can cause disease in its host. Understanding the immune system's components and functions is crucial for developing vaccines, therapies, and strategies to combat infectious diseases and immune-related disorders.

The immune system is divided into two main types: innate immunity and adaptive immunity. These two systems work together to defend the body against pathogens and maintain overall health.

1. **Innate immunity:** this is the body's first line of defence against pathogens. It is non-specific, meaning it responds to a wide range of pathogens in the same way, and it is present from birth. Examples include;
    a. **First line of defence:** This is made up of physical and chemical barriers like skin, mucous membranes, and stomach acid.
    b. **Second line of defence:** These are non-specific responses to pathogens that breach the first line of defence. An example is inflammation (Example redness, heat, swelling, and pain) that occur at the site of infection or injury. Inflammation helps isolate and eliminate pathogens and initiates tissue repair.
2. **Adaptive immunity:** this is a specific defence mechanism that develops over time and involves the activation of specific lymphocytes to target particular pathogens. It has memory, allowing for a quicker and stronger response upon re-exposure to the same pathogen. Adaptive immunity exhibits specificity and memory, that is it targets specific pathogens and retains a memory of them for faster response upon future exposure.

Discuss the Immune Response Process

The immune response process is the sequence of events that occur in the body to recognize, attack, and eliminate pathogens. This process involves both the innate and adaptive immune systems working in coordination. The immune response process includes recognition, activation, response and memory.

1. **Recognition:** Pathogens are recognized by innate immune cells. Antigens are recognized by specific receptors in the adaptive immune system. These antigens are substances that the immune system recognizes as foreign or non-self, which can trigger an immune response.
2. **Activation:** Phagocytes engulf pathogens and present their antigens on their surface initiating adaptive immune responses. Helper T cells activate B cells and cytotoxic T cells through cytokine release. B cells differentiate into plasma cells to produce antibodies.
3. **Response:** Antibodies bind to pathogens, neutralising them or marking them for destruction by phagocytes. Cytotoxic T cells directly kill infected or abnormal cells. Cytokines and other inflammatory mediators increase blood flow and recruit more immune cells to the site of infection.
4. **Memory:** Memory B cells and T cells remain in the body after the infection is cleared, providing rapid and robust responses to future exposures to the same pathogen.

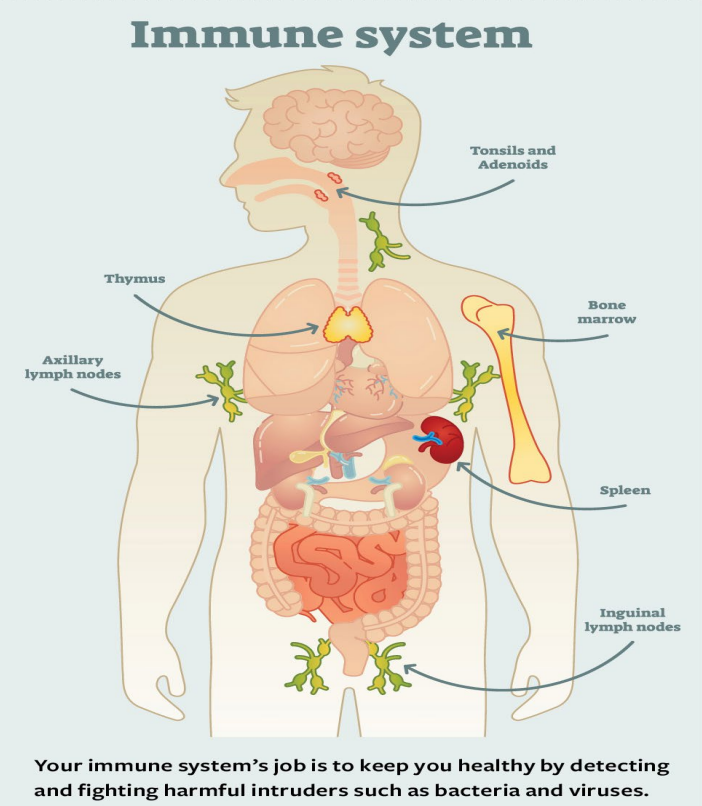


Figure 28: *The immune system*

Focal Area 2: Antigens and the Immune System

Explain the concept of antigens

Antigens are molecules on the surface of pathogens that the immune system recognises as foreign or non-self, which can trigger an immune response. Antigens act as markers that tell your immune system whether something in your body is harmful or not. The term "antigen" is derived from "antibody generator," reflecting their role in inducing the production of antibodies. Antigens are crucial components in the immune system's ability to recognize and respond to foreign substances. Antigens are found on viruses, bacteria, tumours and normal cells of your body. Antigen testing is done to diagnose viral infections, monitor and screen for certain conditions. They can originate from pathogens, environmental sources, or even the body's own tissues in the case of autoimmune diseases. The ability of the immune system to recognize and respond to antigens is essential for protecting the body from infections and diseases.

Explore how the immune system mounts a response against these antigens

Each antigen has a unique shape that your immune system reads like a nametag to know whether it belongs in your body. Your immune cells make antibodies to recognize and destroy harmful antigens. In fact, you can think of antigens as antibody generators. Your body defends itself against harmful antigens with chemicals called antibodies. Antibodies are very specific to the antigens they recognize and destroy. They fit onto the antigen like a key to a lock. When an antigen enters your body, the cells of your immune system inspect it. These cells have special parts (receptors) that test the antigen to see if they fit together, like a lock and key. If it is a fit, the immune cells make chemicals (antibodies) that all have the same shape to recognize the antigen. An antibody's job is to find antigens that fit the specific shape on their surface. Antibodies lock on (bind) to antigens so that the immune system can destroy them.

Once your immune system has seen an antigen, it has special cells that remember it, allowing your body to create a faster and more effective response if it invades again — this is called immunological memory. Unfortunately, antigens change shape when a harmful substance changes shape (mutates), and your immune system may not be able to lock onto it to defend itself effectively anymore. Imagine what would happen if the locks on your house changed every time you left home! Scan QR code 24 in additional reading to watch a video on how antigens and antibodies work.

Learning Task

1. **Antigen-antibody matching game**

   The objective of this activity is to reinforce the concept of specificity in antigen-antibody interactions. Materials needed are cards with pictures or descriptions of different antigens and antibodies.

   Create a deck of cards with shapes and colours indicating binding sites of different antigens and their corresponding antibodies. Have learners work in pairs or mixed groups to match each antigen with its specific antibody. Learners in their groups discuss why certain antibodies only bind to specific antigens, then present their findings to the class.

2. **Role-playing simulation**

   The objective of this role-play is to reinforce learning of the immune response process and the role of antigens and antibodies. Role cards, props (example, hats or signs) can be used to identify different roles such as antibodies, antigens, innate immunity, adaptive immunity and pathogens. Assign learners to the different roles in the immune system. Create a scenario where a pathogen enters the body, and learners act out the immune response, showing how antigens are recognised, and antibodies are produced and used to neutralise the pathogen.

Pedagogical Exemplars

1. **Managing Talk for Learning:** Teacher leads a class discussion on ways learners think the body responds to the invasion of foreign and harmful materials. Learners engage in a discussion on the immune response and the meaning of the term "antigens". Also discuss the basics of antigens and antibodies.

2. **Activity-Based Learning:** Learners work in groups and create models of antigens and antibodies (See Figure 29) using clay, cardboard or other locally available materials. They are to indicate the ligands and receptors and demonstrate the fit between the binding site and the ligand. Learners explain the interaction(s) between antigens and antibodies and also discuss the importance of shape in binding specificity. This activity is to help learners understand the structural relationship between antigens and antibodies as well as their binding specificity.

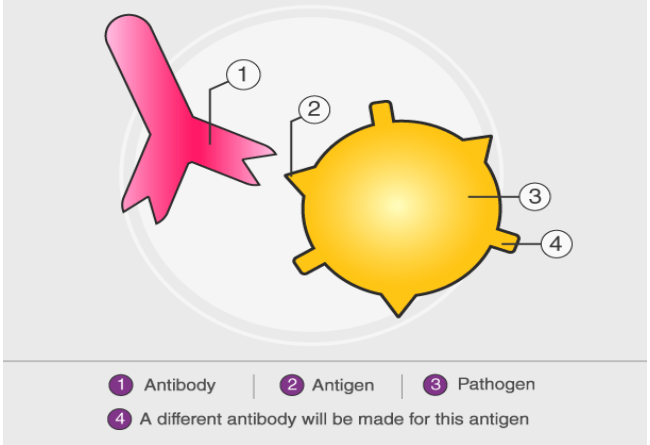


Figure 29: *Example of antibody-antigen structure*

Key Assessment

Level 1 (Recall): What are antigens and antibodies?

Level 2 (Conceptual understanding): How are antigens and antibodies related?

Level 4 (Extended critical thinking and reasoning): How does the specificity of the antibody-antigen relationship influence the effectiveness of the immune response against different mutations of a virus?

WEEK 16

Learning Indicator: Analyse how antibiotics are used to treat infections and explain how effectiveness depends on the causative bacteria

Focal Area 1: Explore How Antibiotics Work in Fighting Bacterial Infections

Antibiotics are drugs that are used to kill bacteria or inhibit their growth. They achieve this by targeting specific structures or functions that are essential for bacterial survival but are either absent or significantly different in human cells. This selectivity allows antibiotics to target bacterial cells without harming human cells. Examples of how antibiotics work by targeting specific bacterial mechanisms are discussed:

1. **Inhibition of cell wall synthesis:** Bacteria have a unique cell wall which provides structural integrity and protection. Antibiotics that inhibit cell wall synthesis interfere with the production of the cell walls leading to weakened cell walls and consequently cell death (lysis). For example, penicillin (example amoxicillin) inhibits enzymes (penicillin-binding proteins) involved in the final steps of the formation of cell walls.
2. **Disruption of cell membrane function:** Some antibiotics disrupt the bacterial cell membrane, causing loss of membrane integrity, leakage of cellular contents, and cell death. These antibiotics are less selective and can be more toxic to human cells.
3. **Inhibition of protein synthesis:** Protein synthesis (building of proteins) is essential for bacterial growth and function. Antibiotics can target bacterial ribosomes, which are structurally different from human ribosomes. These antibiotics inhibit various steps necessary for building up proteins and thereby, preventing the synthesis of essential proteins.
4. **Inhibition of metabolic pathways:** Some antibiotics interfere with bacterial metabolic pathways that are essential for survival but are absent or different in human cells. These antibiotics often target the synthesis of folic acid, a vitamin required for DNA and RNA synthesis.

Explore how the effectiveness of antibiotics depends on the causative bacteria

The effectiveness of antibiotics is closely tied to the specific characteristics and mechanisms of the bacteria causing the infection. The effectiveness of antibiotics depends on the interplay between the mode of action of the antibiotic and the biological characteristics of the causative bacteria. For instance, antibiotics work by targeting specific bacterial structures or functions, such as cell wall synthesis, protein synthesis, nucleic acid synthesis, and metabolic pathways. The effectiveness of an antibiotic depends on whether the bacteria possess the specific target that the antibiotic can act upon. Also, some bacteria naturally lack the target that an antibiotic affect, making them inherently resistant. For example, some bacteria species lack cell walls and are therefore resistant to antibiotics which target cell wall synthesis.

The effectiveness of antibiotics depends on several factors, including the type of bacteria causing the infection, the mode of action of the antibiotics, the presence of resistance mechanisms, the site of infection, and patient-specific factors. The effectiveness of antibiotics is influenced by a complex interplay of factors related to the bacteria, the antibiotic, the infection site, and the patient. Optimal antibiotic therapy requires careful consideration of these factors, often guided by microbiological laboratory testing and clinical judgement, to achieve the best outcomes while minimising the risk of resistance.

Focal Area 2: What is Antibiotic Resistance?

The Concept of Antibiotic Resistance

Antibiotic resistance is a phenomenon where bacteria develop mechanisms to resist the effects of antibiotics, making infections harder to treat. It occurs when bacteria evolve and develop the ability to defeat the drugs designed to kill them. This can lead to infections that are harder to treat and can result in increased medical costs, prolonged hospital stays, and higher mortality rates.

Causes of Antibiotic Resistance

Antibiotic resistance can lead to infections that are more difficult to treat and can increase the risk of severe illness or death. The causes of antibiotic resistance are multifaceted and include the following:

1. **Overuse of antibiotics:** Excessive use of antibiotics accelerates the emergence of resistant bacteria. Using leftover antibiotics or obtaining antibiotics without a prescription will lead to inappropriate use and contribute to resistance.
2. **Misuse of antibiotics:** Incorrectly prescribed antibiotics, such as using them for viral infections or not completing the prescribed course, contribute to resistance. Antibiotics are often prescribed for viral infections (example, colds, flu) where they are ineffective. This misuse creates selective pressure on bacteria to develop resistance. Patients not completing prescribed antibiotic courses can leave surviving bacteria that are more likely to develop resistance.
3. **Poor infection control:** Inadequate infection control measures in healthcare settings can spread resistant bacteria. Failure to implement proper hygiene and sanitation practices can spread resistant bacteria between patients and healthcare workers.
4. **Lack of new antibiotics:** There has been a decline in the development of new antibiotics, making it harder to combat resistant bacteria. The slow pace of development of new antibiotics means that the arsenal of effective drugs is limited. Meanwhile, bacteria continue to evolve and acquire resistance to existing antibiotics.

Consequences of Antibiotic Resistance

1. **Treatment challenges:** Resistant infections require alternative and often more expensive treatments, which may be less effective and have more side effects.
2. **Increased mortality:** Antibiotic-resistant infections can lead to higher death rates.
3. **Economic impact:** Resistance leads to longer hospital stays and the need for more intensive care, increasing healthcare costs.

Learning Task

Consider implementing at least one of the following learning tasks to reinforce understanding and knowledge acquisition among learners.

1. Learners watch a video that depicts how antibiotics work. After watching the video, learners discuss the following questions
   a. What antibiotics are
   b. How antibiotics are able to treat bacterial infections
   c. Importance of completing the full course of antibiotics.

   This can be done as a whole-class discussion or small group brainstorming.
2. Reinforce learning through a take-home assignment. Assign learners to research on a specific antibiotic, its uses, how it works, and any known resistance issues. They should present their findings in a short report or presentation.

Pedagogical Exemplars

Experiential Learning: Using pictures, charts or videos, the teacher guides the class to brainstorm the mechanisms of antibiotic action in killing of bacteria cells or prevention of bacterial multiplication. Learners should discuss the dependence of the efficacy of an antibiotic in relation to the bacteria type and characteristics.

Key Assessment

Level 1 (Recall): What are antibiotics and which type of microorganism do they target?

Level 2 (Conceptual understanding): List and explain how antibiotics work to treat bacterial infections.

Level 4 (Critical thinking and reasoning): A patient experiences persistent infection despite treatment with different types of antibiotics. What might be causing this? Explain the factors that may contribute to the resistance of the antibiotics.

WEEK 17

Learning Indicator: Discuss the global and social impact of infectious diseases caused by bacteria and viruses

Focal Area 1: Global and Social Impact and Control of Some Common Infectious Diseases

Global prevalence, social impact on individuals and communities, and ongoing efforts to control or eradicate the disease

Infectious diseases have life-long effects on not just affected individuals but the global community. Infectious diseases are known to mostly affect developing countries and are the largest contributor to deaths recorded annually worldwide as an effect of globalisation on health. For example, TB disproportionately affects low- and middle-income countries, causing significant economic strain due to healthcare costs and loss of productivity.

Tuberculosis, a bacterial infection, and COVID-19, a viral disease, are prime examples of infectious diseases that are rapidly spreading across borders and causing substantial health and economic challenges. Further discussions on these infectious diseases may focus on the following:

1. **Tuberculosis**
    a. **Causative agent:** Tuberculosis (TB), is air-borne transmissible disease caused by bacteria (*Mycobacterium tuberculosis*) and it most often affects the lungs.
    b. **Mode of transmission:** When an infected person coughs, sneezes or spits, airborne droplets may be inhaled by uninfected individuals leading to the spread of TB. Even though it is preventable and treatable, it remains a serious global health challenge.
    c. **Signs and symptoms:** Individuals with latent TB infections may not feel sick and have symptoms. A person with active TB will have symptoms that will be mild for many months, spreading easily to others without knowing it. Common symptoms of TB:
        i. prolonged cough (sometimes with blood)
        ii. chest pain
        iii. weakness and fatigue
        iv. weight loss
        v. fever
        vi. night sweats

        The symptoms people get depend on where in the body TB becomes active. While TB usually affects the lungs, it also affects the kidneys, brain, spine and skin.
    d. **Global prevalence:** In 2022, an estimated 10.6 million people fell ill with TB worldwide, including 5.8 million men, 3.5 million women and 1.3 million children. TB is present in all countries and age groups. According to the WHO Global Tuberculosis Report in 2023, 192 countries and areas (out of 215) with more than 99% of the world's population reported TB cases (WHO, 2023).

e. **Disease control:** TB is curable and preventable. There has been a continuous and conscious effort in educating the population on the signs and symptoms and prevention of the infection. Vaccines such as neonatal BCG administered to newborn babies a few hours after birth, offers partial protection for infants and young children against severe forms of TB, but it does not protect adolescents and adults, who account for the majority of TB transmission. Visiting the nearest health centre when any of the signs and symptoms of a TB manifest also contributes largely to the prevention of spread of infection.

2. **COVID-19**

a. **Causative agent:** COVID-19 is a highly contagious disease caused by the novel coronavirus SARS-CoV-2. It emerged in late 2019 and rapidly spread globally, leading to a pandemic. The disease primarily affects the respiratory system but can also impact other parts of the body. Usually as viruses spread between people, over time they tend to change and evolve. Since late in 2021, new strains/variants of coronavirus such as Omicron, with slightly different genetic material and structure have emerged.

b. **Mode of transmission:** The virus can spread from infected individuals to other people, even if they do not exhibit symptoms. There are several modes of transmission mentioned below.

i. The majority of the virus transmission occurs between individuals who are in close proximity to one another, such as during a conversation. When an infected person coughs, sneezes, speaks, or breathes, tiny liquid particles from their mouth or nose can spread the virus.

ii. In crowded, poorly ventilated indoor environments where people frequently spend longer periods of time, the virus can spread. This is because aerosols/air droplets can remain suspended in the air or travel farther than conversational distance.

iii. People may also become infected when touching their eyes, nose or mouth after touching surfaces or objects that have been contaminated by the virus.

c. **Signs and symptoms:** Individuals with Covid-19 may experience different symptoms. Symptoms usually begin 5–6 days after exposure to the virus and last 1–14 days. The most common symptoms are:

i. fever

ii. chills

iii. sore throat

iv. runny or blocked nose, or sneezing

Less common symptoms are:

i. muscle aches and heavy arms or legs

ii. severe fatigue or tiredness

iii. headache

iv. sore eyes

v. dizziness

vi. shortness of breath and tightness in the chest

d. **Global prevalence:** The virus spread rapidly across the globe, leading to a pandemic that has affected nearly every country. The prevalence of COVID-19 has varied over time and across different regions due to factors such as population density, healthcare infrastructure, public health policies, and vaccination rates. The global prevalence of COVID-19 continues to evolve with the emergence of new variants and ongoing vaccination efforts. According to the World Health Organisation, as of July 2023, over 750 million cases have been confirmed with over 7 million deaths (WHO, 2023).

e. **Disease control:** Effective control of COVID-19 requires a multifaceted approach that includes widespread vaccination, non-pharmaceutical interventions, robust testing and surveillance, efficient healthcare management, clear public health communication, and international cooperation.

Global and Social Impact of Bacteria (Tuberculosis) And Viral (COVID-19) Infections on Individuals and Communities

Infectious diseases can lock people into poverty, undermine the resilience of communities, and have devastating consequences for a country's economy. Infectious diseases caused by bacteria and viruses can have profound global and social impacts, affecting various aspects of life and society. Apart from these bacterial and viral infections having serious health effects, they significantly impact the social well-being of individuals and the world at large. Understanding these impacts is very important to biomedical science study. Some of the social and global impacts includes:

1. **Global impact**

   a. **Public health crises:** Infectious diseases can lead to widespread outbreaks or pandemics, straining public health systems and overwhelming healthcare resources. Examples include the COVID-19 pandemic, the H1N1 influenza pandemic, and historical pandemics like the Black Death which occurred in the 14th century and resulted in the deaths of an estimated 25-30 million people in Europe, about one-third of the continent's population at the time.

   b. **Economic consequences:** The economic impact of infectious diseases can be severe, including healthcare costs for treatment and prevention, loss of productivity due to illness, and economic disruptions caused by travel restrictions and lockdowns. For instance, the COVID-19 pandemic led to significant global economic downturns and job losses. For example, managing HIV/AIDS and treating TB is time consuming and also expensive. These diseases may cause the individual to stop work which leads to financial instability and poverty.

   c. **Global trade and travel:** Outbreaks can disrupt global trade and travel. Countries may impose travel bans, quarantine measures, and trade restrictions, which can have cascading effects on global supply chains and economies.

   d. **Research and development:** The need to combat infectious diseases drives research and development in medicine and public health. This includes the development of vaccines, treatments, and diagnostic tools, which can lead to scientific advancements but also requires substantial investment.

   e. **International collaboration:** Pandemics often necessitate international cooperation for effective response, including sharing information, resources, and strategies. Organisations like the World Health Organization (WHO) play a crucial role in coordinating global efforts.

2. **Social Impact**
    a. **Stigmatisation and social isolation:** Due to the infectious nature of the disease, people are often condemned and treated with disrespect in places they find themselves which may lead to them isolating themselves. Outbreaks of infectious diseases can lead to stigma and discrimination against affected individuals or communities. This can worsen social isolation and hinder effective public health responses.
    b. **Impact on daily life:** Infectious diseases can disrupt daily life, including education, work, and social activities. Schools may close, workplaces may adopt remote working arrangements, and social gatherings may be restricted. Learners infected with TB or HIV/AIDS are often absent from school which greatly affects their academics and future opportunities.
    c. **Psychological effect:** The stress and uncertainty associated with infectious disease outbreaks can have significant mental health impacts. Anxiety, depression, and other mental health issues can increase during pandemics and outbreaks. Again, the chronic nature and extended treatment and management duration for infectious diseases such as TB leads to fear, anxiety and sometimes depression. People with HIV/AIDS and TB for instance, lose their self- esteem due to physical changes such as weight loss.
    d. **Pressure on healthcare facilities:** The treatment and management of infectious diseases puts pressure on healthcare facilities and delivery. This makes it difficult to provide adequate healthcare for all patients. Infectious diseases can worsen existing health disparities. Vulnerable populations, including those in low-income settings, may face higher rates of infection and poorer health outcomes due to limited access to healthcare.
    e. **Community resilience and solidarity:** Conversely, outbreaks can also foster community resilience and solidarity. Communities often come together to support those affected, promote public health measures, and contribute to recovery efforts. Again, major outbreaks can lead to long-term changes in social norms and behaviours, such as increased emphasis on hygiene, changes in healthcare practices, and shifts in public policy.

Learning Task

Learners research and present on the global and social impact of a selected infectious disease. Put learners into small groups and assign each group a bacterial or viral infectious disease (e.g., tuberculosis, influenza, COVID-19, HIV/AIDS). The research should include information on the symptoms, transmission, prevention and the global and social impact.

Pedagogical Exemplars

1. **Digital Learning:** Guide learners in groups to research on the social and global impact of infectious diseases (for example HIV/AIDS) using available resources, and present their findings to the class. Learners may choose any mode of presentation. Encourage shy learners to lead presentations.
2. **Project-based Learning**: In groups, learners research on historical and recent outbreaks (example, COVID-19, Ebola, Tuberculosis, HIV/AIDS), their global and social impacts and deduce practical strategies and solutions to address these impacts. Learners then design and produce a poster on the impact of their chosen infectious disease and propose practical strategies and solutions for presentation to the class. Learners embrace diversity and tolerate the views of others as they work together to produce their poster.

Key Assessment

Level 1 (Recall): List two common bacterial and two common viral diseases that have significant global impact.

Level 2 (Conceptual understanding): Explain how infectious diseases such as Covid-19 and tuberculosis can lead to social stigma and discrimination within a community.

Level 3 (Strategic reasoning): Suggest two strategies to reduce the social stigma surrounding an infectious disease (example tuberculosis, COVID 19, HIV/AIDS) in a community. Describe how these strategies could change community perceptions and offer support to those living with the disease.

SECTION 4 REVIEW

This section is for review of all the lessons taught for the last seven weeks. A summary of what should have been taught and what each learner should have learnt if differentiation has been successful.

1. Explain how major nervous system disorders impact quality of life.
2. Interpret the symptoms and physical characteristics of a given patient to determine an endocrine system malfunction (for example, Hyperthyroidism).
3. Identify and discuss the causes, symptoms, treatments, effects and impact of diabetes on the human body and human lifestyle.
4. Identify the structural differences between bacteria and viruses.
5. Explore the systems, prevalence, and treatment of bacterial and viral infections considering infections of the reproductive system.
6. Explore the immune response in relation to the introduction of antigens.
7. Analyse how antibiotics are used to treat infections and explain how effectiveness depends on the causative bacterium.

Major disorders of the nervous and endocrine systems significantly impair quality of life by affecting mobility, cognition, and emotional well-being. This section explores how endocrine malfunctions, such as hyperthyroidism, can be identified through symptoms like weight loss and anxiety as well as how issues with insulin can cause diabetes with its profound effects on health and lifestyle. Structural differences between bacteria, which are single-celled organisms, and viruses, which rely on host cells for replication is also explored as well as bacterial and viral infections, particularly in the reproductive system, their symptoms and appropriate treatment protocols. Finally, the variation in the effectiveness of antibiotics based on the specific bacteria involved is analysed, highlighting the importance of targeted treatments to combat resistance.

Additional Reading

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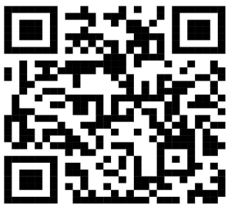

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APPENDIX D: END OF FIRST SEMESTER EXAMINATION

Examination will cover focal areas covered in table of specification such as week 1-12 for semester 1.

a. Paper 1: 50 items (MCQs).

b. Paper 2: 4questions for PART A and PART B

i. Part A: 1 compulsory question

ii. Part B: 3 questions

Learners answer only 2 questions in part B and a one (1) compulsory question in part A

Resources: Printer, A4 sheets, A large exam room, answer booklets, stationary, timers; for e-Assessment, consider a stable internet, computer, or tablet as well, etc.

Duration: 2hours for both paper 1 and 2

Marking Scheme/Rubrics

i. MCQs: 1 mark for each correct key. Total marks: 50marks

ii. Essay type question: 20 marks for Part A and 30marks for Part B (15marks per question)

Task sample

Paper 1: [50 marks]

This paper consists of 50 items. Answer all questions. Each item is followed by four alternatives, A-D. Read each item carefully and select the **best choice** that bears the correct answer.

1. A true statement about nervous system disorders is that
   A. autism and Alzheimer's disease are both classified as the same type of disorder.
   B. conditions like Parkinson's disease and Multiple Sclerosis only affect physical abilities.
   C. damage to the Broca's area of the frontal lobe affects our ability to communicate.
   D. stroke can only occur due to a direct physical injury to the brain and heart.
2. Electroencephalogram (EEG) measures brain activity by
   A. injecting contrast agents to highlight blood flow throughout the brain.
   B. recording electrical activity from neurons using electrodes placed on the scalp.
   C. taking high-resolution images of the brain's anatomy using X-rays with electrodes.
   D. using magnetic fields to visualize brain structures using electrodes on the skin.

Paper 2 [50marks]

This paper consists of two sections, A and B. Answer all the questions in section A and any other two from section B. Award will be given to clarity of expression.

Section A: Compulsory question [20marks]

1. Read the case scenario below and use it to answer the questions that follow:

Sarah is a 35-year-old woman who has been feeling unusually fatigued and has noticed an increase in her thirst and urination. After a visit to her healthcare provider, she is diagnosed with type 2 diabetes mellitus. Her doctor explains that her body is not using insulin effectively, leading to elevated blood glucose levels. Sarah learns that this condition can result in various complications if not managed properly.

As part of her treatment plan, Sarah is recommended to check her blood sugar levels, follow a specific diet, and engage in regular physical activity. She discovered that lifestyle changes can improve her insulin sensitivity and help regulate her hormone levels, which is crucial for controlling blood sugar and preventing complications.

During her follow-up visit, her doctor discusses the importance of hormonal balance in managing diabetes and how disruptions in insulin signalling can lead to health issues like neuropathy and cardiovascular disease.

a. State the symptoms that prompted Sarah to seek medical advice. How do these symptoms connect to her diagnosis of type 2 diabetes mellitus?

b. Explain the specific treatment recommendations provided by Sarah's doctor. How are these recommendations intended to help manage her diabetes?

c. Discuss the potential complications associated with poorly managed diabetes that Sarah learned about. How might these complications affect her overall health?

d. Analyse how Sarah's lifestyle changes can influence her hormone levels and overall metabolic health.

Section B: [30marks]

Answer only two questions from this part.

2. Explain the correct sequence and technique for putting on (donning) personal protective equipment (PPE). In your response, include three types of PPE and describe why proper usage is important in preventing the spread of infections or injuries.
[15marks]

Marking Scheme/Rubrics

iii. MCQs: 1 mark for each option. Total marks: 50marks

iv. Essay type question: 20 marks for Part A and 30marks for Part B (15marks per question)

TABLE OF SPECIFICATIONS FOR END OF SEMESTER 1 EXAMINATION

Week	Focal Area	Type of Question	Depth of Knowledge				
			L1	L2	L3	L4	Total
1	Biomedical Science careers focusing on preventing, diagnosing and treating diseases.	Multiple choice	1	1	1		3
2	How is biomedical science used in forensics?	Multiple choice	1	1			2
3	Clinical and research careers in biomedical science. Explore a chosen clinical or research field	Multiple choice Multiple choice Essay type	1	 1 1	1 1		2 2 1
4	The importance of knowledge of biosafety levels in the laboratory. General biosafety principles that apply in all laboratories, regardless of level.	Multiple choice Multiple choice	1 1	1 1	1		3 2
5	What is a Biosafety Cabinet (BSC)? Proper setup procedures for the BSC and its surrounding environment. Discuss the sequence and technique for proper donning and appropriate use of personal protective equipment (PPE) Discuss the safe removal of PPE to minimise contamination risk.	Multiple choice Multiple choice Multiple choice Multiple choice Essay type	1 1 1 1	1 1 1 1	 1		2 2 2 2 1
6	What is the role of the brain as the central processing unit of the communication system?	Multiple choice	1	1	1		3
7	The concept of brain mapping and its role in understanding communication pathways.	Multiple choice		1	1		2
8	Explain the basic flow of communication in the body. How do disruptions in communication lead to various health issues?	Multiple choice Multiple choice	1	1 1	 1		2 2

9	*Technological tools used in Biomedical Sciences to assess communication within the human body.*	*Multiple choice* *Essay type*	*1* *1*	*1*	*1*		*3* *1*
10	*Explore how various nervous system disorders can impact a person's quality of life.* *Real-life examples of people living with nervous system disorders*	*Multiple choice* *Multiple choice*		*1* *1*	*2* *1*		*3* *2*
11	*The role of the endocrine system in regulating various bodily functions* *Symptoms and physical characteristics of endocrine system malfunction*	*Multiple choice* *Multiple choice*	 *1*	*1* *1*	*1* *1*		*2* *3*
12	*Understanding Diabetes – The concept of diabetes, and the different types.* *Symptoms of Diabetes.* *Treatments and lifestyle adjustments in managing diabetes.* *The Impact of Diabetes*	*Multiple choice* *Multiple choice* *Multiple choice* *Multiple choice* *Essay type*	 *1* *1*	*1* *1* *1*	*1* *1*		*2* *1* *2* *1* *1*
Total		***Multiple choice*** ***Essay type***	***15*** ***1***	***20*** ***2***	***15*** ***1***		***50*** ***4***

APPENDIX E: INDIVIDUAL PROJECT

Individual project should be given to learners in week 13. Final submission of the individual project should be by the 20th week of the academic year.

Steps to Assign Individual Project

Choose a topic: Provide a list of approved biomedical topics (e.g., diagnostic and therapeutic devices, vaccine development, prosthetics and orthotics) or allow learners to propose their own, ensuring alignment with curriculum goals.

- Set guidelines and learning outcome: Outline project requirements (length, format, deadlines) and explain the learning goals. Emphasize the importance of incorporating cross-cutting issues, such as:
- Ethical considerations: Discuss ethical implications of biomedical advancements.
- Health equity: Explore how biomedical innovations impact different communities.
- Sustainability: Consider the environmental impact of biomedical practices.

Research and resources: Guide learners in identifying credible research materials (books, articles, websites) related to their topics and cross-cutting issues.

Regular checkpoints: Schedule brief check-ins to discuss progress, encourage the integration of cross-cutting issues, and provide support, addressing any questions.

***Final submission and reflection*:** Discuss with learners how and when to submit projects. Have learners write a short reflection on their experience, including how they addressed cross-cutting issues and what they learned about their topic.

Assessment criteria: Share the rubric or criteria you will use to assess the project with the groups.

Reflection: Have learners complete a reflection on their experience, discussing what they learned, and the challenges faced. Give feedback by commending them for completing their project work, specify the areas that went well and areas needing improvement, etc.

Task example

Project Topic: Treatment Modalities for Cancer Patients

Research and describe the different treatment modalities available to cancer patients, including examples of how some of these modalities can be paired for effective treatment.

Project outline

1. **Research Phase:** Investigate various treatment modalities used in cancer care, such as: Surgery, Chemotherapy, Radiation Therapy, Immunotherapy, Targeted Therapy, Hormone Therapy.
2. **Pairing modalities:** Identify and explain how certain modalities can be combined to enhance treatment effectiveness.
3. **Written report:** Prepare a report (2-3 pages) that includes:
   a. An introduction to cancer treatment modalities.
   b. Detailed descriptions of each modality.

c. Examples of paired modalities and their benefits.

d. Conclusion summarizing the importance of multimodal treatment approaches.

4. **Presentation:** Create a presentation (3-5 minutes) summarising your findings. Include:
   a. Key points from your research.
   b. Visual aids such as diagrams, charts, etc. to enhance understanding.
   c. A brief Q&A session to engage your audience.

Submission requirements

Report Writing: Each learner will submit a written or printed report (2-3 pages) detailing their research findings.

Administration

1. Develop clear assessment rubrics and inform all learners about it,
2. Determine the format for submission of the project (i.e. written documents, presentations, oral response, or a combination of these) depending on the resources available,
3. For written documents, define the length of the research (e.g., 1-2 pages), include deadlines for drafts and final submissions, etc.
4. Assign topics: Each learner will choose or be assigned a specific topic depending on resources available and considering differentiation, GESI, and learners with special educational needs.
5. Presentation day: Schedule a day for individuals to present their findings to the class. Allow time for questions and discussions after each presentation. (2-5minutes)
6. Use the rubric to evaluate each learner's work and provide feedback.
7. Collect the written or printed reports and provide individual scores based on the rubric.

Research Rubrics (Total marks = 20 marks)

Criteria	*Excellent* *4 marks*	*Good* *3 marks*	*Satisfactory* *2 marks*	*Needs* *Improvement 1mark*
Content Accuracy	*Thoroughly covers 4 treatment modalities with a brief description:* *E.g.,* *Surgery removes tumours; Chemotherapy uses drugs to kill cancer cells;* *Radiation therapy uses high-energy rays to target cancer;* *Immunotherapy boosts the body's immune system to fight cancer*	*Covers 3 treatment modalities with a brief description:* *E.g.,* *Surgery removes tumours;* *Chemotherapy uses drugs to kill cancer cells;* *Radiation therapy uses high-energy rays to target cancer;* *Immunotherapy boosts the body's immune system to fight cancer*	*Covers 2 treatment modalities with a brief description:* *E.g.,* *Surgery removes tumours;* *Chemotherapy uses drugs to kill cancer cells;* *Radiation therapy uses high-energy rays to target cancer;* *Immunotherapy boosts the body's immune system to fight cancer*	*Covers 1 treatment modalities with a brief description:* *E.g.,* *Surgery removes tumours;* *Chemotherapy uses drugs to kill cancer cells;* *Radiation therapy uses high-energy rays to target cancer;* *Immunotherapy boosts the body's immune system to fight cancer*

Examples of Pairing Modalities	*Clearly explains how 4 different modalities can be paired.* *E.g.,* *Chemotherapy with Surgery* *Chemotherapy with Radiation therapy* *Immunotherapy with Surgery* *Radiation therapy with Surgery, etc.*	*Provides 3 examples of pairing modalities* *E.g.,* *Chemotherapy with Surgery* *Chemotherapy with Radiation therapy* *Chemotherapy with Immunotherapy* *Immunotherapy with Surgery, etc.*	*Mentions 2 pairing modalities.* *E.g.,* *Chemotherapy with Surgery* *Chemotherapy with Radiation therapy* *Chemotherapy with Immunotherapy* *Immunotherapy with Surgery*	*Gives 1 example of a paired modality* *E.g.,* *Chemotherapy with Surgery* *Chemotherapy with Radiation therapy, etc.*
Written or Typed Report Quality	*Report shows 4 of these qualities:* *E.g.,* *Well-organised* *Clear and concise* *Free of grammatical errors* *Meets length requirement, etc.*	*Report shows 3 of these qualities:* *E.g.,* *Well-organised* *Clear and concise* *Free of grammatical errors* *Meets length requirement, etc.*	*Report shows 2 of these qualities:* *E.g.,* *Well-organised* *Clear and concise* *Free of grammatical errors* *Meets length requirement, etc.*	*Report shows 1 of these qualities:* *E.g.,* *Well-organised* *Clear and concise* *Free of grammatical errors* *Meets length requirement, etc.*
Presentation Skills	*Presents with 4 of the skills:* *E.g.,* *Audible voice,* *Keeping eye contact* *Pay attention to audience* *Engaging the audience with interaction* *Use of gesture, etc.*	*Presents with 3 of the skills:* *E.g., Audible voice,* *Keeping eye contact* *Pay attention to audience* *Engaging the audience with interaction* *Use of gestures, etc.*	*Presents with 2 of the skills:* *E.g.,* *Audible voice,* *Keeping eye contact* *Pay attention to audience, etc.*	*Presents with 1 of the skills:* *E.g.,* *Audible voice,* *Keeping eye contact* *Pay attention to audience, etc.*
Use of Technical terms	*Uses 4 appropriate terms accurately and effectively in the report and presentation* *e.g.* *Tumour* *Chemotherapy* *Radiation therapy* *Immunotherapy* *Oncology* *Metastasis, etc.*	*Uses 3 terms correctly in both report and presentation* *e.g.* *Tumour* *Chemotherapy* *Radiation Therapy* *Immunotherapy* *Oncology* *Metastasis, etc.*	*Uses 2 terms e.g.* *Tumour* *Chemotherapy* *Radiation Therapy* *Immunotherapy* *Oncology* *Metastasis, etc.*	*Rarely uses terms or uses 1 term* *e.g.* *Tumour* *Chemotherapy* *Radiation Therapy* *Immunotherapy* *Oncology* *Metastasis, etc.*

Feedback

Appreciate learners' overall work: Wonderful job on presenting your project! Keep it up.

Strengths: Excellent research and clear explanations of treatment modalities, good integration of pairing examples to enhance understanding.

Areas needing improvement: Ensure your written report is well-structured and free of grammatical errors before, practice your presentation to improve clarity and engagement.

SECTION 5: DIAGNOSTIC AND THERAPEUTIC DEVICES

STRAND: BIOMEDICAL INTERVENTION

Sub-Strand (1): Diagnostic Devices (*Weeks 18 and 19*)

Learning Outcome: *Describe the importance of technology in clinical diagnosis and the composition of diagnostic medical devices and explain basic principles relating to diagnostic medical device design*

Content Standard: *Demonstrate an understanding of the concepts applied to build diagnostic devices*

Sub-Strand (II): Therapeutic Devices (*Weeks 20-22*)

Learning Outcome: *Describe some treatment and management strategies for cancer, disabilities, damaged tissues, and organs*

Content Standard: *Explore how therapies are used in health facilities to address health problems*

HINT

- *The recommended mode of assessment in week 18 is mid-semester examination. Refer to Appendix F for sample table of specifications at the end of this section on how to develop assessment items for mid-semester examinations.*
- *Remember to take the **individual project** and **individual portfolio** by weeks 20 and 22 respectively for evaluation using the rubrics shared with learners.*

INTRODUCTION AND SECTION SUMMARY

Learners are introduced to the significance and practical applications of technology in clinical diagnosis and healthcare delivery in this section. Additionally, the principles of designing and manufacturing diagnostic medical devices as well as their composition will be covered. Learners will explore strategies used in managing and correcting certain disabilities like functional limb loss such as the use of prostheses and orthoses. The various cancer therapies and treatments, as well as the outcomes of these therapies, will also be covered in this section.

The weeks covered by the section are:

Week 18: Investigate the application of technology in the provision of healthcare

Week 19

1. Identify the components of a diagnostic device and their function
2. Discuss the bioinstrumentation principles used in the construction of a diagnostic device.

Week 20: Explain the use of prostheses and orthoses to manage, correct and treat disabilities

Week 21: Investigate the treatments and therapies available to treat cancer and its physical, mental and emotional effects

Week 22: Explore the future application of regenerative medicine for patients with disabilities.

SUMMARY OF PEDAGOGICAL EXEMPLARS

To meet the content standard for this section, the following pedagogical exemplars are suggested. First, using exploratory learning, learners should visit a hospital or medical laboratory, where they will observe the devices used, take Notes, and ask questions to better understand how they work. They will also investigate how measurement accuracy, sensitivity, and specificity influence the performance of these medical devices. Through "talk for learning," learners will engage in discussions about the technologies used for diagnosing, treating, and preventing diseases in humans. Additionally, activity-based, project-based and experiential learning methods will be employed as learners disassemble a diagnostic medical device (such as a glucometer or ECG monitor) and identify its different components, including the measurand type, electrodes or sensors, signal processing units, and display or recording units. Collaborative, digital and structured talk for learning will be used to explore regenerative medicine.

SUMMARY OF ASSESSMENT

To assess learners' understanding of the significance and practical applications of technology in clinical diagnosis and healthcare delivery, DOK levels 1, 2, 3 and 4 are recommended. DOK level 1 focuses on recalling basic knowledge, such as listing examples of devices and technologies used for diagnosis, treatment and monitoring as well as recalling the definitions of concepts such as bioinstrumentation and regenerative medicine. At DOK level 2, learners are evaluated on their understanding of the functions of devices and the use of prosthesis and orthoses in managing, treating and correcting impaired mobility. DOK level 3 assesses strategic reasoning, asking learners about the implications of the lack of technological tools in modern medicine as well as troubleshooting of medical device as well as to analyse a case of cancer from diagnosing to outcome of treatment as well as the analysis of the physical side effects of the treatment. DOK level 4 assesses learners extended critical thinking and reasoning abilities by developing a persuasive argument for or against the use of public funds to support regenerative medicine research.

Week 18: Mid-Semester Examination

Week 19: Discussion

Week 20: Peer assessment

Week 21: Project-based

Week 22: Pop quiz

WEEK 18

Learning Indicator: Investigate the application of technology in the provision of healthcare

Focal Area 1: A Broad Overview of How Technology is Used in Healthcare Delivery

The integration of technology in healthcare has reshaped the way medical services are delivered, enhancing the efficiency, accuracy, and accessibility of healthcare. Technology plays an important role in modern healthcare by equipping facilities with cutting-edge technology to improve patient care.

Discussions on how technology is used in various aspects of healthcare may focus on the following:

1. **Diagnostics:** advancement in diagnostic tools and devices used in healthcare delivery has improved diagnosing health conditions. These diagnostic tools can further be divided into three categories, which include;
   a. **Imaging tools** like X-ray machines, computed tomography (CT) scans, ultrasound, and magnetic resonance imaging (MRI) machines. (*Refer to year one teacher manual for more details.*)
   b. **Laboratory analysis tools,** including clinical centrifuges, clinical laboratory incubators, cell counters, and chromatography machines**—see Figure 30.**

(a) (b)

Figure 30: *Laboratory analysis tools; clinical centrifuge (a) and cell counter (b)*

   c. **Point-of-care technology (POCT) devices**: these are mostly diagnostic devices or services that are used to provide rapid or real-time laboratory results and clinical decision support. They are ideally small in size and portable.

      These devices can be categorised into

      i. paper-based diagnosis, for example, urinalysis strips and paper-based devices for assessing liver function—see Figure 31.

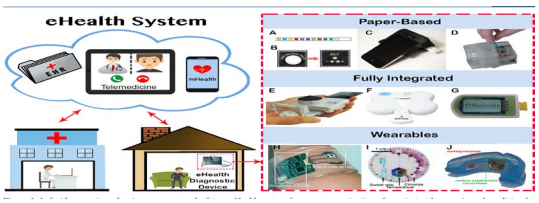


Figure 31: *Paper-based device for assessing liver function*

ii. **fully integrated devices** such as surface acoustic waves (SAW) biochips for HIV detection in blood—see **Figure 32.**

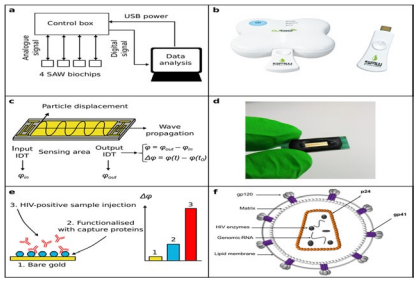
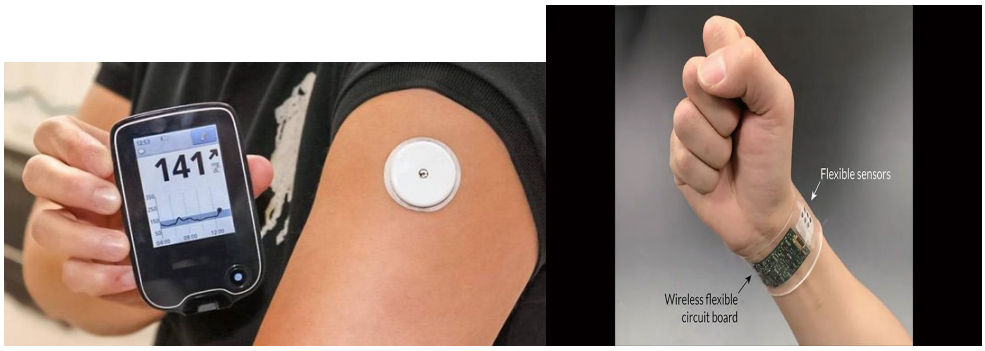


Figure 32: *SAW biochip for HIV*

iii. **wearables,** which include diabetes patches and electrochemical wristband sensors for real-time monitoring of metabolites such as glucose and lactate (see **Figure 33**).



(a) Diabetic patch (b) Electrochemical wristband

Figure 33: *Wearables*

Most fully integrated wearables mentioned in (ii) and (iii) work by converting biological signals into electrical signals. They combine biological components with physicochemical detectors to detect chemical or biochemical compounds present in the body. See Figure 47 in Additional Reading for advancements in POC testing platforms.

2. **Treatment**: technological advancements in healthcare assist in the treatment of diseases and health conditions. Some of these treatment technologies include:

   a. **Surgical Robots:** These are devices with robotic arms that can hold small surgical instruments, high-definition cameras that show magnified 3D views of the surgical area, and a surgical console that surgeons use to control the surgical process. They are mostly used for brain and cardiothoracic surgeries.

Figure 34: *Surgical Robot*

b. **Radiation therapy machine:** also known as radiotherapy machines, these are devices that use high-energy radiation to target and eliminate diseased cells. These devices are popularly used in the treatment of cancers to shrink tumours, cure cancer, or slow its growth.

Figure 35: *Radiotherapy Machine*

c. **Dialysis machine:** These are devices used to treat and manage kidney failures. The machine filters your blood through a dialyser, also known as an artificial kidney, with built-in safety checks to be sure the process is safe and effective. It is made up of a series of membranes that act as filters and a special liquid called dialysate. The membranes filter waste products from your blood, which are passed into the dialysate fluid.

Figure 36: *Dialysis Machine*

3. **Monitoring**: Technology is also used in the aspect of monitoring in healthcare provision. These devices assist healthcare providers and patients to effectively manage and monitor health conditions in real-time. Some of these devices include;

    a. **Wearable health trackers:** a range of devices designed to monitor and enhance several aspects of patient health. There are fitness trackers built into watches that do more than step counting but go further to measure calories burnt, heart rate, blood oxygen levels, and sometimes blood pressure. Some individuals also use these devices to maintain a healthy lifestyle.

Figure 37: *Health Tracker Watches*

    b. **Telemedicine devices for remote consultations:** devices designed for this aspect of healthcare range from simple webcams to sophisticated digital stethoscopes. These devices enable healthcare professionals to provide patient care remotely (without close contact with patients).

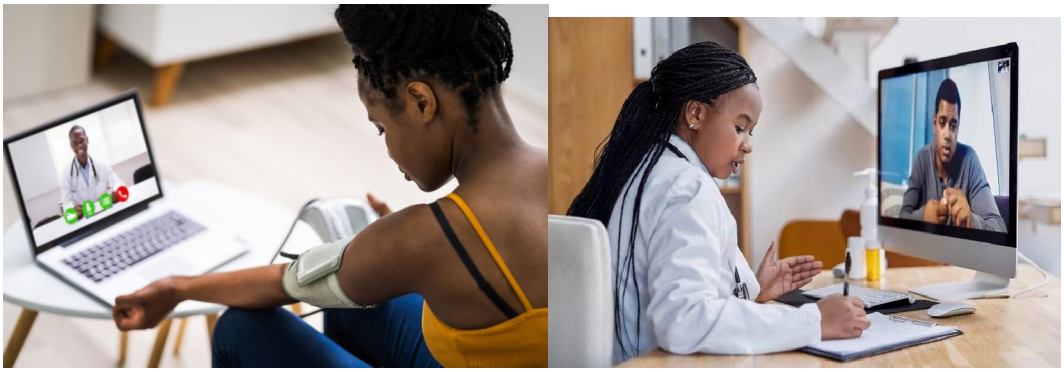


Figure 38: *Telemedicine devices*

4. **Drug Discovery and Development:** Technologies designed to enhance drug discovery and development in the pharmaceutical industry include robotics for drug testing and computer modelling to aid in designing the safest drugs that are least likely to have side effects. Using these approaches helps reduce the number of years that would have initially been needed to produce these safe and effective medicines.

Pedagogical exemplars

Exploratory Learning: Organise a field visit to a hospital or any medical laboratory and guide learners in observing and taking Notes of some of the devices mentioned in the lesson. Encourage learners, particularly shy learners, to ask questions during the visit.

Note

- Learners should observe all safety protocols during their visit.
- Where a field trip may not be possible, let learners have a virtual visit by watching pictures and videos of these devices.

Talk for Learning: Learners engage in a discussion on technologies available for diagnosis, treatment, and prevention of diseases in humans. Learners explore various physiological measures (blood pressure, heartbeat, temperature, blood sugar level, morphology by imaging, etc.) for diagnosis and how patterns recorded may be indicative of abnormalities.

Activity-Based Learning: Learners work in mixed ability groups. Assign each group one of the various healthcare technologies (for example telemedicine, wearable devices, point-of-care devices, imaging techniques, drug discovery and development and robotic surgery). Let each group research their assigned technology based on the following key points:

1. what the technology is
2. how it is applied in healthcare settings
3. benefits and challenges in patient care
4. future potential and ethical considerations

Each group creates a real-life scenario that demonstrates the application of their assigned technology (example, a hospital uses point-of-care device(s) to predict patient outcomes for a chronic disease) and present their findings as a case study. Allow time for a short Question & Answer session after each presentation to encourage peer feedback. Debrief by facilitating a class discussion on the pros and cons of each technology; what the learners learnt from the activity; how they see technology shaping the future of healthcare; what ethical or social considerations need to be considered when using these technologies.

Key Assessment

Level 1 (Recall): Name two technologies or devices in healthcare used in the categories stated below.

1. Diagnosis
2. Treatment
3. Monitoring
4. Drug discovery and development

Level 2 (Conceptual understanding): Briefly describe the functions of the following clinical diagnostic devices:

1. X-ray machine
2. Ultrasound scanners
3. Computed Tomography (CT) scan
4. Clinical centrifuge
5. Clinical laboratory incubator
6. Chromatography

7. Blood glucose biosensor
8. Electrochemical biosensor

Level 3 (Strategic reasoning): Visit any healthcare facility in your community and identify the technological devices that are not available in the facility. Write an essay discussing the implications of not having those devices in the health facilities.

Learning Task

Technology in Healthcare Field Trip

1. Plan a visit to a general hospital in your region where learners can see healthcare technology in action. Provide learners with a list of technologies they may encounter during their visit. (*Divide learners into smaller groups to visit on different days if you have a large class)*
2. Arrange with the hospital to be given a healthcare professional who can explain and demonstrate how these devices work.
3. Encourage learners to take Notes and ask questions where they require further explanation or clarity.
4. After the trip, learners will have a class discussion about what they observed and learnt.

WEEK 19

Learning Indicators

1. Identify the components of a diagnostic device and their function
2. Discuss the bioinstrumentation principles used in the construction of a diagnostic device

Focal Area 1: Diagnostic Devices and Their Functional Components

Choose a specific diagnostic device (for example, an X-ray machine will be discussed) and delve deeper into its components. Explain how each part contributes to the overall function (for example, X-ray source, detector, computer processing).

X-ray machines are made up of a number of components that contribute to the overall function. Some of these parts include the

1. **X-ray source:** The x-ray tube is the source or producer of the X-rays. It is a vacuum tube that uses high voltage to drive electrons to very high speeds. The energy of the resulting X-rays depends on the voltage of the X-ray tube.
2. **The image detector:** This component captures the X-rays that pass through the patient to create an image.
3. **User Interface:** This is how the radiologist operates the radiography system.
4. **Processor or Image Reader:** This is what the radiologist uses to view and analyse the X-ray images created.

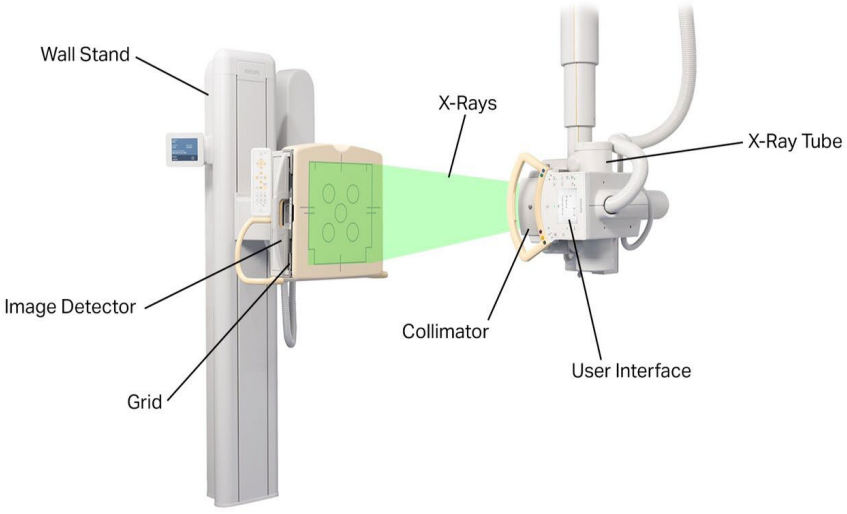


Figure 39: *Components of a typical x-ray machine*

Focal Area 2: Understanding biological principles and the technology used to build some types of diagnostic devices

A brief introduction to bioinstrumentation as the field that applies engineering principles to measure biological signals and processes.

Biomedical instrumentation is a subfield of biomedical engineering that focuses on developing devices and systems for measuring, evaluating, and treating biological systems. Most of the devices developed make use of sensors to track biological signals (heartbeat, muscle contractions)/physiological parameters in the body for diagnostic and treatment purposes. Main areas of focus in bioinstrumentation include:

1. **Biological signals:** these physical carriers of information about the condition of a particular biological function. Biological signals generate electrical, chemical, and mechanical activity in the body, which produces measurable signals.
2. **Sensors:** these components capture and amplify signals from the body, allowing biomedical scientists and doctors to analyse the data. These components of bioinstrumentation are found in devices like thermometers, brain scanners, and electrocardiograms.
3. **Spectroscopy:** Analysing the interaction of light with biological molecules to identify substances or diagnose diseases (for example, blood tests).
4. **Amplification Techniques:** Techniques like PCR (polymerase chain reaction) that amplify minute amounts of genetic material for detection (for example, in infectious disease testing).
5. **Imaging Techniques:** Techniques like X-rays, ultrasounds, and MRIs use various physical principles to create internal body images for diagnosis.

Discussion on the various types of biological signals used in diagnostics may include:

1. **Electrical activity generated by the heart:** electrocardiography (ECG) heart rate is measured using three electrodes that are stuck onto the skin of the chest over the heart. Heart rate changes during exercise and physical activity, during times of emotional duress, and bodily fatigue (Chęć et al., 2015).
2. **Electrical signals in the brain:** Electroencephalography (EEG) through the use of electrodes that are placed on certain points on the skull assesses the activity of specific regions of the brain. With more technological advancements Brain-computer interfaces (BCIs) are EEG devices that communicate between the neural pathways and a computer. These have been developed to decode brain signals and translate them into computer programs. Moreover, researchers are able to perform tests using EEG to understand how the brain responds to certain stimuli, such as music, or how the brain behaves in a person experiencing sleep disturbances or epilepsy.
3. **Electrical activity generated by muscles:** Electromyography (EMG) is a technique used to measure and record the electrical activity generated by the muscles. EMG has been widely used for rehabilitation.

Diagnostic devices should be designed and manufactured in a way that is safe for use under all conditions to meet their intended purpose. Diagnostic devices, like all other medical devices, have principles that guide how they are designed to ensure the safety of the user and the environment.

Discussion on principles informing the design and function of the components of the different categories of selected diagnostic devices based on their function may focus on:

1. **Imaging devices:** X-ray machines, ultrasound, and MRI scanners are diagnostic devices that work on the principles of wave absorption and magnetism.
   a. X-rays emit electromagnetic radiation. This type of radiation is a form of energy that travels in waves, which can pass through certain materials like skin and muscle but are absorbed by denser materials like bones.
   b. Ultrasound machines use sound waves to create images of your body. These sound waves bounce off different tissues and organs, creating echoes. The machine then uses these echoes to create a picture on a screen.
   c. MRI machines produce detailed images of your body using a powerful magnet and radio waves. As you lie in the machine, the magnet aligns the atoms in your body. Radio waves are then sent through, causing these atoms to emit signals. These signals are used to create a 3D picture.

   Overall, X-rays are good for seeing bones; MRI shows soft tissues and organs in detail, and ultrasound is used to see organs filled with fluid.
2. **Laboratory equipment:** such as blood analysers and genetic testing equipment like the Polymerase Chain Reaction (PCR) machines used for genetic screening, have had several advancements in their designs based on several principles.
   a. **Blood analyser:** also known as haematology analyser, is used to count blood cells, classify leukocytes, and determine haemoglobin levels. The detection principle includes two principles: the electrical (for example, electrical resistance) and optical (for example, laser scattering and spectrophotometry). Based on the blood test being run by the analyser, one of the detection principles may be applied. See QR Code 25 in Additional Reading for more information on the principles of blood analysis using the analyser.

Note

It may be helpful to have a brief "1-minute" lesson on DNA replication with a mention of the key enzymes involved in the reaction (helicase and DNA polymerase), leading and lagging strands before delving into PCR machines.

   b. **PCR Machines:** PCR is based on using the ability of DNA polymerase to synthesise a new strand of DNA that is complementary to a template strand (see Figure 40 for an illustration of DNA replication). The process produces millions of copies of nucleic acids (DNA) from a target sequence. In the machines there is a thermal block with holes where tubes with the PCR reaction mixtures can be inserted. For this reason, PCR machines are referred to as thermocyclers because there is a cycler that increases or decreases the temperature during amplification (see Figure 41(a) and (b) for illustrations of the workflow of the PCR used in Covid-19 testing).

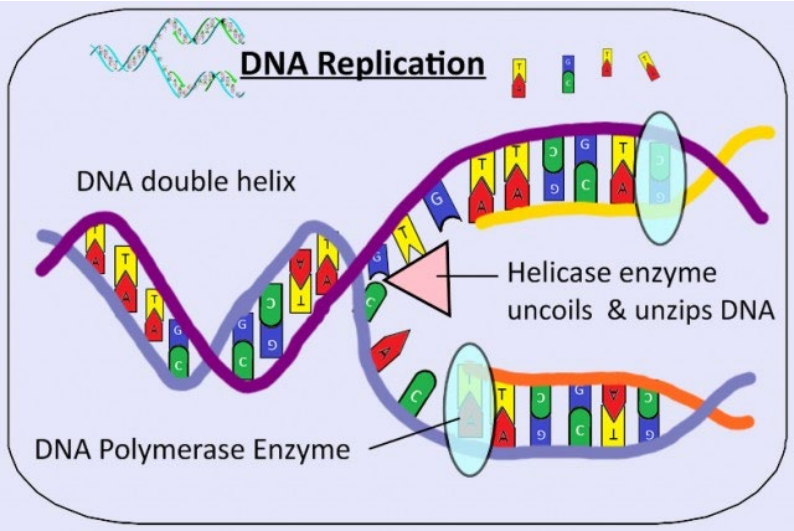
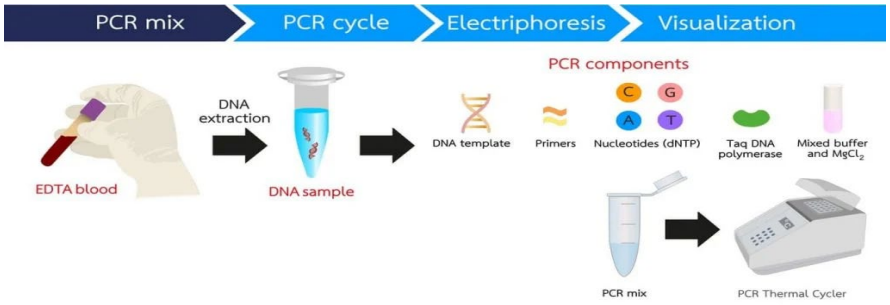
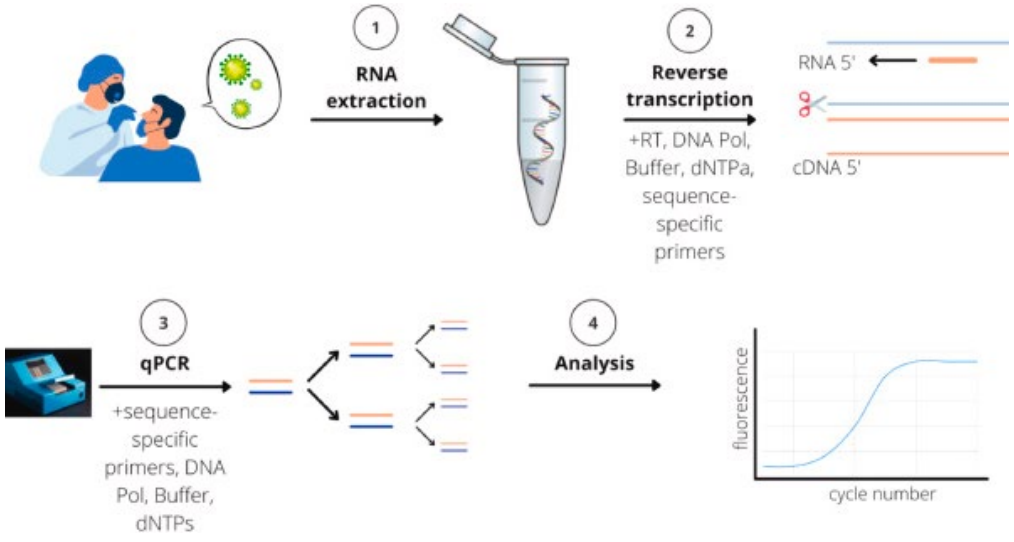


Figure 40: *A simplified illustration of DNA replication*



(a)



(b)

Figure 41: *Use of PCR machines in Covid-19 tests*

Pedagogical exemplars

Experiential Learning: with the help of a technician, learners disassemble a diagnostic medical device (for example, a glucometer or ECG monitor) and try to identify the various components under the type of measurand, electrode or sensor, signal processing unit, and display or recording unit. After noting the various components, guide learners to reassemble the medical device.

Learners should then discuss the functions of the various components and how the individual components work together to achieve the overall objective of the device. Make sure all learners participate by supporting discussions with leading questions and providing further explanations to learners who may need them.

Exploratory Learning: with the aid of models or pictures, learners explore how measure and accuracy, sensitivity, and specificity affect the performance of medical devices.

Use Figure 42 below to guide learners in a discussion on how accuracy, sensitivity, and specificity inform the design, construction, and final use of medical devices.

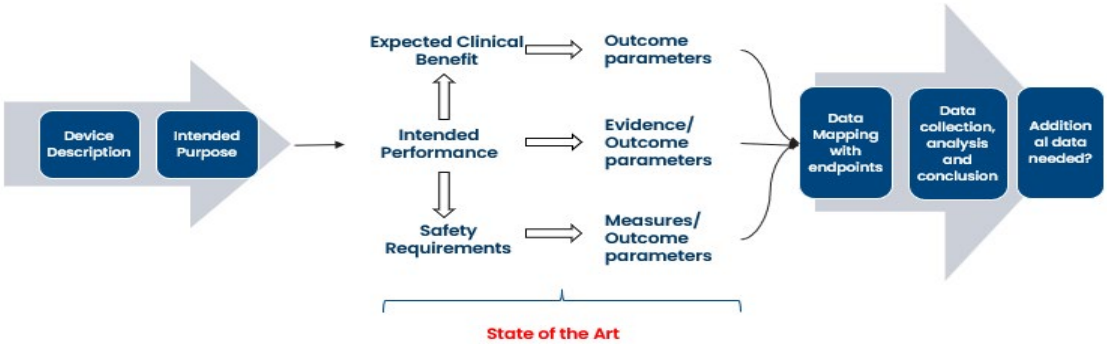


Figure 42: *Evaluation of Medical Devices*

Key Assessment

Level 1 (Recall): What is bioinstrumentation?

Level 2 (Conceptual understanding): Complete the table with the correct function(s) of the following components.

Component	Function (s)
Sensor	
User interface	
Amplifier	
Microprocessor	
Power supply	

Level 3 (Strategic reasoning): A hospital's x-ray machine is malfunctioning, and the output signals are inconsistent and weak. Based on your knowledge of the device's components and bioinstrumentation principles, identify which component(s) could be responsible for this issue. Discuss the reasoning behind your diagnosis.

Learning Task

Consider implementing at least one of the following learning tasks to reinforce understanding and knowledge acquisition among learners.

1. In this task, learners will disassemble a simple diagnostic device (for example, a digital thermometer or pulse oximeter) to identify its components and understand their functions. Divide learners into small groups and provide each group with a diagnostic device and basic disassembly tools (for example, screwdrivers). Guide learners to carefully disassemble their assigned device, identifying and labelling each component (for example, sensor, microprocessor, power source, display). Each group creates a diagram or table listing the components and explaining their functions within the device. Walk around and assist groups as needed, ensuring they correctly identify and understand each component's role. Groups will create a short report or presentation summarising the components they identified and their functions.
2. Divide learners into groups and assign each group a specific diagnostic device (or allow them to choose one). For example, an electrocardiogram (ECG) machine, pulse oximeter, glucometer, ultrasound machine, and blood pressure monitor. Each group should explore a different device to ensure variety and exposure to different bioinstrumentation principles. Each group will disassemble or analyse their assigned device (if disassembly is not possible, use diagrams or virtual simulations) to identify key components. Learners should create a table summarising the components, their function, and how they contribute to the operation of the device for presentation to the whole class. Learners should focus on identifying the following:
    a. Power Supply
    b. Sensors/Transducers (e.g., electrodes in ECG, infrared sensor in pulse oximeter)
    c. Amplifiers
    d. Signal Processors
    e. Display units or output mechanisms

WEEK 20

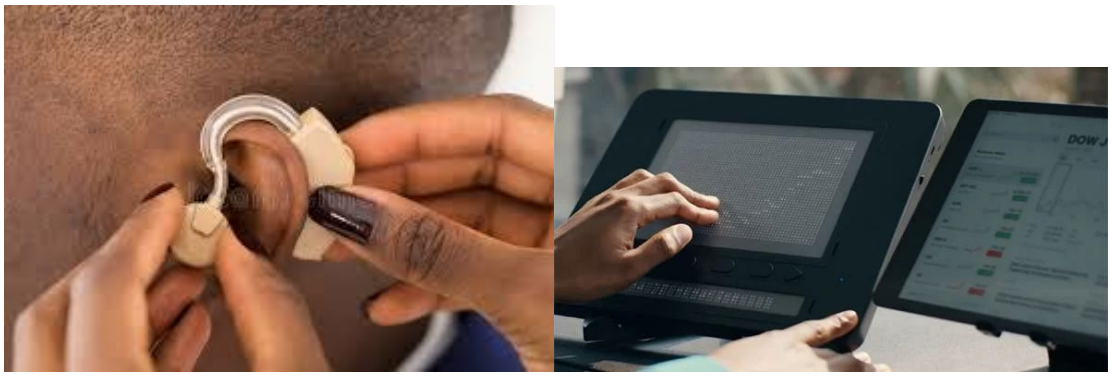
Learning Indicator: Explain the use of prostheses and orthoses to manage, correct, and treat disabilities

Focal Area 1: Prosthetics vs. Orthotics: Understanding the Difference

Briefly introduce and discuss different categories of Assistive Technology (AT), including mobility devices, communication aids, and sensory aids.

Assistive Technology (AT) comprises a variety of tools, software, and devices designed to aid individuals with disabilities in performing tasks that would otherwise be challenging. The primary categories of AT include mobility devices, communication aids, and sensory aids.

1. **Mobility Aids:** As the name suggests, these devices help people who have problems moving around. They provide numerous benefits to the patients, ranging from independence to improved self-esteem. Some examples of mobility aids include canes, crutches, walkers, wheelchairs, prostheses, and orthoses (refer to Year 1 Book 2 Teacher Manual for pictures).
2. **Communication Aids:** They help individuals with speech, language, or hearing impairments to communicate effectively. Communication aids range from visual aids, audiovisual aids, digital aids, and tactile aids (refer to Year 1 Book 2 Teacher Manual for pictures).
3. **Sensory Aids:** Sensory aids are types of assistive technology designed to support people who have sensory problems, such as those affecting vision or hearing. Braille, screen readers, and hearing aids are some examples of sensory aids.



(a) Hearing aid for hearing impairment (b) Braille screen readers for visual impairment

Figure 43: *Sensory aids*

Focusing on the use of prosthetics and orthoses as aids used in managing, correcting, and treating disabilities associated with mobility, define prostheses as artificial limbs or body parts that replace missing structures and orthoses as devices that support, improve, or correct the function of existing body parts.

A **prosthesis is,** in simple terms, an artificial body part. It is made for a part of the body that may have been missing at birth, lost in an accident, or through amputation. In some practical applications, a prosthesis may be used in the following situations:

1. Some people have a limb removed (amputated) as part of treatment for cancer, diabetes, or a severe infection.

2. As an alternative to reconstructive surgery. For example, a prosthetic breast may be created after a breast has been removed to treat cancer. Other examples may include artificial eyeballs, nose, and ear replacements after reconstructive surgery.

Generally, prostheses help restore the function and appearance of a missing limb or body part, allowing individuals to carry out daily activities and enhancing their quality of life.

Unlike prostheses, which replace body parts, **orthoses** are devices designed to support, improve, or correct the function of existing body parts to enhance their performance. Some examples of orthotic devices include dental braces, cervical braces, knee braces, ankle foot orthoses, hip orthoses, and spinal orthoses.

Refer to **Year 1 Book 2 Teacher Manual** for pictures of prostheses and orthoses.

Pedagogical Exemplars

Exploratory Learning: Learners individually conduct research on the internet about the usage of prostheses and orthoses. Support learners with images or videos that may be useful in their research.

Cooperative Learning: Learners engage in a class discussion to arrive at the definition and functions of prosthesis and orthosis, using examples from videos, pictures, and experiences of learners. Discuss the pathological effects of disease, trauma, malformation, and loss of the lower and upper limbs and relate them to functional loss.

Encourage learners approaching proficiency to lead discussions in order to build their confidence as well as understanding of the topic being discussed.

Project-Based Learning: Learners engage in research and identify examples of functional losses of the limbs, deduce whether these effects are a result of pathological effects, trauma, malformation, or loss of upper/lower limbs, and propose solutions to these effects using prostheses or orthoses.

Learners make group presentations to the class based on their findings.

Key Assessment

Level 1 (Recall): What is the main difference between prosthesis and orthosis?

Level 2 (Conceptual understanding): Describe the use of prostheses and orthoses in managing, correcting, and treating impaired mobility.

Level 3 (Strategic reasoning)

1. Explain how wearing a knee brace helps someone with arthritis.
2. Provide examples of each type of device (e.g., prosthetic leg, ankle brace) and discuss how prosthetics and orthotics can address various disabilities and functional limitations.

Learning Task

This case study aims to explore the practical application of prostheses and orthoses as mobility aids.

1. In a whole class discussion, present learners with a case involving prosthesis and orthosis. For example;

Kukua, a 25-year-old athlete, had her left leg terribly injured in a car accident. Due to the severe damage, she needed an amputation. Kukua had her amputation below her left knee. Prior to the accident, she was a passionate runner and participated in various marathons. The accident drastically changed her life, leaving her with limited mobility and a loss of independence, but she was determined to find a solution to her problem.

2. Give learners some time to think through the case and come up with answers to the following questions.
    a. What were the challenges Kukua might have faced after her amputation?
    b. What would they have done if they were in Kukua's shoes?
    c. Do you think a custom-made prosthesis will help Kukua regain her mobility and independence?
3. If learners' response to question **2c** is yes, then in groups, let learners design the appropriate prosthesis for Kukua using locally sourced materials.

WEEK 21

Learning Indicator: Investigate the treatments and therapies available to treat cancer and its physical, mental, and emotional effects

Focal Area 1: Introduction to Cancer and Its Different Types

Cancer refers to a group of diseases characterised by the uncontrolled growth of cells in the body. Cancerous cells usually originate from normal, healthy cells. They become cancerous when they start to multiply uncontrollably without receiving signals from the body, leading to the formation of tumours. Tumours are either benign or malignant.

1. **Benign tumours** are slow-growing tumours that stay in their original location without spreading to other parts of the body and are usually not problematic. Skin tags, warts, neuromas, and fibroids are examples of benign tumours.
2. **Malignant tumours** are cancerous tumours that can invade and spread to other tissues. Cancers are named based on the area they start from and the type of cells they are made of. Some examples are breast cancer, cervical cancer, prostate cancer, throat cancer, leukaemia, and skin cancers.

Cancerous cells differ from healthy cells in a number of ways. Some of these differences include;

1. The basic difference between healthy cells and cancer cells is that cancer cells are constantly and freely dividing and multiplying without properly responding to signals that stop cells from growing. This excessive growth forms a lump (tumour), which continues to grow in size unlike healthy cells, which stop growing when signals are sent (see **Figures 44 and 45).**

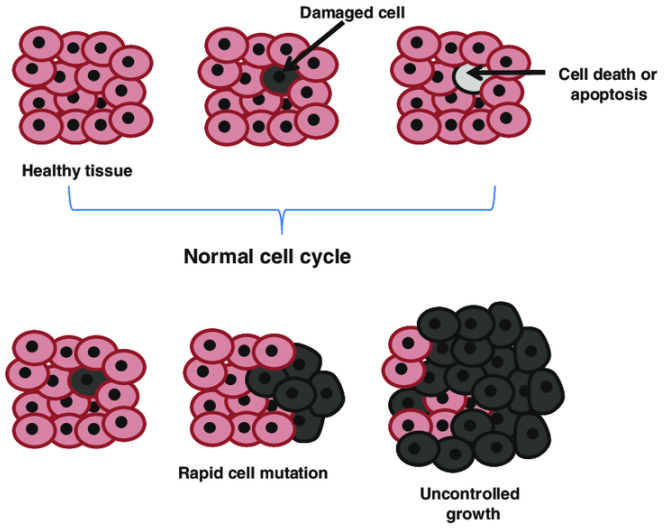


Figure 44: *Healthy cell growth vs. cancer cell growth*

2. For healthy cells to start their growth process, they get a signal to start growing, but cancer cells start that process without a signal prompt.
3. Cells communicate with each other by sending chemical signals. Healthy cells halt their growth process when they come into contact with others, but the uncontrolled growth of cancer cells allows them to invade nearby cells and tissues, eventually damaging them.

4. Healthy cells in the body can repair themselves when their genes are damaged through a process known as DNA repair, or they die if the damage is beyond repair, but cancer cells do not repair themselves or die.
5. Cancer cells, as a result of their rapid reproduction, do not get the chance to mature and specialise (differentiation) to carry out their functions in the body, unlike healthy cells which do.

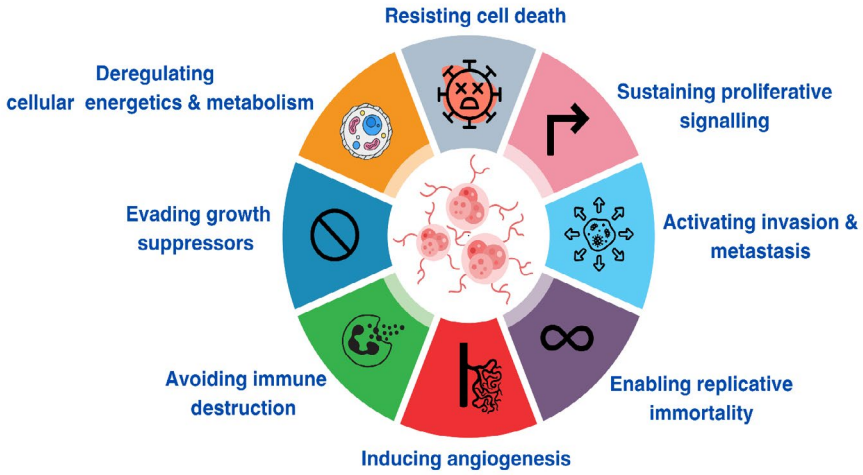


Figure 45: *Eight (8) hallmarks of cancer cells*

Focal Area 2: Treatment Options for Cancer

An early diagnosis of cancer is key to the effectiveness of treatment modalities. The treatment options to be used mostly depend on the type of cancer, the stage it has reached, and the generality of the patient and their preferences. Sometimes, just one treatment modality may not work for a type of cancer and its stage; in those situations, a number of modalities are combined to increase the effectiveness of the treatment.

Explore various treatment modalities used to combat cancer, including;

1. **Surgery:** Surgery refers to the removal of cancerous tumours or as much of it as possible. This treatment option may not always be a choice available to every patient, depending on the stage of the cancer and the location of the tumour in the body.
2. **Radiation therapy:** This treatment modality makes use of high doses of radiation to kill cancerous cells or slow down their growth by destroying their DNA. Radiation causes tumours to shrink. Radiation therapists are trained professionals who use radiation therapy machines like the radiotherapeutic x-ray machine to administer radiation therapy to cancer patients.
3. **Chemotherapy:** Chemotherapy is a form of anti-cancer drug treatment where medications are used to target and destroy cancer cells. Treatment by chemotherapy is either done with one drug or a combination of drugs, and it is dependent on the type of cancer and its origin. This means that the chemotherapy drug used to combat breast cancer that has spread to the lungs might be different from the one used for lung cancer.
4. **Immunotherapy:** Cancer immunotherapy is also known as immuno-oncology. This treatment modality makes use of the power of the body's immune system to fight cancer.

This boost to the immune system comes in different forms, including cancer vaccines, tumour-infecting viruses, and targeted antibodies. Gene therapies are another form of immuno-oncology. This treatment is done by using genetic engineering to enhance the cancer-fighting capabilities of immune cells.

Scan QR code 26 for additional reading resources on types of cancer treatments.

Focal Area 3: Emotional and Mental Impact of Cancer

Getting a cancer diagnosis, living with it, the treatment process, and survival have a significant impact on the quality of life of an individual.

Discussions on the significant physical, mental, and emotional challenges faced by cancer patients may focus on,

1. **Physical Challenges:** Some common physical challenges that occur include persistent pain, unexplained weight loss, anaemia, fatigue, changes in skin, unusual bleeding or discharge, persistent cough or trouble breathing, lumps or thickening of tissue, and loss of body parts, like in the case of breast cancer. These physical challenges occur at various stages of the disease and may also depend on the type of cancer that an individual has.
2. **Mental & Emotional Challenges:** As a major factor of stress, a cancer diagnosis is like a death sentence, which may cause notable psychological distress as well as mental health disorders. Upon receiving a cancer diagnosis, patients may go through a rollercoaster of emotions and feelings. Depression and anxiety about the future and life changes that will occur are part of the first few emotional challenges faced by cancer patients. Other common ones include adjustment disorder, panic disorder and post-traumatic disorder. The fear of recurrence also causes emotional stress.

Briefly explore support systems available to help patients cope with these challenges

Coping with challenges from cancer treatment is based on the type of challenge it is, whether physical, emotional, or mental.

1. Coping strategies for physical challenges include:
    a. Pain relievers or medications, nerve blockers that stop pain signals from being sent to the brain, and integrative therapies like massages, meditation, and physical therapy (relaxation exercises and stretches) are strategies for coping with pain and fatigue.
    b. Meal plans from nutritionists or dietitians, food supplements, and nutritional support using tubes inserted through the nose, or abdomen to the stomach, in severe cases where patients are unable to eat. These are all coping strategies for unexplained weight loss.
    c. Dietary supplements like iron, folic acid, and vitamin B12 for the production of healthy red blood cells, medications, blood transfusions, and bone marrow transplants to replace unhealthy stem cells with healthy ones are ways to cope with anaemia.
2. Coping strategies for emotional and mental challenges include,
    a. Medications like antidepressants can be used as coping strategies for depression and anxiety.
    b. **Psychotherapy:** Talk therapy and counselling can help patients recognise and process their feelings and learn techniques for managing negative thoughts.

c. Joining support groups where people can share their concerns and learn how others have coped. Support groups help patients deal with their feelings and other side effects of treatment.

Pedagogical exemplars

Digital Learning: To introduce learners to how cancer cells behave, let learners watch a video, or observe an illustration, of how cancer cells develop and behave (scan **QR code 27** for a video).

With the aid of pictures, PowerPoint presentations, and videos (scan **QR code 28(a)-(d)** for videos), guide learners in exploring the mechanisms of therapeutic remedies such as immunotherapy, chemotherapy, radiation therapy, and stem cell implants to treat cancer.

Collaborative Learning: learners discuss the physical, mental, and emotional effects of chemotherapy and radiation therapy, such as hair loss, vomiting, fatigue, nausea, headache, memory, and concentration problems. Prompt learners to tolerate and respect the views of others during the discussions. Provide clarifications where necessary.

Key Assessment

Level 1 (Recall)

1. Name the two types of tumours.
2. State the basic difference between cancerous cells and healthy cells.

Level 2 (Conceptual understanding)

1. Explain the different treatment modalities available to cancer patients mentioning examples of how some of these modalities can be paired.
2. Give two differences between a regular x-ray machine and a radiotherapeutic x-ray machine.

Level 3 (Strategic reasoning): Based on a particular type or example of cancer, create a case study focusing on the patient's journey from the diagnosis to the outcome of treatment and analyse some physical side effects experienced by the patient.

Learning Task

Consider implementing at least one of the following learning tasks to reinforce understanding and knowledge acquisition among learners.

1. Cancer Treatment Pamphlet
   a. Place learners into mixed ability groups to create an informative pamphlet for patients and their family members about the treatment of a particular cancer type.

   The pamphlet should provide essential information about the treatment options available, the processes of those treatment modalities, and possible side effects of the treatment modalities listed.
2. Patient Testimonial Video Analysis (Scan **QR code 29** for an example of a testimonial video)
   a. Present learners with a video that depicts patients testimonials about their experiences.
   b. Learners analyse the video based on the following questions:

   i. What type of cancer is the patient diagnosed with, and what treatment modalities are used?

   ii. How does the video contribute to public understanding of cancer?

c. Learners discuss their thoughts. This can be done as a whole-class or small group discussion.

WEEK 22

Learning Indicator: Explore the future application of regenerative medicine for patients with disabilities

Focal Area 1: Future Applications of Regenerative Medicine for Disabilities

Briefly discuss regenerative medicine as a field that focuses on repairing, replacing, or regenerating damaged or diseased tissues

Disease and injury-related organ and tissue loss has prompted the development of therapies that can regenerate tissues and reduce the need for transplants. Regenerative medicine is a new and interdisciplinary field of science that applies engineering and life science principles aimed at potentially helping people recover from injuries and diseases. Regenerative medicine helps restore functionality using biologics instead of only mechanical or hardware processes. Through research and several preclinical trials, scientists are working to create treatments that can repair damaged tissues or even grow new organs. The field of regenerative medicine has been developing for many years. There are already some treatments available, especially for healing wounds and orthopaedic applications.

Discuss some applications of regenerative medicine

The simplest and most common application of regenerative medicine is transplanting human tissues, which includes autografts (a patient's own tissue), allografts (tissue taken from another person), and xenografts (tissue taken from an animal).

In areas of a genetic mutation leading to a disease, gene and cellular therapy regenerative techniques may be used. With this method, stem cells are used. There are several types of stem cells, which include:

1. **embryonic stem cell** (develops from an embryo during fertilisation, which divides (differentiates) into different cells like nerve, skin, and blood cells).
2. **adult stem cells** (found in bone marrow, which can replace damaged cells but don't form a new tissue like embryonic stem cells do)

Scan **QR Code 30** for a video on what stem cells are and their application in regenerative medicine.

Discussion on other applications may include the following:

1. **Skin grafts for burn victims**: A skin graft is a surgical procedure where we take a piece of healthy skin and attach it to an area of burnt skin. While first-degree (superficial) burns heal naturally, more severe burns require skin grafts.
2. **Bone marrow transplants for blood cancers**: stem cell or bone marrow transplants are treatments for some types of cancer, including leukaemia, lymphoma, and myeloma. They are sometimes referred to as stem cell rescue, bone marrow rescue, or intensive treatment. Cells used are usually in high doses in chemotherapy and sometimes radiotherapy.

Provide examples of disabilities that could potentially benefit from advancements in regenerative medicine

Regenerative medicine aims to improve the body's ability to heal itself. When tissue healing is significantly impaired due to ageing or disease, or when an injury is severe, regenerative medicine approaches may be recommended. On the other hand, with musculoskeletal injury leading to disabilities that affect movement, physical rehabilitation optimises the quality of life for people with limitations imposed by functional loss resulting from disease or trauma through the development of prosthetic devices.

Though prostheses have been beneficial in restoring functionality, in cases of large tissue defects, the use of extracellular matrixes or scaffolds may aid in the healing process following a musculoskeletal disease or injury. This is known as tissue engineering, which provides support for the body to heal itself using a biologically inductive, 3-dimensional construct. For example, in the case of a peripheral nerve injury, large gap defects prevent the residual nerve buds from rejoining and regenerating into a functioning structure. The use of a scaffold or channel allows communication between nerve ends; in animal models, this technique has resulted in significantly improved healing. With such promising results, it will be interesting to see regenerative medicine help in the regrowth of a limb.

Pedagogical Exemplars

1. **Structured Talk for Learning:** Introduce learners to the strategies for regenerative medicine such as cell therapy (injection of stem cells at disease sites) and implantation of tissue constructs (skin grafts for burns) and artificial organs through a PowerPoint presentation or a video.
2. **Experiential Learning**: Guide learners to surf the internet for and watch pictures or documentaries on regenerative medicine and suggest ways it could be applied to solve medical problems in the communities.
3. **Digital Learning:** Design Word clouds on regenerative medicine. See Figure 46 for an example of the word cloud.

In situations where digital tools may not be available, instruct learners to use other resources like manila cards and markers so they are involved in the creation of word clouds.

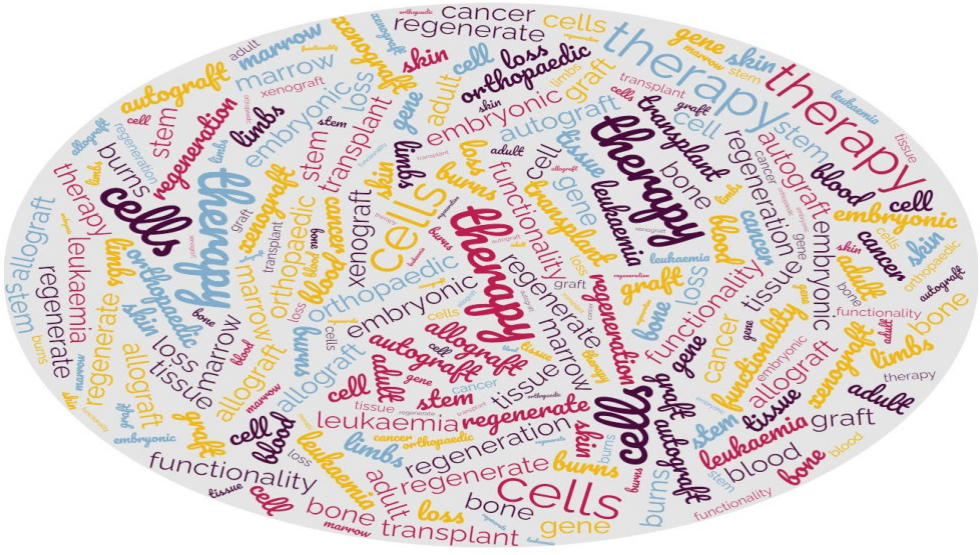


Figure 46: *Word Cloud*

Key Assessment

Level 1 (Recall)

1. What is the basic definition of regenerative medicine?
2. Name one type of stem cell used in regenerative medicine research.

Level 2 (Conceptual understanding)

1. Describe the difference between the following:
   a. allografts and xenografts
   b. embryonic stem cells and adult stem cells.
2. Explain how stem cells can be used to treat diseases and injuries.

Level 4 (Extended critical thinking and reasoning)

Debate

Develop a persuasive argument for or against the use of public funds to support regenerative medicine research. Consider the potential benefits and costs to society.

Learning Task

This task is to reinforce understanding of regenerative medicine strategies through a creative and collaborative project.

Materials needed for task:

1. Large sheets of paper or manila cards.
2. Magazines, newspapers, or online resources with images
3. Markers, glue, scissors
4. Digital devices for online image searching (optional)

Task:

1. Divide the class into small mixed gender/ability groups.
2. Begin by instructing learners in their groups to briefly review the strategies for regenerative medicine, such as cell therapy, tissue constructs, and artificial organs.
3. **Where digital tools are available:** Assign each group a specific regenerative medicine strategy. Have them use their devices to search for and print out relevant images (e.g., stem cells, tissue grafts, artificial organs).

   Without digital tools: Provide groups with magazines, newspapers, or other printed materials. Ask them to cut out images related to the assigned strategy.

1. Instruct groups to create a collage on their large sheets of paper. They should arrange the images creatively and add captions or explanations to describe each element.
2. Have each group present their collage to the class, explaining their choices and how the images relate to the different strategies of regenerative medicine. Encourage them to discuss potential applications of these strategies in their community.

SECTION 5 REVIEW

This section is a review of all the lessons taught for the last five weeks. A summary of what should have been taught and what each learner should have learnt if differentiation has been done.

1. How does the accuracy and sensitivity of medical devices impact the diagnosis and treatment of diseases?
2. Explain the function of the sensor in an ECG monitor. How does it help in diagnosing heart conditions?
3. Explain the role of sensors in a diagnostic device?
4. Discuss how advancements in prosthetic technology have impacted the treatment and rehabilitation of individuals with physical disabilities.
5. How could stem cell therapy be used to help regenerate damaged tissues for patients with spinal cord injuries in the future?

Additional Reading

QR Code 25

QR Code 26

QR Code 27

QR Code 28 (a)

QR Code 28 (b)

QR Code 28 (c)

QR Code 28 (d)

QR Code 29 test

QR Code 30

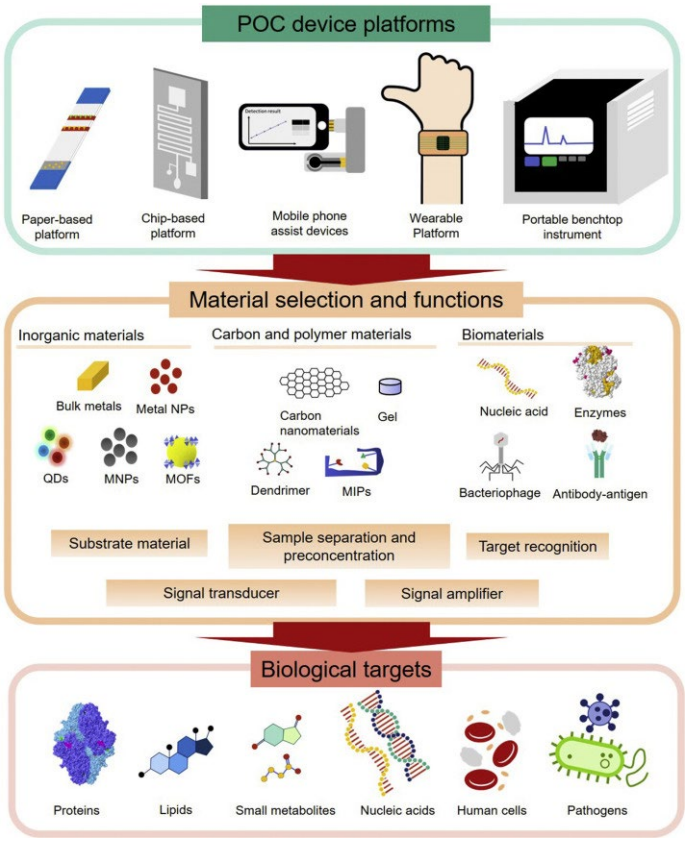


Figure 47: *Advancements of point-of-care (POC) testing platform for biomolecules (Manmana et al., 2021)*

APPENDIX F: NATURE OF MID-SEMESTER EXAMINATION FOR SEMESTER 2

20 items (MCQs) covering focal areas 13-17 for semester 2 as in the table of specifications. Use the table of specification as a guide.

Resources: Printer, A4 sheets, answer booklets, stationary, timers; for e-Assessment, consider a stable internet, computer, or tablet as well, etc.

Duration: 25 minutes.

Marking scheme: **1 mark for each correct answer. Total marks = 20 marks**

Task example

There are 20 items. Answer all questions. Each item is followed by four alternatives, A-D. Read each item carefully and select the best choice that bears the correct answer.

1. The primary difference between bacteria and viruses is that
   A. bacteria are living organisms, while viruses are non-living infectious agents.
   B. bacteria can only replicate inside living cells, while viruses cannot replicate.
   C. both bacteria and viruses are beneficial to human health.
   D. viruses are treated with antibiotics, while bacteria are not.
2. When untreated, syphilis can lead to severe complications affecting
   A. skin and heart.
   B. lung and brain.
   C. liver and lung.
   D. heart and brain.

Marking scheme: 1 mark for each correct key.

1. A. bacteria are living organisms, while viruses are non-living infectious agents.

2. D. heart and brain

Total exams score = 20 marks

TABLE OF SPECIFICATION FOR MID SEMESTER EXAMINATION

Week	Focal Area	Type of Question	Depth of Knowledge			
			L1	L2	L3	Total
13	Bacteria and Viruses – microscopic organisms that can cause disease.	Multiple choice	1	1	1	3
14	Bacterial and viral infections of the reproductive system	Multiple choice	1	1	1	3
	Treatment strategies for bacterial and viral infections	Multiple choice		1	1	2
15	The body's defence system – The immune system	Multiple choice		1	1	2
	Antigens and the Immune System	Multiple choice	1	1		2
16	Explore how antibiotics work in fighting bacterial infections.	Multiple choice	1	1	1	3
	What is antibiotic resistance?	Multiple choice	1	1		2
17	Global and social impact and control of some common infectious diseases.	Multiple choice	1	1	1	3
Total			**6**	**8**	**6**	**20**

SECTION 6: RESEARCH AND DESIGN IN BIOMEDICAL SCIENCE

STRAND: BIOMEDICAL INNOVATION

Sub-Strand: Research and Design in Biomedical Science

Learning Outcome: *Use scientific literature and statistics to design experiments and analyse results*

Content Standard: *Demonstrate understanding and application of a variety of biomedical experimental designs*

HINT

- *The recommended mode of assessment for week 24 is End of Second Semester Examination. See Appendix G at the end of this section for table of specification and other guidelines on how to develop assessment items for end of semester 2 examination. Strictly use it in developing all the questions.*
- *Ensure that all outstanding mandatory modes of assessment are accordingly recorded to the Student Transcript Portal.*

INTRODUCTION AND SECTION SUMMARY

In this section, the focus is on the innovative side of biomedical science. Learners will critically examine and compare scientific data from popular media sources with those found in scientific journals, helping them to differentiate between general and research-based information. They will also use specific statistical analysis methods to interpret and analyse results from experimental studies, applying their knowledge to draw accurate conclusions. This encourages critical thinking and enhances their ability to evaluate scientific data through practical application of analytical techniques.

The weeks covered by the section are:

Week 23: Critique and compare science data presented in popular media with data presented in scientific journals.

Week 24: Apply knowledge of specified statistical analysis methods to analyse the results of experimental studies.

SUMMARY OF PEDAGOGICAL EXEMPLARS

For this section, the following pedagogical exemplars are recommended to achieve learning outcomes and content standards. Using collaborative learning and in groups, learners assess two articles on similar topics from different sources. In teacher-moderated sessions using activity-based learning strategies, learners explore how to review scientific articles, calculate

basic statistical measures, and interpret results. Additionally, using structured talk-for-learning strategies, learners discuss dependent and independent variables of biomedical experiments.

SUMMARY OF ASSESSMENT

To assess learners' understanding of research and design in Biomedical Science, DOK levels 1, 2, 3, and 4 assessments are recommended. DOK level 1 focuses on recalling basic concepts such as distinguishing between scientific journals and popular media, naming a biomedical research journal, and identifying common types of data visualisation. At DOK level 2, learners' conceptual understanding is tested, including why peer review is essential in journals, how sensational headlines affect public perception of science, and how standard deviation measures data variability. DOK levels 3 and 4 assess strategic reasoning, asking learners to evaluate the credibility of scientific studies based on factors like publication source, sample size, and research methods. Learners also critically analyse published research papers, focusing on the appropriateness of statistical methods and the validity of the conclusions.

Week 23: Critiquing

Week 24: End of Second Semester Examination

WEEK 23

Learning Indicator: Critique and compare science data presented in popular media with data presented in scientific journals

Focal Area 1: Explore Differences Between Scientific Journals and Popular Media Sources When it Comes to Presenting Scientific Data

Scientific journals and popular media sources both present scientific data, but they do so in very different ways. Scientific journals are written by scientists for other scientists. For that reason, they use complex language and include lots of technical details about the research. This is because they need to be precise and accurate for other scientists to understand and build upon their work.

Popular media sources, like newspapers and magazines, are written for a wider audience. They use simpler language and focus on the main findings of the research. This is because they want to make the science easy to understand for people who are not scientists.

Provide examples of scientific data presented in both a scientific journal and a news article related to the same topic

Below is an example of how scientific data might be presented in a scientific journal and a popular media source:

Scientific Journal

Title: "The Effects of Caffeine on Cognitive Performance in Adolescents"

Data: "Participants were randomly assigned to receive either a placebo or 200 mg of caffeine. Cognitive performance was assessed using a series of standardised tests. Analysis of variance revealed a significant main effect of caffeine on reaction time ($F(1, 48) = 4.23$, $p = .045$))."

Popular Media Source

Headline: "Coffee Can Boost Brainpower in Teens"

Data: "A new study shows that drinking coffee can help teenagers think faster and more clearly."

Note

Present other examples to learners during the lesson and ask them to identify the differences. Comparison should be based on:

- Clarity and Specificity: How detailed and precise is the data presented?
- Context and Methodology: Does the source explain the study design and limitations?
- Overall tone: Is the focus on objective reporting or sensationalising findings?

Highlight the rigorous peer-review process of scientific journals to ensure data accuracy

Scientific journals use a rigorous peer-review process to ensure that the research they publish is accurate and reliable. This procedure involves the critical evaluation of submitted manuscripts by independent experts in the same field. The goal is to identify any potential flaws or biases in the research and ensure that the findings are supported by solid methodology and evidence.

The peer review process typically involves several steps.

1. First, the editor of the journal assigns the submitted manuscript to one or more reviewers who are experts in the relevant field. These reviewers carefully examine the manuscript, assessing the originality of the research, the appropriateness of the methods used, the validity of the conclusions drawn, and the overall clarity and presentation of the work. The reviewers may also suggest revisions or corrections to improve the quality of the manuscript.
2. Once the reviewers have submitted their reports, the editor carefully considers their feedback and makes a decision regarding the publication of the manuscript. If the reviewers have raised significant concerns, the author may be asked to revise the manuscript and resubmit it for further review. If the manuscript is deemed to be of high quality and meets the journal's standards, it will be accepted for publication.

This rigorous peer-review process helps to maintain the credibility and integrity of scientific research and ensures that only the most reliable and trustworthy findings are published in scientific journals.

Discuss the potential biases that can occur in popular media

Popular media sources may contain biases that influence how information is presented. These biases can include:

1. Confirmation bias, which occurs when people seek out and believe information that confirms their pre-existing beliefs.
2. Selection bias occurs when certain stories or perspectives are preferred over others, resulting in a skewed representation of the issue.
3. Sensationalism can also be a problem, as media outlets may exaggerate or sensationalise stories to attract attention, potentially distorting the truth.
4. Corporate bias can influence reporting, as media outlets may prioritise stories that align with the interests of their corporate sponsors.

Pedagogical Exemplars

Collaborative Learning: Present learners with two articles (one from public media and another from scientific journals) on the same topic (e.g., homoeopathy, infection, etc.) and lets the learners read these two articles. Working in groups, learners comment on the credibility, accuracy, and reliability based on the source (trustworthiness of the author or organisation), truthfulness and correctness of the information backed by evidence, and how correct the information is.

Activity-Based Learning: Guide learners in creating a checklist of the scientific article review process. After the creation of the checklist, moderate a discussion on the review process of scientific articles. Let learners then compare science data presented in popular media and in scientific journals in terms of using the checklist.

Key Assessment

Level 1 (Recall)

1. What is the main difference between a scientific journal and a popular media source?
2. Name one type of scientific journal that publishes biomedical research.

Level 2 (Conceptual understanding)

1. Explain why scientific journals often undergo peer review before publishing articles.
2. How can sensationalised headlines in popular media affect public perceptions of scientific research?

Level 3 (Strategic reasoning): Evaluate the credibility of a scientific study based on the following factors:

1. The journal where it was published
2. The sample size used
3. The research methods used

Level 4 (Extended critical thinking and reasoning): Research a topic in biomedical science (for example, genetically modified organisms or stem cell research) and analyse how it is presented in popular media versus scientific journals.

Learning Task

These tasks are to help learners develop critical thinking skills and evaluate the credibility of scientific information from various sources.

Materials needed for the task:

1. **Two articles:** one from the public media and one from a scientific journal on the same topic (a study on nutrition or an infection).
2. Whiteboard or chart paper
3. Markers or pens

Task:

1. Put learners into small groups and distribute the two articles to each group. Instruct them to read both articles carefully.
2. Ask each group to discuss the credibility of the source for each article. They should consider factors such as:
   a. **Trustworthiness of the author or organisation:** Is the author or organisation known for accurate and reliable information?
   b. **Evidence:** Does the article provide evidence to support its claims? Are the sources cited credible?
   c. **Accuracy and reliability:** Is the information presented consistent with other reputable sources?
3. Guide groups to evaluate the accuracy, truthfulness, and correctness of the information presented in each article. They should consider factors such as:

a. **Consistency with scientific evidence:** Does the information align with established scientific knowledge?

b. **Logical reasoning:** Are the arguments presented logical and well-supported?

c. **Bias:** Are there any signs of bias or prejudice in the article?

4. Have learners in their groups compare the information presented in the two articles. Facilitate a discussion on the differences between popular media articles and scientific journal articles in terms of:

   a. **Depth of information:** How detailed is the information presented?

   b. **Target audience:** Who is the intended audience for each article?

   c. Language and style: How is the information presented (e.g., jargon, simple language)?

WEEK 24

Learning Indicator: *Apply knowledge of specified statistical analysis methods to analyse the results of experimental studies*

Focal Area 1: Basic Statistical Concepts Relevant to Analysing Data in Biomedical Research

Explain the concept of dependent and independent variables

When conducting scientific research, it's important to identify the variables involved in the study. **Dependent variables** are the outcomes or responses that are measured, while **independent variables** are the factors that are manipulated or controlled by the researcher. By understanding these variables, we can better analyse the relationship between them and draw meaningful conclusions from our data.

Independent variables are factors that are manipulated or controlled by the researcher. They are the "causes" or "inputs" in a study.

Dependent variables are the outcomes or responses that are measured in response to changes in the independent variables. They are the "effects" or "outputs" of the study.

Example

A study on the effects of fertiliser on plant growth

1. Independent variable: The amount of fertiliser applied to the plants.
2. Dependent variable: The height of the plants.

Data set:

Fertiliser Amount (g/plant)	Plant Height (cm)
0	10
5	15
10	20
15	25
20	30

In this example, the amount of fertiliser is the independent variable, and the plant height is the dependent variable. The researcher manipulates the fertiliser amount and measures the corresponding plant height to determine the relationship between the two.

Note

Notify learners through a discussion on experimental and control groups used in biomedical research

Discuss some statistical terms used in scientific research

In biomedical science, statistics is an essential tool used in analysing data. There are several software programs, such as GraphPad Prism, Excel, SPSS, and MATLAB, that are used in computing statistical data. However, there are certain basic concepts that should be discussed to support understanding of statistical analysis. These are discussed briefly below.

1. **Measures of central tendency** (mean, median, mode): these provide a single value to represent the typical or central value of a dataset. The *mean* is the sum of all values divided by the number of values. The *median* is the middle value when the data is arranged in order. The *mode* is the value that appears most frequently.

Note

Give learners a set of numbers and ask them to identify the measures of central tendencies

2. **Measures of variability** (range, standard deviation): Measures of variability quantify how spread out the data is. The *range* is the difference between the largest and smallest values. Standard deviation measures how much the data points deviate from the mean. A higher standard deviation indicates greater variability.
3. **Hypothesis testing** (p-values): This is a statistical method used to determine if a hypothesis about groups being studied has a real difference between the groups or conditions being studied. It involves setting up a null hypothesis (no difference) and an alternative hypothesis (there is a difference). A p-value is calculated to assess the evidence against the null hypothesis. A p-value less than 0.05 is typically considered to be statistically significant, in which case the null hypothesis should be rejected. A p-value greater than 0.05 means that deviation from the null hypothesis is not statistically significant, and the null hypothesis is not rejected.

For example, the effect of caffeine found in energy drinks on the cognitive performance of adolescents was studied. Two groups were tested. **Group A (caffeine group)**: participants received a caffeine-laced drink before a blood test, and **Group B (placebo group)**: participants got purified water before a blood test. This exercise was carried out every morning for 20 days. The p-value obtained was $p = 0.045$. Since this is less than the commonly used significance level of 0.05, it suggests that the observed difference in reaction time between the caffeine and placebo groups is statistically significant and is unlikely to be due to chance.

Focal Area 2: Observe and Analyse Sample Data Sets

Analyse simplified data sets from biomedical research (for example, drug trial results)

In biomedical research, experiments are carried out in replicates over a period of time. For example, in drug trial tests, samples are tested mostly three times to ensure accuracy. In analysis of data sets, software programs mentioned earlier, like Excel and GraphPad Prism, can be used by entering data. Some parameters that may be calculated using these programs are standard deviation (SD), standard error mean (SEM), and p-value to compare samples within a data set.

After all data has been collected, data may be beautifully visualised using the same software or other programs (for example, Databox, PowerBI, Tableau Public, and Infogram), such as those that develop interesting and eye-catching visuals for data (see Figure 48), which makes

it easier to interpret and present the results of a study. Some of the graphs that may be used in data visualisation include:

Bar charts, pie charts, histograms, area charts, line charts, scatter plots, box plots, tree maps, and box charts.

Figure 48: *Examples of different types of data visualisation*

Learning Task

Below is an example of a study that learners may practice, applying the scientific method (observation, forming a hypothesis, and analysing data) to arrive at a conclusion of the study.

Note

Guide learners in a discussion in answering the questions below.

Effect of Abraxane on Stage 1 pancreatic cancer cells and weight gain.

This study aimed to investigate the effects of a new drug (Abraxane) on pancreatic cancer cells and the weight gain. We used animal models: wild-type (WT) mice without cancer and knockout (KO) mice with throat cancer. The drug was tested on both groups of mice at the same time, one hour after they were fed the same diet for three days. Tissue samples were collected from mice 8 hours after drug administration on each of the test days. The weights of mice were taken each day before administration of the drug and at the time of collection of the sample, and the mean weight was calculated. Samples (pancreatic cells) were then tested using both immunoblotting and fluorescent imaging techniques to evaluate the effect of the drug. Table 3 shows the results obtained after tests were run on samples collected for 3 days. Using appropriate software, guide learners to analyse the data and determine if the drug had a significant effect on cancer cells. A p-value of 0.05 can be used as a threshold to assess the statistical significance of the findings.

Note

Learners should formulate a hypothesis before analysing data.

Table 3

Sample no.	Sample	Weight/kg (Day 1, Day 2, and Day 3)	Day 1	Day 2	Day 3
1	WT	3.2, 3.0, 2.8	0.302	0.285	0.312
2	KO	2.5, 2.6, 2.5	0.257	0.323	0.30
3	WT	2.7, 3.4, 3.3	0.219	0.317	0.259
4	KO	3.2, 2.8, 2.6	0.246	0.229	0.281
5	WT	3.0, 2.6, 3.1	0.237	0.249	0.232
6	KO	2.7, 2.5, 2.3	0.264	0.314	0.313

1. After computing the p-value, was your hypothesis true or not?
2. According to the study, is there a dependent variable and an independent variable? If there are any, what are they?
3. Do you think there are any limitations in the study according to the data presented?

Pedagogical exemplars

Structured Talk for Learning: Learners engage in a discussion on the explanation and identification of dependent and independent variables of a sample biomedical study. Discuss statistical measures and the effect of sample size on the representation of a population.

Activity-Based Learning: Using data from the study, learners calculate measures of central tendency (mean, mode, and median) and measures of variability (range, variance, and standard deviation). On scatter plots or histograms, learners are tasked with changing scales on the y-axis (ordinate) for the same data and observe how changes in scale may exaggerate or diminish an outcome.

Key Assessment

Level 1 (Recall)

1. What is the mean of a data set?
2. Name two types of graphs commonly used to visualise data.

Level 2 (Conceptual understanding)

1. Describe how the standard deviation is used to measure the variability of data.
2. In the data set below, indicate the dependent and independent variables. Explain your choices.

The Effect of Studying Hours on Exam Scores

Student	Hours Studied	Exam Score
A	5	75
B	10	85
C	3	65
D	8	90
E	12	95

Level 3 (Strategic reasoning)

With the research question "Does a new drug (Drug X) improve patient outcomes compared to a standard treatment for a specific disease?"

1. Generate a null (no improvement) and alternative (improvement) hypothesis for the study.
2. Design an experiment considering the following:
    a. Sampling size
    b. Experimental and control group
    c. Patient outcomes that will be measured (for example, disease progression, etc.)
    d. Duration of study
3. Draw up a probable data set and analyse data using appropriate software.

Level 4 (Extended critical thinking and reasoning): Critically evaluate a published research paper, focusing on the appropriateness of the statistical methods used and the validity of the conclusions drawn

SECTION 6 REVIEW

This section is for review of all the lessons taught for the last two weeks. A summary of what should have been taught and what each learner should have learnt if differentiation has been done.

1. Why is peer review important in the publication process of scientific journals, and how does this influence the credibility of the data presented?
2. How is the mean of a data set calculated, and why is it important in summarising biomedical research data?
3. What does standard deviation tell us about the variability of data in a biomedical experiment, and how can it affect the interpretation of research results?
4. How are bar graphs and scatter plots commonly used to visualise biomedical research data, and when would each be most appropriate?

APPENDIX G: END OF SECOND SEMESTER EXAMINATION

1. The examination will cover all focal areas from weeks 13 to 24 of the second semester, following a distribution of 30% DOK 1, 40% DOK 2, and 30% DOK 3 for each paper.
2. **Paper 1**: 50 multiple choice questions.
3. **Paper 2**: Essay type questions including short answer questions consisting of
   a. Part A: 1 compulsory question (20 marks).
   b. Part B: 4 questions from which learners will answer only 2 (15 marks per question).
4. **Practical Work, Demonstration or Project-Based**: There will be practical work or demonstration by learners in the end of semester 2 examination which will be scored at 40%. Select one based on the availability of resources.

Resources: Printer, A4 sheets, A large exam room, answer booklets, stationary, timers; for e-Assessment, consider a stable internet, computer, or tablet; diagnostic tools and devices, scientific journals vs. popular media article, prosthetics vs orthotics

Duration: 2 hours for paper 1 and 2, and 1 hour for paper 3

Mark scheme breakdown

Paper 1 = 50 marks

Paper 2 = 50 marks

Total marks for paper 1 + 2 = 100 marks; strike this to 60%

Practical work, project-based or demonstration = 40 marks

Therefore, final exam marks = 60% + 40% = 100%

Note

Please strictly follow the 30% DOK 1, 40% DOK 2, and 30% DOK 3 distribution whenever you are setting tasks for the mid-semester and end-of-semester examinations, using a table of test specifications that includes the focal areas covered and their DoK levels

Sample Table of Test Specification for End of Second Semester Examination

Weeks	*Focal Areas*	*Type of question*	*Depth of Knowledge*			
			L1	*L2*	*L3*	*Total*
13	*Bacteria and Viruses – microscopic organisms that can cause disease.*	*Multiple choice*	*1*	*1*	*1*	*3*
14	*Bacterial and viral infections of the reproductive system*	*Multiple choice*	*1*	*2*		*3*
	Treatment strategies for bacterial and viral infections	*Multiple choice*	*1*	*1*		*2*
		Essay type	*1*			*1*

15	The body's defence system – The immune system Antigens and the Immune System	Multiple choice Multiple choice	1 1	1 1	1 1	3 3
16	Explore how antibiotics work in fighting bacterial infections. What is antibiotic resistance?	Multiple choice Multiple choice Essay type	1 1	1 1	1 1 1	3 3 1
17	Global and social impact and control of some common infectious diseases.	Multiple choice		1	1	2
18	A broad overview of how technology is used in healthcare delivery	Multiple choice	1	1	1	3
19	Diagnostic devices and their functional components Understanding biological principles and the technology used to build some types of diagnostic devices	Multiple choice Multiple choice Essay type	1 1	1 1 1	1 1	3 3 1
20	Prosthetics vs. Orthotics: Understanding the Difference.	Multiple choice	1	1	1	3
21	Introduction to cancer and its different types Treatment Options for Cancer Emotional and Mental Impact of Cancer	Multiple choice Multiple choice Multiple choice	1	1 1 1	1 1	2 2 2
22	Future Applications of Regenerative Medicine for Disabilities	Multiple choice Essay type	1	1 1	1	3 1
23	Explore differences between scientific journals and popular media sources when it comes to presenting scientific data.	Multiple choice	1	1	1	3
24	Basic statistical concepts relevant to analysing data in biomedical research Observe and Analyse Sample Data Sets	Multiple choice Multiple choice	1	1 1	1	2 2
Total: Multiple Choice			15	20	15	50
Essay type			1	2	1	4
			30%	40%	30%	

Sample End of Second Semester Assessment

PAPER 1

[50marks]

This paper consists of 50 items. Answer all questions. Each item is followed by four alternatives, A-D. Read each item carefully and select the best choice that bears the correct answer.

1. Cytokines contribute to the body's immune response by
   A. creating physical barriers at the site of infections.
   B. killing pathogens directly in victims with infections.
   C. producing more antibodies to the site of infection.
   D. recruiting more immune cells to the site of infection.
2. One common application of skin grafts is for
   A. healing first-degree burns in victims.
   B. repairing damaged nerves in victims.
   C. treating burn victims with severe injuries.
   D. treating heart disease to reduce deaths.

PAPER 2

This paper consists of two parts, A and B. Answer **question 1** in part A and any **other two** from part B. Award will be given to clarity of expression.

Part A
[20 marks]
Answer all questions

1.
   a. Discuss the three types of tissue grafts used in regenerative medicine. [6marks]
   b. Explain the difference between embryonic stem cells and adult stem cells in terms of their sources and capabilities. [4marks]
   c. Describe the purpose of a skin graft in the treatment of burn victims. [5marks]
   d. Analyse the role of scaffolds in tissue engineering for nerve injuries? [5marks]

Part B
[30marks]
*Answer **only two** questions from this part.*

2.
   a. Why is it important to find and treat infections like Syphilis and HIV early? [5marks]
   b. Discuss the function(s) of the following clinical diagnostic devices:
      i. Clinical centrifuge
      ii. Clinical laboratory incubator
      iii. Computed Tomography (CT) scan
      iv. Ultrasound scanners
      v. X-ray machine [10marks]

Part C

[40 marks]

Practical Work, Project-Based or Demonstration

Duration: 1 hour

Answer ***all*** questions. All safety measures should be strictly adhered to throughout this session. (Provide the diagnostic devices where necessary and allow learners to identify the various components and demonstrate their usage, they can also work with diagnostic test kits, etc.)

Scenario

A local clinic has recently acquired two types of diagnostic devices: a rapid test kit for malaria and a digital blood glucose monitor. Your task is to analyse these devices based on their functional components and the biological principles involved.

a. Identify the key functional components of both the rapid test kit for malaria and the digital blood glucose monitor. For each device, explain how these components work together to achieve accurate diagnostics.

b. Discuss the biological principles that underlie the functioning of the rapid test kit for malaria. How do these principles relate to the detection of the malaria parasite?

c. Describe the technology used in both diagnostic devices. How does this technology enhance the accuracy and efficiency of diagnostics in the Ghanaian healthcare setting?

d. Analyse how the availability of these diagnostic devices impacts healthcare delivery in Ghana. Consider factors such as accessibility, speed of diagnosis, and patient outcomes.

Mark scheme for the assessment sample

Paper 1 (MCQs): 1 mark for each correct answer

The right key for

1. D. recruiting more immune cells to the site of infection. 1 mark
2. C. treating burn victims with severe injuries. 1 mark

Total score for paper 1 (MCQs) = 50 marks
Expected responses for Paper 2

Part A

1.

a. Autografts (patient's own tissue), allografts (tissue from another person), and xenografts (tissue from an animal). 6 marks

b. Embryonic stem cells develop from an embryo and can differentiate into various cell types, while adult stem cells are found in tissues like bone marrow and can replace damaged cells but do not form new tissue. 4 marks

c. A skin graft involves taking a piece of healthy skin and attaching it to an area of burned skin to promote healing and restore functionality, especially in cases of severe burns. 5 marks

d. Scaffolds provide a supportive structure that allows communication between nerve ends, helping the regeneration of nerve tissue and improving healing in cases of large gap defects. 5 marks

Part B

2.

a. **Syphilis:** Initial treatment can cure the infection with antibiotics, preventing serious health problems like damage to the heart, brain, and other organs. If left untreated, these complications can be severe.

HIV: Initial treatment with antiretroviral therapy (ART) helps people manage the virus and stay healthy. It also reduces the risk of spreading the virus to others. 5 marks

Or

General Importance: Finding and treating these infections early helps protect the individual's health and prevents the infections from spreading in the community. Timely treatment can save lives and improve the quality of life for those affected.

b.

i. **X-ray Machine:** Creates images of the inside of the body to help find injuries and conditions. 2 marks

ii. **Ultrasound Scanners:** Uses sound waves to produce images of organs and tissues, often used during pregnancy. 2 marks

iii. **Computed Tomography (CT) Scan:** Combines X-ray images to create detailed cross-sectional pictures of the body. 2 marks

iv. **Clinical Centrifuge:** Spins samples to separate their components based on density, such as blood parts. 2 marks

v. **Clinical Laboratory Incubator:** Provides a controlled environment to grow bacteria or cells for testing. 2 marks

Q1 = 15 marks

Total score for Paper 2 = 50 marks

Expected responses for Paper C

a. 2 marks for each correct component and function

Rapid Test Kit for Malaria

- **Test Strips:** Contain antibodies that specifically bind to malaria antigens.
- **Sample Chamber:** Where the blood sample is placed for testing.
- **Control Line:** Indicates whether the test has functioned correctly.
- Result Line: Shows whether malaria antigens are present.

Digital Blood Glucose Monitor

- **Test Strips:** Contain enzymes that react with glucose in the blood sample.

- **Meter Display:** Shows the glucose level reading.
- **Lancing Device:** Used to prick the skin and obtain a blood sample.
- **Battery/Power Source:** Powers the device for operation.

Explanation: In the rapid test kit, the antibodies in the test strips bind to malaria antigens if present, showing a result on the test line. In the blood glucose monitor, the enzymes react with glucose, producing an electrical signal that the meter converts into a reading displayed on the screen. 4 marks

b. **Rapid test kit for malaria**

The kit works on the principle where antibodies specific to malaria antigens are used to detect the presence of the parasite in the blood. This principle allows for quick identification of malaria infections, enabling prompt treatment. 5 marks

c. **Technology in Diagnostic Devices**

Rapid test kit for malaria: Utilises lateral flow technology, which allows for rapid results without the need for laboratory equipment. The simplicity of the design promotes easy use in remote areas, making it ideal for healthcare settings in Ghana. 5 marks

Digital blood glucose monitor: Employs electrochemical technology to provide accurate and quick glucose readings. This technology enhances patient self-monitoring and management of diabetes, crucial in areas with limited access to healthcare facilities. 5 marks

d. **Implications for Healthcare**

The availability of these diagnostic devices significantly improves healthcare delivery in Ghana by:

Accessibility: Rapid test kits can be used in remote clinics, reducing the time to diagnosis for malaria.

Speed of diagnosis: Quick results from both devices allow for immediate treatment decisions, which can improve patient outcomes.

Patient outcomes: Early detection and management of malaria and diabetes can reduce complications, hospitalizations, and overall healthcare costs. 5 marks

Total score for practical = 40 marks

Total MCQs = 50marks (paper 1)

Total essay question marks=50marks (paper 2)
Total marks for paper 1+2=100 marks; strike this to 60%
Practical work = 40%
Final exam mark = 60% + 40% = 100%

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