MINISTRY OF EDUCATION

Biomedical Science

TEACHER MANUAL

YEAR 1 - BOOK 1

NATIONAL COUNCIL FOR CURRICULUM & ASSESSMENT OF MINISTRY OF EDUCATION

MINISTRY OF EDUCATION

REPUBLIC OF GHANA

Biomedical Science

Teacher Manual

Year One - Book One

NATIONAL COUNCIL FOR CURRICULUM & ASSESSMENT OF MINISTRY OF EDUCATION

BIOMEDICAL SCIENCE TEACHERS MANUAL

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INTRODUCTION

The National Council for Curriculum and Assessment (NaCCA) has developed a new Senior High School (SHS), Senior High Technical School (SHTS) and Science, Technology, Engineering and Mathematics (STEM) Curriculum. It 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 of Biomedical covers all aspects of the content, pedagogy, teaching and learning resources and assessment required to effectively teach Year One of the new curriculum. It contains this information for the first 12 weeks of Year One, with the remaining 12 weeks contained within Book Two. Teachers are therefore to use this Teacher Manual to develop their weekly Learning Plans as required by Ghana Education Service.

Some of the key features of the new curriculum are set out below.

Learner-Centred Curriculum

The SHS, SHTS, and STEM curriculum places the learner at the center of teaching and learning by building on their existing life experiences, knowledge and understanding. Learners are actively involved in the knowledge-creation process, with the teacher acting as a facilitator. This involves using interactive and practical teaching and learning methods, as well as the learner's environment to make learning exciting and relatable. As an example, the new curriculum focuses on Ghanaian culture, Ghanaian history, and Ghanaian geography so that learners first understand their home and surroundings before extending their knowledge globally.

Promoting Ghanaian Values

Shared Ghanaian values have been integrated into the curriculum to ensure that all young people understand what it means to be a responsible Ghanaian citizen. These values include truth, integrity, diversity, equity, self-directed learning, self-confidence, adaptability and resourcefulness, leadership and responsible citizenship.

Integrating 21st Century Skills and Competencies

The SHS, SHTS, and STEM curriculum integrates 21st Century skills and competencies. These are:

- **Foundational Knowledge:** Literacy, Numeracy, Scientific Literacy, Information Communication and Digital Literacy, Financial Literacy and Entrepreneurship, Cultural Identity, Civic Literacy and Global Citizenship
- **Competencies:** Critical Thinking and Problem Solving, Innovation and Creativity, Collaboration and Communication
- **Character Qualities:** Discipline and Integrity, Self-Directed Learning, Self-Confidence, Adaptability and Resourcefulness, Leadership and Responsible Citizenship

Balanced Approach to Assessment - not just Final External Examinations

The SHS, SHTS, and STEM curriculum promotes a balanced approach to assessment. It encourages varied and differentiated assessments such as project work, practical demonstration, performance assessment, skills-based assessment, class exercises, portfolios as well as end-of-term examinations and final external assessment examinations. Two levels of assessment are used. These are:

- Internal Assessment (30%) – Comprises formative (portfolios, performance and project work) and summative (end-of-term examinations) which will be recorded in a school-based transcript.
- External Assessment (70%) – Comprehensive summative assessment will be conducted by the West African Examinations Council (WAEC) through the WASSCE. The questions posed by WAEC will test critical thinking, communication and problem solving as well as knowledge, understanding and factual recall.

The split of external and internal assessment will remain at 70/30 as is currently the case. However, there will be far greater transparency and quality assurance of the 30% of marks which are school-based. This will be achieved through the introduction of a school-based transcript, setting out all marks which learners achieve from SHS 1 to SHS 3. This transcript will be presented to universities alongside the WASSCE certificate for tertiary admissions.

An Inclusive and Responsive Curriculum

The SHS, SHTS, and STEM curriculum ensures no learner is left behind, and this is achieved through the following:

- Addressing the needs of all learners, including those requiring additional support or with special needs. The SHS, SHTS, and STEM curriculum includes learners with disabilities by adapting teaching and learning materials into accessible formats through technology and other measures to meet the needs of learners with disabilities.
- Incorporating strategies and measures, such as differentiation and adaptative pedagogies ensuring equitable access to resources and opportunities for all learners.
- Challenging traditional gender, cultural, or social stereotypes and encouraging all learners to achieve their true potential.
- Making provision for the needs of gifted and talented learners in schools.

Social and Emotional Learning

Social and emotional learning skills have also been integrated into the curriculum to help learners to develop and acquire skills, attitudes, and knowledge essential for understanding and managing their emotions, building healthy relationships and making responsible decisions.

Philosophy and vision for each subject

Each subject now has its own philosophy and vision, which sets out why the subject is being taught and how it will contribute to national development. The Philosophy and Vision for Biomedical Science is:

Philosophy: Every learner can be equipped to excel in the pursuit of further studies and/or working life in the Biomedical Science domain through comprehension of foundational concepts, problem-based inquiry, experimentation and ethical development of clinically translatable solutions to healthcare delivery in a well-supported Teacher-Learner Environment.

Vision: Learners equipped with 21st century skills and competencies will understand the core Biomedical Science principles and research techniques required to define healthcare challenges and develop interventions and innovations to human health conditions.

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BIOMEDICAL SCIENCE SUMMARY

S/N	STRAND	SUB-STRAND	YEAR 1			YEAR 2			YEAR 3		
			CS	LO	LI	CS	LO	LI	CS	LO	LI
1	Biomedical Science In Society	Biomedical Science Practice	1	1	3	1	1	3	1	1	3
		Biosafety	1	1	3	1	1	3	1	1	3
2	Human Body System	Anatomy and Physiology	1	1	3	1	1	3	1	1	4
		Diseases and Disorders	1	1	3	2	2	7	1	1	4
3	Biomedical Intervention	Diagnostic Devices	1	1	3	1	1	3	1	1	3
		Therapeutic Devices	1	1	3	1	1	3	1	1	3
4	Biomedical Innovations	Research and Design In Biomedical Science	1	1	4	1	1	4	-	-	-
Total			**7**	**7**	**22**	**8**	**8**	**26**	**6**	**6**	**20**

OVERALL TOTALS (SHS 1 – 3)

Content Standards	**21**
Learning Outcomes	**21**
Learning Indicators	**68**

SECTION 1: INTRODUCTION TO BIOMEDICAL SCIENCE

Strand: **Biomedical Science in Society**

Sub-Strand: Biomedical Science Practice

Content Standard: Demonstrate understanding of Biomedical Science

Learning Outcome: *Describe what Biomedical Science is and how scientific investigation is applied in Biomedical Science*

INTRODUCTION AND SECTION SUMMARY

This section introduces learners to the concept of biomedical science, biomedical science practice and how it is applied to solve problems in society through scientific investigation. At the end of this section, learners are expected to know that Biomedical Science is the application of science and biology to medical practice, involving research, analysis and technological tools to identify problems in society and develop new solutions for human health and well-being. Biomedical Science combines knowledge from other fields of science such as biology, chemistry, physics, physiology, and medicine. It focuses on applying scientific knowledge and techniques to investigate the causes, mechanisms, and treatments of health-related problems.

The weeks covered by the section are:

Week 1: *Describe what biomedical science is.*

Week 2: *Identify problems in society that can be solved by applying biomedical science.*

Week 3: *Explain how the scientific method can be applied to undertake investigations or address problems in biomedical science.*

SUMMARY OF PEDAGOGICAL EXEMPLARS

To help all categories of learners understand the concept of biomedical science, its practice and application, different pedagogical exemplars are recommended for teaching the content of this section. These are digital learning, talk-for-learning, collaborative learning, problem-based learning and structuring-talk-for-learning. Through digital learning platforms, learners watch pictures and videos of Biomedical Scientists in practice. Using talk-for-learning, collaborative learning, and structured-talk-for learning, guide learners to discuss the roles played by Biomedical Scientists in their society. Different pedagogical exemplars will help learners acquire foundational knowledge about biomedical science, Biomedical Science practice and products. All categories of learners are expected to be able to demonstrate an understanding of biomedical science.

ASSESSMENT SUMMARY

Considering the content standard for this section, formative and diagnostic assessments are recommended. A formative assessment evaluates learners' learning outcomes and identifies areas for improvement. Information on learners' progress on content and misunderstanding is also identified and clarified. Learners should be encouraged to ask questions for further classification and understanding of the subject content. The following strategies are recommended for formative assessment: oral or written quizzes and homework. Diagnostic assessment should be used to gather information about learners' prior and current knowledge. A diagnostic assessment will help identify learning gaps in

a learning area to inform teaching and learning. Examples of diagnostic assessment strategies are question and answer, short quizzes and group discussions. Because of the different ability levels of learners, the depth of knowledge (DOK) levels should be applied to crafting questions and answers. Closed-ended questions should be asked at Level 1 with an expected "Yes or No" and "True or False" response. Open-ended questions that begin with words like "what," "why," or "how." should be asked at Level 2 to test learners' conceptual understanding. Probing questions to test learners' strategic thinking abilities should be asked at Level 3. Questions requiring extended critical thinking and reasoning should be asked at Level 4.

Week 1

Learning Indicator(s): *Describe what Biomedical Science is.*

Theme/Focal Area (s) 1: Definition and Description of biomedical science

Biomedical Science can be defined as:

- an integration of biology, chemistry, physics, physiology, and medicine to improve health (See **Fig. 1**).
- an application of science concepts to develop new solutions for human health and well-being.
- application of scientific knowledge and techniques to investigate the causes, mechanisms, and treatments of health-related problems (See **Fig. 2**).

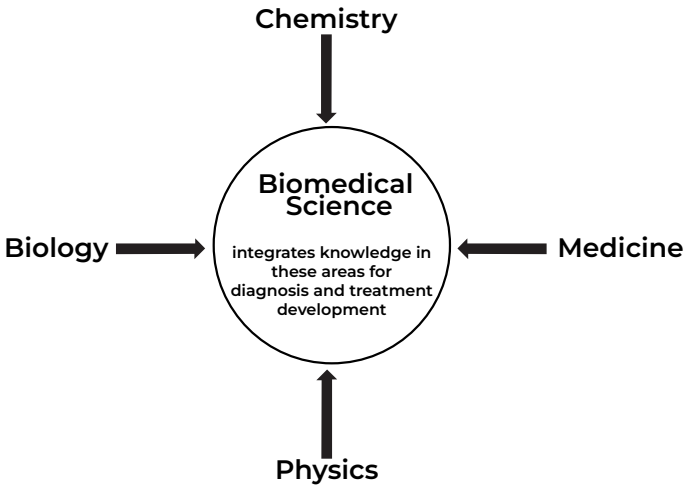

Fig. 1: *Scope of Biomedical Science*

Fig. 2: *A biomedical scientist (Balaban, 2017)*

Key features of Biomedical Scientist

1. Good scientific knowledge
2. Critical thinking and problem-solving skills
3. Ethical behaviour awareness
4. Good communication skills
5. Ability to work in teams
6. Attention to details
7. Commitment to public health

Theme/Focal Area (s) 2: **Biomedical Scientists in practice and the products of Biomedical Science.**

Biomedical Scientists play a crucial role in advancing healthcare, conducting research, and developing new treatments and technologies to improve human health. These are potential careers in Biomedical Science: Nutritionists, physiotherapists, neuroscientists, medical laboratory technicians, microbiologists, biomedical engineers, pharmaceutical scientists, biostatisticians, forensic scientists and genetic counselling.

Discuss personal experiences with Biomedical Scientists and/or products of Biomedical Science.

1. Learners share their experiences with biomedical scientists for example, doctors, nurses, medical laboratory scientists, physiotherapists and physician assistants.
2. Learners share their experiences with biomedical products for example, vaccines, dental braces, crutches, inhalers, wheelchairs, spectacles, hearing aids, Plaster of Paris (POP), dental implants, infusion pumps, glucometers, Rapid Diagnostic Test (RDT) kits (for example malaria test kits, covid test kits and pregnancy test kits).

Products of Biomedical Science.

Biomedical Science encompasses a wide range of products that contribute to various aspects of healthcare, research, and medical advancements. Examples of products of Biomedical Science are as follows:

Diagnostic tools and devices:

Fig. 3: *(a) An X-ray image showing a fractured ankle (Kim et al, 2021)*

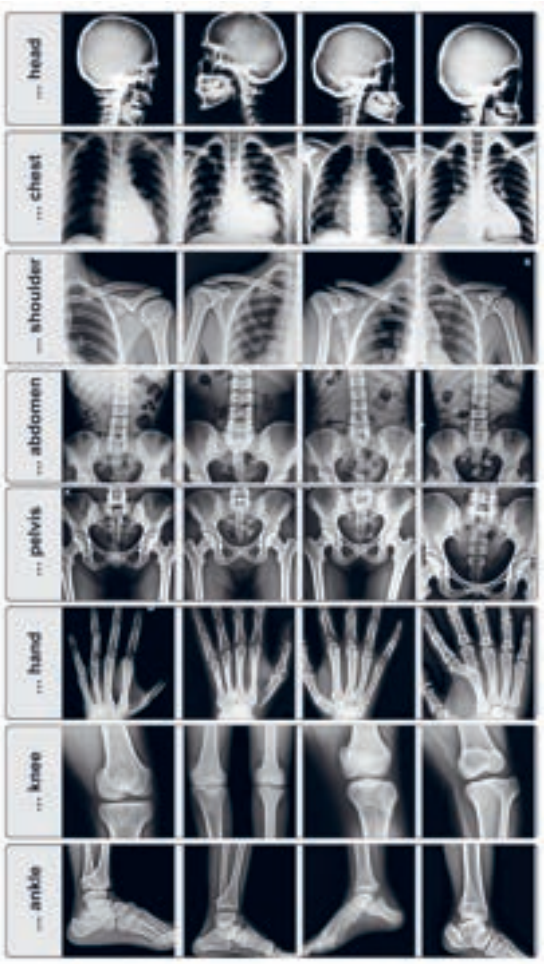

Fig. 3: *(b) X-ray images of different anatomical parts (Adams et al, 2022)*

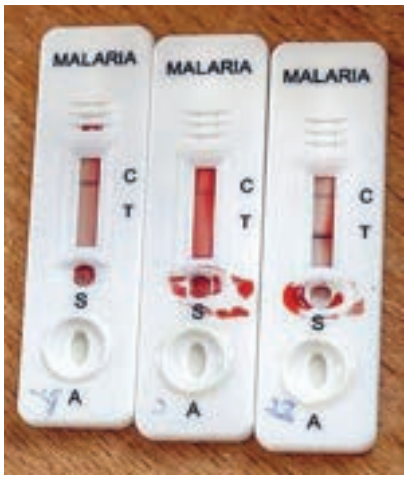

Fig. 4: *Diagnostic kit (Ferraiolo, 2018)*

Drugs (medicine):

Fig. 5: *Medicines (Hammett, Nd)*

Assistive devices and implants:

Fig. 6: *Prosthetic leg (Legs for Africa, 2021)*

Fig. 7: *Wheelchair (Advocacy Project, 2011)*

Fig. 8: *Tooth implant (Borba, 2020)*

Theme/Focal Area 3: Misconceptions of Biomedical Science.

1. Misconception: Biomedical Science is the same as medical practice.

   Fact: *Biomedical scientists support medical practice but they are not directly involved in patient care or treatment.*

2. Misconception: Biomedical Science is only for those pursuing medical careers.

   Fact: *Biomedical Science offers a diverse range of career paths beyond traditional medical professions.*

3. Misconception: Biomedical Science is only about finding cures.

   Fact: In addition to finding cures, Biomedical Scientists investigate the underlying causes of diseases, study their mechanisms, develop diagnostic tools, and contribute to understanding human health and disease.

4. Misconception: Biomedical scientists are solely focused on human health.

   Fact: Though the primary focus of Biomedical Science is human health, biomedical scientists may study other living organisms to gain insights and develop treatments and interventions for human diseases.

Pedagogical Exemplars

Digital learning: As a whole class activity, watch videos and pictures (**refer to QR Codes 1 and 2 in Additional Reading**) of biomedical scientists in practice as well as the products of Biomedical Science. Videos should contain mixed gender showing the various careers of biomedical scientists in practice. Consider and provide further explanation to support learners who might struggle with the content of the video to reinforce learning.

Talk-for-learning: Through a whole class session, discuss observations made and relate them to personal experiences with biomedical scientists and/or products of Biomedical Science. In mixed-ability groups, a diversity of opinions must be accepted as they share their personal experience with a biomedical scientist and/or product. Use probing or leading questions to seek feedback or clarification from learners.

Collaborative learning: Through think-pair-share, identify the key features of Biomedical Science as a field of study and outline some misconceptions about the subject. Learners exhibit leadership roles and responsibilities for various tasks assigned to individual members of the group.

Assessment

Level 1 (Recall)

Indicate if each of the following statements is True or False.

1. Biomedical Science combines elements of biology and medicine to understand human health and diseases.
2. Biomedical Science always deals with issues relating to the health sector.
3. Biomedical scientists are neither biologists nor chemists.
4. Biomedical Science is the same as clinical medicine.

Level 2 (Conceptual understanding)

1. What is Biomedical Science?
2. List three sectors where biomedical scientists work.
3. List four products of biomedical scientists.

Level 3 (Strategic reasoning)

1. From your knowledge of what biomedical Science is, state at least two misconceptions of biomedical science in our society and justify why they are conceptions.
2. How will your newly acquired understanding of Biomedical Science address the misconceptions about careers and products of biomedical science?
3. Create a mind map to relate at least three careers in Biomedical Science and the work they do.

Learning Tasks for Practice

1. Learners watch videos and identify at least three careers and products of biomedical science.
2. Learners observe and identify some products of Biomedical Science used in any of these experiments, for example, ABO grouping, a sickling test, and a Rapid diagnostic test for malaria by a teacher or laboratory technician.

Conclusion

Throughout history, Biomedical Science has been a collaborative effort involving contributions from various cultures, disciplines and individuals. It has transformed our understanding of health and disease and has led to significant improvements in medical care and quality of life. The field continues to evolve and future breakthroughs hold the promise of even more advancements in healthcare.

Week 2

Learning Indicator(s): *Identify problems in society that can be solved by applying biomedical science.*

Theme/Focal Area 1: Identify problems within society and explain how Biomedical Science can be applied to solve these problems.

Guide learners to select any biomedical science-related problem in their society, examples; sanitation problems such as choked gutters, defecation into water bodies, improper disposal of refuse/waste, diseases such as COVID-19, cholera, tuberculosis, malaria, elephantiasis, diarrhoea, dysentery and disorders such as diabetes, hypertension, asthma, arthritis and cancer and discuss how they can be treated or controlled.

Below are some health challenges in our society and how Biomedical Science may be applied to tackle them:

1. Unsafe medicines and herbal concoctions: develop safe medicines for the population through drug formulation and engage in public education on medicine use.
2. Environmental pollution: investigating the impact of pollutants on the development and progression of diseases and contributing to the development of ways such as determining safe exposure limits, environmental health education, and developing biodegradable materials for medical devices and packaging to protect public health.
3. Failed organs or non-functioning body parts: design and develop artificial organs to replace them.
4. Nutrient deficiency disease: nutritionist or dietician advice on the type of diet that must be taken to improve health.
5. Wrong drug dosage: health education on the importance of appropriate dosage of drugs to prevent overdose, under-dose, and abuse of drugs.
6. Contagious diseases like mumps and "apollo" (acute haemorrhagic conjunctivitis): education on proper hygiene and transmission control measures.

Identify other Biomedical Science-related issues or problems outside the local society that can be addressed through Biomedical Science.

1. Unfair healthcare access: availability of biomedical professionals to improve access to good healthcare.
2. Failed organs or non-functioning body parts: design and develop artificial organs to replace them.
3. Ageing population: develop technologies and medications to improve the quality of lives of elderly persons.

Pedagogical Exemplars

Problem-based learning: In groups, identify and research problems within the society and explain how Biomedical Science can be applied to solve these problems. Learners critically analyse problems in society and apply the knowledge acquired to solve these problems.

Talk-for-learning: Through a whole class discussion identify other issues or problems outside the local society that can be addressed through Biomedical Science. All learners should be allowed to provide oral contributions on societal problems that can be addressed using Biomedical Science (Ensure introverts and shy learners participate fully).

Collaborative learning: Learners work in mixed groups, discussing the various ways of applying Biomedical Science to solve societal problems (infectious diseases and chronic diseases). Learners exhibit leadership roles and responsibilities for various tasks assigned to individual members of the group.

Assessment

Level 1 (Recall): State at least three biomedical science-related problems in society.

Level 3 (Strategic reasoning): In groups, make presentations on the problems identified and propose Biomedical Science solutions to address the problem.

Level 4 (Extended critical thinking and reasoning): Give any biomedical science-related challenge in your locality and use the knowledge acquired in Biomedical Science to propose a solution.

Learning task for practice

Present each group with a case study (**see Case Studies 1, 2 and 3**). Each group is expected to identify the biomedical science-related problems in their case study and suggest ways to address them.

Case Study 1:

During the rainy season, it has been noted that villagers frequently get sick with common symptoms of high body temperature, headache, dehydration, frequent vomiting and passing of loose stool. In this community, there is a river which serves as the source of water for multiple uses by the villagers. Due to the lack of an appropriate place of convenience for nature's call, the villagers resorted to the bush around the river as their place of convenience. When it rains, the debris along the river bank and surrounding areas is washed into the river thereby contaminating the river.

Hints for Case Study 1:

1. This case study presents multiple Biomedical Science problems: cholera, typhoid and malaria. Cholera is an acute illness caused by *Vibrio cholerae* bacteria. Key symptoms of Cholera are diarrhoea and dehydration. Typhoid fever is caused by *Salmonella typhi* and is characterised by high fever, headache, body aches and diarrhoea. Malaria is caused by *Plasmodium falciparum* and causes headache, fever and fatigue in infected individuals. The bush serves as a breeding ground for mosquitoes which transmit the malaria parasite.
2. Either of the diseases can be identified as a biomedical science-related problem in the community. Typhoid fever and Cholera can be solved by developing an appropriate and hygienic place of convenience for the community to prevent the river from being contaminated with faecal matter. To reduce the incidence of malaria, the use of mosquito nets and weeding around the area should be encouraged to reduce mosquito bites and breeding respectively.

Case Study 2:

Mr. Amanor visits the Community Clinic and complains of coughing, chest pains and a sore throat. He was given cough syrup to treat the cough. After two weeks, he returned to the clinic because his symptoms were persistent and more severe. He also has traces of blood in his handkerchief when he coughs. Furthermore, it was observed that Mr Amanor had grown lean after his first visit and his wife and three children were also presenting the same symptoms he was presenting two weeks ago.

Hints for Case Study 2:

1. The clinic decided to perform additional tests: Chest x-ray and Sputum test. The chest x-ray showed Mr Amanor had chest cavities and the Sputum test also indicated positive.
2. Since tuberculosis is an air-borne disease, the family members were also tested.
3. Isolation of infected individuals and vaccination of non-infected individuals should be encouraged to prevent further spread and infection.

Case Study 3:

Kofi observed that he had to shout whenever he had to talk to his grandmother before she could hear what he was saying. Also, he realised that his grandmother often shouted when talking to people even when they were close by.

Hint for Case Study 3:

1. In this case study, it is likely Kofi's grandmother has a hearing impairment. As a result, anybody who had to communicate with her had to shout for her to hear. Hearing impairment as a Biomedical Science problem in this case can be managed by providing a hearing aid which will amplify the sound for her to hear audibly.
2. Learners should be encouraged to identify other disability issues and suggest assistive devices that can be used.

Conclusion

Biomedical Science plays a crucial role in understanding and addressing local health problems such as infectious disease control, chronic disease management, care for the ageing population, drug formulation and replacement of diseased organs. By applying scientific knowledge and innovative technologies, Biomedical Science addresses various medical challenges, improves healthcare practices and enhances overall well-being.

Week 3

Learning Indicator(s): *Explain how the scientific method can be applied to undertake investigations or address problems in Biomedical Science.*

Theme/Focal Area 1: Identify a local problem that could be addressed through the scientific method and focus on the hypothesis of the scientific method.

The scientific method of inquiry is an approach scientists use to investigate and understand natural phenomena in the world around us.

The scientific method is the process of objectively establishing facts through testing and experimentation. The basic process involves making an observation, forming a hypothesis, making a prediction, conducting an experiment, analysing the results and making conclusions.

The scientific method can be broken down into several key steps:

1. Observation: Making observations about the natural world. Scientists use their senses, instruments, and tools to gather data on specific phenomena or events.
2. Questioning: Based on observations, scientists develop research questions that seek to explain the observed phenomena or to explore a particular aspect of the natural world.
3. Hypothesis: Scientists will often develop a hypothesis based on their research and observations. A hypothesis is a testable statement that proposes a possible explanation for the observed phenomena. It is typically formulated to predict the relationship between variables.
4. Prediction: From the hypothesis, scientists make specific predictions about what they expect to observe if the hypothesis is true. These predictions are used to design experiments or gather further data.
5. Experimentation or Data Collection: Scientists conduct experiments or gather data. The goal is to test the predictions and collect evidence to either support or refute the hypothesis.
6. Analysis: The data collected from experiments are analysed using statistical methods and other tools to draw meaningful conclusions. This step involves interpreting the results and determining whether they support or reject the initial hypothesis.
7. Conclusion: Based on the data analysis, scientists conclude the validity of the hypothesis. If the data consistently supports the hypothesis, it may be considered a reliable explanation for the observed phenomena. If not, the hypothesis may be rejected or modified.

Problems such as malnutrition, loss of body function and poor sanitation could be addressed using scientific methods **(**See **Table 1)**.

Pedagogical Exemplars

Structuring talk for learning: in a whole group discussion, initiate an interactive talk session on how a local problem could be addressed through the scientific method, focusing on the main steps of the scientific method. Learners orally share their ideas as they work in groups on the steps of the scientific method to address local problems.

Problem-based learning: In mixed-ability groups develop a hypothesis on a local/societal problem that falls under the field of Biomedical Science. Learners critically analyse problems in society and carry out investigations using the scientific method. Problems such as malnutrition, loss of body function and poor sanitation could be addressed using scientific methods. See the example in Table

1 outlining how the scientific method is used to investigate a case of malnutrition of a student in a community school.

Table 1: Example of an application of the scientific process in Biomedical Science

Scientific Method	Example
Observation	A colleague who is usually cheerful comes to school and appears very dull and complains of a headache. He/she sleeps through the entire first-period lesson.
Questioning	Why is he/she so dull today? What is the cause of the headache? Could it be because of a lack of enough sleep or a medical condition?
Hypothesis	1. The dullness and headache could be due to lack of sleep OR 2. Could it be due to a medical condition with a headache accompanied by dullness and sleepiness as symptoms?
Prediction	These symptoms suggest the possibility that he/she has malaria and is anaemic or simply did not get a good night's sleep.
Experimentation	To determine what the exact condition is, a full blood count (FBC) and a malaria rapid diagnostic test (RDT) are carried out in the laboratory.
Analysis	The results of the FBC showed a Haemoglobin (Hb) level of 8.5g/dl (the range for healthy individuals is 11.5g/dl - 18.0g/dl) and the malaria test was negative. The colleague was further questioned on lifestyle and eating habits, with his/her responses indicative of malnutrition explaining the results obtained from the FBC.
Conclusion	With an Hb level of 8.5g/dl and a negative test for malaria, it was concluded that the colleague was anaemic which resulted from malnutrition.

Assessment

Level 1 (Recall): State at least three stages of the scientific method of investigation.

Level 2 (Conceptual Understanding): Explain at least three stages of the scientific method.

Level 4 (Extended critical thinking and reasoning): Describe how the scientific method of investigation can be applied systematically to diagnose diseases such as cholera, malaria and COVID-19.

Learning task for practice

In groups, ask learners to apply the scientific method of investigation to identify the symptoms of biomedical science-related problems such as malnutrition, high blood pressure, amputation and poor sanitation and suggest ways to address them (See **Table 1**).

Conclusion

The scientific method of investigation is a systematic process comprising seven basic stages that help to identify biomedical science-related problems in society and identify ways to address them. The systematic nature of the investigation process is important for deriving valid conclusions and

the potential for designing suitable solutions for specific problems. Every biomedical science-related solution to a problem was designed based on this scientific method of investigation.

Section 1: Review

This section is a review of all the lessons taught for the last 3 weeks and a summary of what the learner should have learnt.

1. What is Biomedical Science as a field of study?
2. What are the fields of science related to biomedical science?
3. What are the careers related to biomedical science?
4. What are the products of biomedical science?
5. What are the features of Biomedical Science as a field of study?
6. What are the misconceptions about biomedical science?
7. What are the problems in society that are related to biomedical science?
8. In what ways can these problems be addressed?
9. Describe the scientific method of investigation.
10. How important is the scientific method of investigation to Biomedical Science practice?

Throughout history, Biomedical Science has been a collaborative effort involving contributions from various cultures, disciplines, and individuals. It has transformed our understanding of health and disease and has led to significant improvements in medical care and quality of life. The field continues to evolve, and future breakthroughs hold the promise of even more advancements in healthcare.

Additional Reading

QR Code 1 **QR Code 2** **QR Code 3**

Scan QR code 1 to watch "Behind every COVID-19 test is a Biomedical Scientist" and QR code 2 to watch "What Biomedical Science Is"

Scan QR Code 3 or use this link **(**https://crosswordlabs.com/view/biomedical-science-related-problems-in-society**)** to engage learners in learning about biomedical science-related problems in society

References

1. Figure 2: Balaban, V. (2017). Rapid Diagnostic Capacity. CDC Global, https://www.flickr.com/photos/cdcglobal/36813878060

2. Figure 3: Fermariello, M. (2018), Malaria Rapid Diagnostic Test Strips. Pixels, New York, https://pixels.com/profiles/science-photo-library/art/malaria+diagnostic+test+strip
3. Figure 4: Hammett, E. (nd), Understanding and managing medication – how to avoid prescription mistakes and drug errors. https://firstaidforlife.org.uk/understanding-managing-medication/
4. Figure 5: Asante, E. (2021), 4 friends who have received limbs from OTC, Nsawam, Ghana, Nsawam, https://www.legs4africa.org/quarterly-report-2021-q4/
5. Figure 6 (a): Kim, Ji-Hun, Yong-Cheol Mo, Seung-Myung Choi, Youk Hyun, and Jung Woo Lee. 2021. "Detecting Ankle Fractures in Plain Radiographs Using Deep Learning with Accurately Labeled Datasets Aided by Computed Tomography: A Retrospective Observational Study" *Applied Sciences* 11, 19: 8791. https://doi.org/10.3390/app11198791
6. Figure 6 (b): Adams, Lisa, Busch Felix, Truhn Daniel, Makowski R. Marcus, Aerts Hugo and Bressem, Keno. (2022). What Does DALL-E 2 Know About Radiology? DOI:10.48550/arXiv.2209.13696
7. Figure 7: Gulu Disable Persons Union (2011), The Advocacy Project, Gulu, Uganda https://www.pexels.com/photo/dental-implants-with-screw-on-table-in-clinic-4687905/
8. Figure 8: Borba, J. (2020), Dental implants with screw on table in clinic, https://www.pexels.com/photo/dental-implants-with-screw-on-table-in-clinic-4687905/

SECTION 2: BIOSAFETY

Strand: **Biomedical Science in Society**

Sub-Strand: Biosafety

Learning Outcome: *Describe various biohazards and critically analyse their routes of exposure.*

Content Standard: Demonstrate an understanding of biohazard and route of exposure.

INTRODUCTION AND SECTION SUMMARY

In this section, learners are introduced to biohazards, their classification and the appropriate personal protective equipment required to prevent exposure. The section also introduces learners to pathogens and their routes of exposure leading to infections and diseases. Furthermore, learners get to know about laboratory-acquired infections. At the end of this section, learners are expected to know about biohazards as well as the risk groups, identify the routes of exposure of pathogens to humans and how to prevent exposure.

The weeks covered by the section are

Week 4: *Discuss the various biohazards as well as the risk groups.*

Week 5: *Describe the routes of exposure of pathogens to humans.*

Week 6: *Analyse laboratory-acquired infections (LAIs), including some case studies.*

SUMMARY OF PEDAGOGICAL EXEMPLARS

To facilitate learners' understanding of biohazards, routes of exposure to pathogens and laboratory-acquired infections, these pedagogical exemplars are suggested for teaching the content of this section. These are initiating talk-for-learning, collaborative learning, activity-based learning, demonstrative learning, exploratory learning and structured-talk-for-learning. The use of talk-for-learning, collaborative learning, and structured-talk-for learning is to guide learners to discuss the biohazards they have encountered or observed in their society and how to prevent exposure to them. Activity-based learning, demonstrative learning and exploratory learning are recommended to help learners engage in practical activities that will help them develop competencies in the areas of teamwork, communication, collaboration and tolerance. Through mixed gender and ability groupings, learners exhibit leadership and followership skills as they share tasks assigned to individual members. Through activity-based learning, learners develop observational, analysis and identification skills.

ASSESSMENT SUMMARY

The focus of this section is for learners to know what biohazards are and the routes of exposure to pathogens. Additionally, learners are expected to explain how laboratory-acquired infections (LAIs) come about. Based on this knowledge, learners' ability to recall what a biohazard is and the routes of exposure to pathogens should be assessed using questions that demand reproducing what they have been taught. Furthermore, learners' conceptual reasoning and strategic thinking/critical thinking skills should be assessed to determine their ability to explain how laboratory-acquired infections occur and how they can be prevented.

Week 4

Learning Indicator(s): *Discuss the various biohazards as well as the risk groups*

Theme/Focal Area(s) 1: Define biohazards; identify the various biohazards and the risk levels.

For an introduction to this week, refer to the Learning Tasks for Practice 1 and 2 and **Fig.12** to introduce learners to hazards in general and the types of hazards.

Define a biohazard as

> a biological substance or infectious agent that poses a threat to the health or well-being of living organisms, especially humans and animals.
>
> any biological material such as bacteria, viruses, toxins, or other microorganisms that has the potential to cause harm.

Categorise biohazards into the following groups

Biological agents: bacteria, viruses, fungi, other microorganisms and their associated toxins.

Biotoxins: poisonous substances produced by living organisms for example snake poison.

Clinical samples: for example, blood, urine, faecal matter.

Medical waste: for example, used syringes, needles, contaminated dressing, laboratory specimens.

There are universally recognised symbols used to indicate the presence of hazardous biological materials. These symbols are designed to alert individuals about potential risks and the need for appropriate precautions. The general biohazard symbol is shown in **Fig. 11 (a)**. Additional information can be added to the general biohazard symbol to specify the details of the biohazard. See **Fig. 11 (b)** and **(c).**

Fig 11 (a): *General biohazard*

Fig. 11 (b): *Biohazard caution*

Fig 11(c): *Biohazard danger symbol*

Risk levels of biohazards

Biohazards are classified into different levels based on their level of risk to human health and the environment. The levels are commonly referred to as Biosafety levels (BSL).

Biosafety Level 1 (BSL-1): agents that 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.

Biosafety level 2 (BSL-2): involves handling moderate-risk biohazardous materials that pose a moderate risk of infection or disease. Common pathogens like *Staphylococcus aureus*, *Salmonella*

typhi, Human immunodeficiency virus, hepatitis B and C viruses and certain strains of influenza virus are examples.

Biosafety Level 3 (BSL-3): involves handling high-risk biohazardous materials that can cause serious diseases through inhalation. Micro-organisms 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.

Biosafety level 4 (BSL-4): pathogens that pose the highest risk of disease for which there are no treatments or vaccines. Examples include the Ebola virus and the Lassa virus.

Pedagogical Exemplars

Initiating talk for learning: With the aid of flashcards or pictures showing biohazards, engage learners to identify and discuss common features. Learners critically examine the common features of biohazards.

Collaborative Learning: In mixed ability groups, learners identify and group a set of randomised biohazards according to their risk levels (Levels 1, 2, 3 and 4). Learners explain the reasons behind the groupings through class presentations (Ensure introverts and shy learners participate fully). Through collaborative learning, learners exhibit leadership roles and responsibilities for various tasks assigned to individual members of the group.

Activity-based learning: Identify various hazards in varied scenarios (within the community or through the use of videos or pictures) and determine the potential negative outcome(s) of a given hazard and the frequency of occurrence (that is, "risk"). Learners observe, analyse and identify the various forms of hazards and their risk levels.

Assessment

Level 1 (Recall)

1. What is biohazard?
2. Indicate if each of the following statements is true or false:
    a) Biohazard poses a threat only to human health.
    b) Biohazards include infectious agents, such as bacteria, viruses and fungi that can cause diseases in humans.
    c) Biohazardous waste should be disposed off in regular trash bins.
    d) Biohazard symbols are used to identify materials that are dangerous to the environment.
    e) Biohazardous materials should be stored in designated containers that are clearly labelled with the biohazard symbol.
    f) Biohazards are only present in laboratories and medical facilities.

Level 2 (Conceptual understanding)

1. Name and describe the various categories of biohazards.
2. Give examples of biological agents for each of the four biohazard levels.

Level 3 (Strategic reasoning): In a group, identify biohazardous materials in your environment and classify them according to the risk levels and justify your classification.

Learning task for practice

1. Ask learners to share their experiences with domestic accidents. This is to serve as an introduction to the lesson on biohazards. After learners share their experiences with domestic accidents, Fig.12 should help introduce learners to what hazards are and the different types.

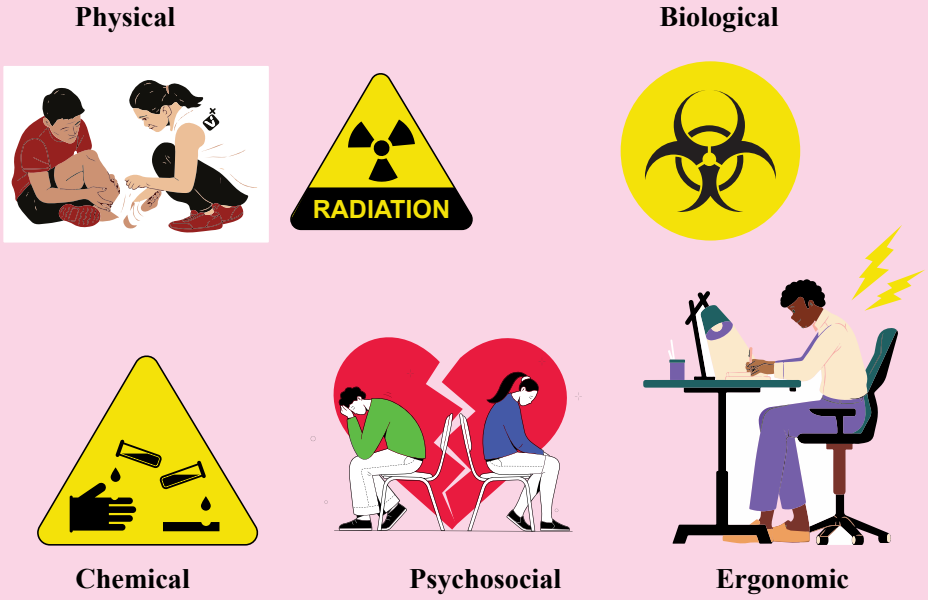

Fig. 12: *Types of Hazards*

2. Present learners with scenes depicting biohazards, for example, rubbish dumps, and hospital laboratories with potential biohazards. Task learners to identify the biohazards and classify them.
3. **Scan QR code 4** under additional readings to access the Word Search Puzzle and print for each group to identify the biohazardous agents listed below the puzzle. After identifying the agents, learners classify the agents according to the Biosafety levels 1-4.

Conclusion

Hazard refers to any source of danger and biohazard refers to biological substances that have the ability to cause harm. Biohazards are categorised into groups: biological, biotoxins, medical waste and chemical samples. Biohazard symbols are used to signal the presence of a biological danger. Based on the level of risk, biohazards are grouped into levels 1, 2, 3 and 4. The knowledge and application of biohazard symbols and risk levels of biohazards are important for managing and preventing harm in the workplace, home and our environment.

Week 5

Learning Indicator(s): *Explain the routes of exposure of pathogens to humans*

Theme/Focal Area: Pathogens and how they are spread in humans.

Define pathogens

Pathogens are microorganisms, such as bacteria, viruses, fungi or protozoans that have the potential to cause diseases in their hosts. They can be found virtually everywhere in the environment, and some are specifically adapted to infect humans, animals, or plants. Pathogens can be transmitted through various means, including direct contact, contaminated food or water, airborne droplets, and vectors like mosquitoes or ticks.

Examples of pathogens include:

Bacteria: These are microscopic single-celled organisms, which can cause a wide range of infections for example, *Escherichia coli* (E. coli) and *Staphylococcus aureus* (staph).

Viruses: These are sub-microscopic infectious agents, such as influenza virus, Human Immunodeficiency Virus (HIV), and coronavirus, which can lead to various viral diseases.

Fungi: Organisms like *Candida albicans* and *Aspergillus* can cause fungal infections, particularly in individuals with weakened immune systems.

Protozoans: Parasitic organisms like *Plasmodium falciparum* (malaria parasite) and *Giardia lamblia* (diarrhoea-causing agent) can cause infections in humans.

Routes of pathogens exposure

Direct contact: Contagious diseases readily spread by transmission of a pathogen through direct contact with an infected person. Examples include touching a person with skin infections such as herpes simplex virus, *Staphylococcus aureus*, handling contaminated objects or surfaces, body fluids, or through sexual contact with an infected person.

Inhalation route: pathogens can be transmitted through the air and inhaled into the respiratory system. This can occur through droplets produced when an infected person coughs, sneezes, talks, or even breathes. Examples include influenza viruses, tuberculosis, bacteria, SARS-COV-2 and the common cold.

Ingestion (Faecal-oral Route): Pathogens can spread through the ingestion of food, water, or objects contaminated with faecal matter containing infectious agents to cause diseases like cholera and typhoid fever.

Inoculation (Vector-borne Transmission): Certain pathogens depend on vectors such as mosquitoes, ticks, fleas, or other arthropods, to transmit them from infected hosts to individuals. The vectors can bite and introduce pathogens into the bloodstream during feeding and can cause diseases like malaria, and dengue fever.

Pedagogical Exemplars

Demonstrative Learning: Ask volunteers to apply a dye or coloured powder on bare hands and shake hands with different people to demonstrate how pathogens spread. (Plan ahead of time, how to acquire the materials needed). Learners' curiosity and level of awareness are aroused as they

shake hands or touch comfortable body parts among themselves while they walk in and see stains transferred to surfaces.

Structuring talk for learning: Brainstorm on how humans are exposed to pathogens example through ingestion and inoculation. Guides learners to share experiences of something they have eaten that led to a stomach upset to demonstrate ingestion as a route of exposure.

Collaborative Learning: Work in pairs to create mind-maps on ways humans are exposed to pathogens. Learners embrace a diversity of ideas as they work in mixed-ability groups. Learners also creatively use their knowledge to, Create a mind map for the various routes of pathogen exposure.

Assessment

Level 1 (Recall)

1. What are pathogens?
2. Give at least two examples of pathogens.

Level 2 (Conceptual understanding): Explain how human beings are exposed to pathogens.

Level 3 (Strategic reasoning):

Case study
In a village, a group of boys were engaged in a football match. During the game, two players collided with each other with evidence of a bleeding nose. Close to the football field is a river which is the source of water for the whole village. This river serves as the main source of water for cooking, drinking and bathing. The injured boys went to wash off the blood in the river nearby. One of the players is HIV positive, however, he did not know. Based on your knowledge of pathogens and routes of exposure, justify if the residents will be at risk of being infected with HIV should they continue drinking from the same river.
Accept independent or group work, either oral or written.

Learning tasks for practice

1. Use any of the following examples to demonstrate inhalation as a route of pathogen exposure. Open a bottle of any scented substance that is not hazardous to human health, for example, perfume, ammonia, formalin, methylated spirit/ethanol or burn dry orange peels.

   CAUTION: Under no circumstance should learners directly inhale from the bottle. The bottle should be opened in one corner while the learners stand far away. The bottle should be opened just briefly. Learners with asthma and other respiratory challenges should be excused from this practice to avoid triggers.

2. Learners share experiences of how exposure to mosquito bites can increase the plasmodium parasite load leading to malaria.

Conclusion

Pathogens are microorganisms that can be found everywhere and have the potential to cause diseases making them dangerous. Knowledge of pathogens and their route of exposure is necessary to avoid infections. Because pathogens have their unique route of exposures, an understanding of how the route of exposure supports transmission is important for disease prevention.

Week 6

Learning Indicator(s): *Analyse laboratory-acquired infections (LAIs), including some case studies*

Theme/Focal Area: Define Laboratory-Acquired Infections (LAIs)

Laboratory-acquired infections (LAIs) are infections (that can range from mild to severe infections) that affect laboratory workers as a result of occupational exposure to infectious agents or materials.

LAIs occur due to accidental exposure to pathogens, either through direct contact with contaminated specimens, inhalation of infectious agents, needle stick injuries, or other routes of exposure.

Sources of laboratory-acquired infections (LAIs)

Pathogenic microorganisms: laboratory personnel work with various pathogenic microorganisms, such as bacteria, viruses, fungi and protozoa. Accidental exposure to these microorganisms can lead to infections.

Improper handling of infectious materials/contaminated samples: failure to handle contaminated samples or infectious agents properly can pose a risk to the laboratory personnel and increase the risk of LAIs. This includes inadequate use of personal protective equipment (PPE), improper disinfection techniques, or mishandling of sharp objects and improper disposal.

Accidental needle sticks or sharps injuries: laboratory personnel working with needles, syringes, or other sharp objects are at risk of accidental needle sticks or sharps injuries. If these objects have been in contact with infectious materials, they can transmit infections to the personnel.

Preventions of laboratory-acquired infections (LAIs)

Personal protective equipment (PPE): Laboratory personnel should always use appropriate PPE based on the nature of the work being performed. These include gloves, lab coats, safety glasses or goggles, face shields, hair nets, nose masks, closed-toed shoes and respirators. PPE should be properly selected, fitted and worn consistently (See Fig 16).

Standard operating procedures (SOPs): Developing and following standardised operating procedures for all laboratory activities is crucial. SOPs should include guidelines for handling hazardous materials, proper waste disposal, decontamination procedures, and emergency response procedures. SOPs should also include maintaining cleanliness and organisation within the laboratory, proper labelling and storage of chemicals and materials and maintaining accurate records of experiments and procedures. These procedures should be regularly reviewed and updated as needed.

Waste management: proper handling and disposal of laboratory waste, including sharp objects like needles, contaminated materials, and biological waste, should be strictly followed. This includes using designated containers, autoclaving or disinfecting waste as required and following local regulations for waste disposal.

Biosafety levels and containment: laboratories should be classified into appropriate biosafety levels (BSL) based on the types of microorganisms being handled. Implementing the necessary containment measures, such as biosafety cabinets, glove boxes or isolation rooms, according to the designated BSL, helps prevent the release of infectious agents and minimise the risk of LAIs.

Training and monitoring: proper training and education on laboratory safety practices and procedures are essential for all laboratory personnel. This includes training on handling hazardous materials, proper use of personal protective equipment (PPE), and understanding the risks associated with different laboratory procedures. Conducting regular inspections and audits of laboratory facilities, equipment,

and practices helps identify any potential safety gaps or non-compliance. These inspections should be followed by appropriate corrective actions to address any identified issues.

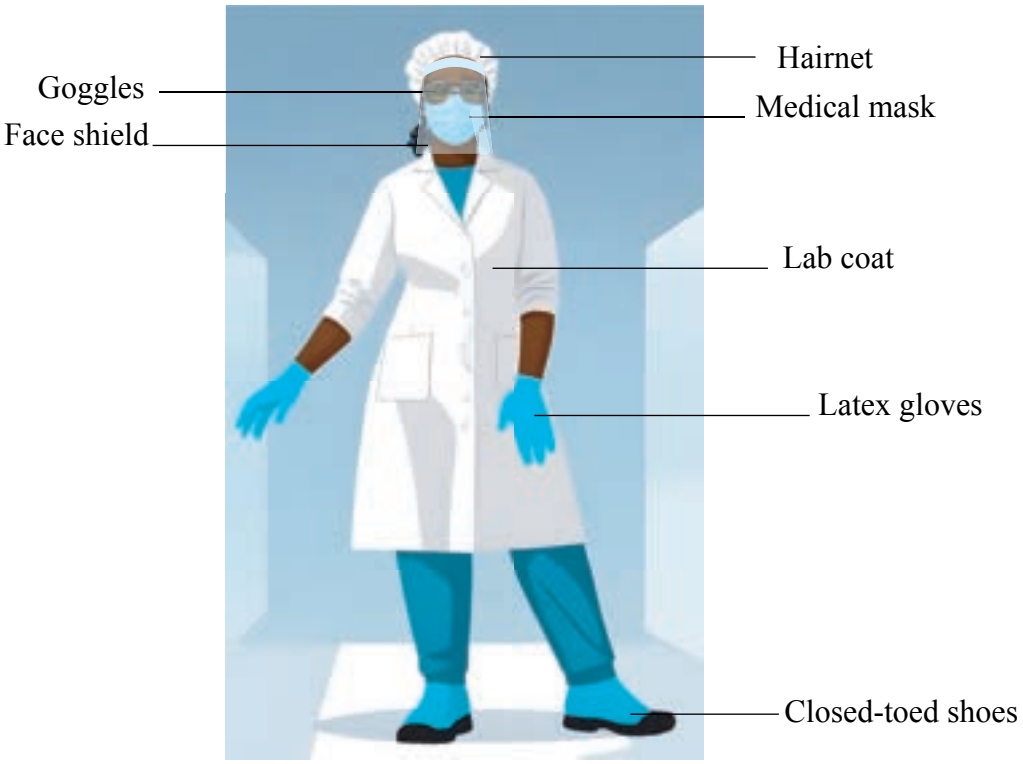

Fig. 16: *Laboratory personal protective equipment (PPE)*

Pedagogical Exemplars

Initiating talk for learning: Watch videos on a case study of LAI (for example "Outbreak", "93 Days") or listen to summarised conversations on LAIs. Learners are disciplined as they can properly represent safety in the laboratory when there is an inappropriate representation. Learners are also able to conduct themselves in good manners by following the dos and don'ts of safety in the laboratory.

Exploratory learning: Engage on a field trip to a laboratory for a talk on LAIs or invite a resource person to the class. Plan ahead of time for the field trip as learners are from different socioeconomic backgrounds. Learners must be obedient, and respectful and pay attention to details as they embark on a field trip or engage with a resource person.

Collaborative learning: Through think-pair-share, write down examples, sources, and prevention of LAIs. Learners embrace diversity of ideas as they work in mixed-ability groups.

Assessment

Level 1 (Recall)

1. What are Laboratory-acquired infections (LAIs)?
2. What are the specific infectious agents or materials being handled in the laboratory that could pose a risk of infection?
3. List and explain at least three sources of laboratory-acquired infections (LAIs) in the laboratory.

Level 2 (Conceptual Understanding)

1. Identify rules that must be ensured to promote safety in the laboratory.
2. Give the specific procedures needed for the safe handling, transportation, and disposal of infectious materials.
3. List and explain at least three Personal Protective Equipment (PPE) that must be used in the laboratory for the prevention of Laboratory-Acquired Infections (LAIs).

Learning task for practice

1. Ask learners to share the rules and regulations concerning lessons in the classroom. This is to introduce the learners to Standard Operating Procedures (SOPs).
2. Ask learners to come up with SOPs for working in the lab based on the knowledge acquired on pathogens, biohazards and LAIs.
3. Based on the videos, summarised conversations or case studies, ask learners to write down at least three items or practices observed that may have been inaccurate or interesting representations of safety in the laboratory.

Conclusion

Biomedical scientists who work in laboratories have the potential of acquiring infections from the laboratory; these infections are called Laboratory Acquired Infections (LAIs). Due to the high-risk nature of the laboratory environment, biomedical scientists can be infected through improper handling of samples or through accidental exposure to the pathogens they work on. To prevent LAIs, laboratory SOPs, waste management, PPEs, biosafety containment and training are methods that are applied to prevent LAIs.

Section 2 Review

This section is for a review of all the lessons taught for the last 3 weeks. A summary of what the learner should have learnt.

1. What is a biohazard?
2. What are the levels of biohazard based on risk?
3. What are LAIs?
4. How do LAIs come about?

Additional Reading

QR Code 4

Scan QR code 4 to access WordBox on Biohazardous Agents.

SECTION 3: INTRODUCTION HUMAN BODY SYSTEMS

Strand: **Human Body Systems**

Sub-Strand: Anatomy and Physiology

Learning Outcome: *Describe the Human Body Systems and establish the interrelations between the systems for life.*

Content Standard: Demonstrate an understanding of the Human Body Systems and how they are interconnected.

INTRODUCTION AND SECTION SUMMARY

This section introduces learners to the human body systems. The expectation is to explore the parts and functions of the major: Musculoskeletal, Nervous, Cardiovascular or Circulatory, Endocrine, Integumentary, Respiratory, Digestive, Lymphatic, Reproductive, and Urinary systems. Furthermore, the interconnections between the Body Systems and how these systems work together to maintain health through homoeostasis are discussed.

The weeks covered by the section are**:**

Week 7: *Explore the parts and functions of the major human body systems.*

Week 8*: Describe the interconnections between the human body systems and how these systems work together to maintain health and homeostasis.*

Week 9*: Evaluate how the interconnections and interactions of multiple body systems are necessary for life.*

SUMMARY OF PEDAGOGICAL EXEMPLARS

To foster learners' interest and participation, exploratory, collaborative, activity-based, initiating-talk and project-based learning strategies are recommended as pedagogical exemplars for facilitating the content standard for the section. Exploratory and collaborative strategies will promote learners' ability to identify the human body systems and their parts. To promote a sense of teamwork among learners, they are encouraged to collaborate and create models of the human body systems using local materials. Using activity-based and initiating-talk for learning strategies, learners describe the interconnections between the human body systems and how these systems work together to maintain health through homeostasis. Again, using activity-based and project-based learning strategies, learners gain the ability to establish how the interconnectedness of the systems works to promote health. With the proper application of these pedagogical exemplars, learners are expected to demonstrate an understanding of the human body systems and how they are interconnected.

ASSESSMENT SUMMARY

To assess learners' ability to demonstrate an understanding of the human body systems and how they are interconnected, four levels of assessments are recommended. Level 1 (Recall) assessment will evaluate learners' ability to recall the human body systems, their parts and functions. Level 2 assessment will test learners' conceptual understanding of how the systems function. Level 3 assessment will test learners' strategic reasoning ability to identify the interconnections between the systems and how they work together. Level 4 assessment will allow learners to evaluate how the interconnections and interactions of multiple body systems are necessary for life.

Week 7

Learning Indicator(s): *Explore the structure, functions and parts of the major human body systems.*

Theme/Focal Area(s) 1: Define Human Anatomy and relate it to Human Physiology

Introduce learners to the concepts of Anatomy and Physiology and establish the relationship between them.

Define human anatomy as the study of the structure and relationships between the body parts.

Define human physiology as the study of how the body parts function together.

List of the human body systems:

- Musculoskeletal System
- Nervous System
- Cardiovascular or Circulatory System
- Endocrine System
- Integumentary System
- Respiratory System
- Digestive System
- Lymphatic System
- Reproductive System
- Urinary System

Describe the human body systems, the components of these systems and their functions

(Scan QR Code 5 for reference**)**

1. **Musculoskeletal System**
   Components: Bones, Muscles, Tendons, Ligaments and Cartilage.
   Discussion should be tailored along the following functions;
   a. Movement i.e., Support and stability (Skeleton and Muscle).
   b. Blood cell production (bone marrow).

2. **Nervous System**
   Components: Brain, Nerves, Spinal Cord and Neurons.
   Discussion should be tailored along the following functions;
   a. Sensory: response to stimuli such as touch, pain, temperature, sound, and light.
   b. Integration: analysis of the data to form appropriate responses.
   c. Motor function: allows to perform physical actions such as touching, walking and running.
   d. Emotional and cognitive function: Learning, Intelligence, Happiness and Sadness.
   e. Involuntary or reflex function: Heartbeat, Breathing, Digestion and Sneezing.

3. Circulatory/Cardiovascular System

Components: Heart, Blood Vessels (Arteries, Veins, Capillaries) and Blood – Plasma, White Blood Cells (Leukocytes), Red Blood Cells (Erythrocytes), and Platelets.

Discussion should be about the following functions;

a. Transportation: Oxygen, Nutrients and Hormones.
b. Protection and Immunity: Blood Clotting and White Blood Cells.
c. Removal of Waste: Carbon Dioxide and Metabolic by-products.
d. Regulation: Fluid Balance.

4. Endocrine System

Components: Hypothalamus, Pancreas, Pituitary Gland, Adrenal Glands, Thyroid Gland, Testes and Ovaries.

Discussion should be tailored along the following functions;

a. Production and Secretion of Hormones: Adrenaline, Oestrogen, Progesterone and Testosterone.
b. Regulation and Control**:** Metabolism, Growth and Development, Reproductive Function, Stress Response, Sleep/Wake Cycle, Body Temperature, Water Balance, Blood Pressure.

5. Integumentary System (the skin)

Components: Skin, Hair, Nails and Sweat Glands, Sebaceous (Oil) Glands

Discussion should be tailored along the following functions;

a. Protection: the skin serves as a barrier to mechanical injuries, pathogens and harmful substances.
b. Sensation: receptors in the skin for touch, pressure, temperature, and pain.
c. Thermoregulation: regulation of body temperature by controlling heat exchange with the environment (sweating
d. Excretion: excretion of waste products, for example, water, urea and salts.
e. Vitamin D synthesis through the exposure of the skin to sunlight.

6. Respiratory System

Components: Nostrils, Mouth, Larynx (Voice Box), Pharynx (Throat), Trachea, Bronchi, Bronchioles, Alveolar Ducts, Alveoli Sac and Lungs.

Discussions should be tailored along the following functions;

a. Transportation of oxygen and carbon dioxide.
b. Gaseous exchange: inhalation of oxygen and exhalation of carbon dioxide.
c. Olfaction
d. Speech Production.

7. Digestive System

Components: Mouth, Pharynx, Oesophagus, Stomach, Small Intestines, Large Intestines, Rectum and Anus.

Discussion should be tailored along the following functions;

a. Ingestion: the process of taking in food.
b. Digestion: mechanical and chemical by enzymes (amylase, pepsin, lipase)
c. Absorption of nutrients (amino acids, fatty acids, glucose, vitamins) and minerals.
d. Excretion of indigestible and Unabsorbed Materials (Faecal Matter) from the Body through the Rectum and Anus during defecation.

8. **Lymphatic System**

   The lymphatic system protects the body against infections and diseases and works hand-in-hand with the circulatory system.

   Components: Lymph Nodes, Lymphatic Vessels, Tonsils, Spleen, Thymus.

   Discussion should be tailored along the following functions;

   a. Immune system support: spleen, tonsils and white blood cells.
   b. Fluid balance: prevents accumulation of excess fluid.
   c. Waste removal: Filtering out bacteria and dead cells.
   d. Nutrient transport: Transports dietary fats and fat-soluble vitamins.

9. **Reproductive System**

   Components: Ovaries, Fallopian Tubes, Uterus, Cervix, Vagina, Prostate, Testes, Penis.

   Discussion should be tailored along the following functions;

   a. Production of gamete (ovaries and sperm).
   b. Fertilisation.
   c. Gestation and Pregnancy.
   d. Hormone production.
   e. Milk production/ lactation.
   f. Sex differentiation.

10. **Urinary System**

    Components: Kidneys, Ureters, Bladder and Urethra.

    Discussions should be tailored along the following functions;

    a. Filtration of blood: removal of waste products, excess ions, and water from the blood.
    b. Formation of urine: kidneys process the filtered substances to form urine.
    c. Excretion of waste products: elimination of urea, creatinine and excess ions from the body
    d. Regulation of blood volume, and pressure and control of blood pH, and levels of metabolites.

Pedagogical Exemplars

Exploratory learning: Using charts, models or videos, assist learners in identifying the components, functions and key processes of each of the human body systems. Learners critically observe diagrams and models of the various body systems and the functions played.

Collaborative learning: Learners work in mixed-ability groups to study the parts and functions of the human body systems and create their own models using local materials. Learners work in mixed-ability groups by accepting constructive feedback from peers as they relate their observations on the components and relate them to the functions of the human body system to peers and come out with agreed answers. Learners share tasks among themselves to show leadership and followership skills.

Assessment

Level 1 (Recall): List at least three human body systems

Level 2 (Conceptual Understanding): Identify any three human body systems and list at least three organs that are found in these systems.

Level 4 (Extended Critical Thinking and Reasoning): Using appropriate local materials, create a model of the human body systems.

Learning task for practice

Let learners work in groups to model the human body systems using local materials (such as plastic bottles, straws, paper and balloons) and present their models to the whole class. This is to examine the learners' knowledge and understanding of the human body systems. (**Scan QR code 7 for an example of the respiratory system**).

Conclusion

The concept of anatomy and physiology of the human body systems identifies the components of eleven human body systems and their functions. The Pedagogical Exemplars provide learners the opportunity to visualise the different human body systems and their parts. Through collaborative learning, learners become aware of the functions of the human body systems.

Week 8

Learning Indicator(s): *Describe the interconnections between the human body systems and how these systems work together to maintain health and homeostasis*

Theme/Focal Area 1: Discuss the interconnection between the human body systems.

The human body systems are interconnected and work in harmony to ensure the proper functioning of the body.

Discussions on the interconnectedness of the human body systems should be hinged on the following examples:

Nervous System and Endocrine System

The nervous system and the endocrine system are the two major regulatory systems of the body. The nervous system uses electrical impulses to transmit rapid signals while the endocrine system releases hormones into the bloodstream for slower long-term regulation. These systems work together to coordinate and control various body functions. For example, the hypothalamus in the brain regulates body temperature through the nervous system and also releases hormones that signal the thyroid gland to release thyroid hormones to regulate metabolism.

Respiratory System and Circulatory System

The respiratory system and circulatory system work together to ensure the delivery of oxygen to cells and the removal of carbon dioxide. The respiratory system, including the lungs, exchanges oxygen and carbon dioxide between the air and blood. The circulatory system, consisting of the heart, blood vessels and blood transports oxygenated blood from the lungs to the body tissues and carries deoxygenated blood back to the lungs. The two systems rely on each other to supply oxygen and nutrients to cells while removing waste products from cells.

Digestive System and Circulatory System

The digestive system breaks down food into nutrients that can be absorbed into the bloodstream. The circulatory system, particularly the cardiovascular system, transports these nutrients to the cells throughout the body for energy production, growth and repair.

Endocrine System and Reproductive System

The endocrine system regulates various processes in the body through the release of hormones. In the reproductive system, hormones play a crucial role in the development and functioning of reproductive organs, as well as regulating menstrual cycle, sperm production and the release of eggs.

Skeletal System and Muscular System

The skeletal system provides structural support to the body and protection to the vital organs. It also serves as an attachment point for muscles allowing movement and providing stability. The muscles, in turn, work in conjunction with the skeletal system to generate movement and maintain posture.

Immune System and Lymphatic System

The immune system defends the body against infections and diseases. The lymphatic system, which is a part of the immune system, helps circulate lymph fluid containing immune cells throughout the body, aiding in the identification and elimination of pathogens.

Theme/Focal Area(s) 2: Explain homeostasis and how the human body systems work together to maintain health

Define homeostasis as

the ability of the body to maintain internal stability in an organism in response to environmental changes.

Importance of Homeostasis

Maintenance of a stable internal environment despite external fluctuations is crucial for various physiological processes.

Thus, the significance and importance of homeostasis can be discussed along these key points:

1. Optimal Functioning: homeostasis ensures that cells, tissues and organs in the body receive the necessary conditions to perform their functions optimally. This includes regulation of body temperature, blood pH, blood glucose levels and fluid balance.
2. Survival and Adaptation: living organisms need to adapt and adjust to changes in their external environment. These adjustments include moving in a dark room (accommodation of the eye) and shivering to produce heat when one is cold. Homeostasis allows one to respond and adjust to these changes, enabling survival in various conditions.
3. Energy Efficiency: a stable internal environment helps conserve energy by preventing unnecessary physiological responses to external variations. Instead of continuously responding to changing conditions, the body can focus its energy on essential functions. For example, the loss of appetite when one is full and the feeling of thirst when dehydrated.
4. Organism Health: homeostasis plays a crucial role in maintaining overall health. It ensures that organs and systems work in harmony, reducing the risk of diseases and disorders caused by imbalances, for example, kwashiorkor, hyperthyroidism (goitre) and beriberi.
5. Cellular Communication: homeostasis involves complex communication between cells, tissues and organs through various signalling pathways. This communication is vital for coordinating responses and maintaining balance. For example, during a fight-or-flight response (at the sight of a snake), the nervous system alerts the endocrine system to release hormones like adrenaline and cortisol. The communication between the nervous and endocrine systems causes an increase in blood pressure, breathing and heart rates. This, in turn initiates rapid muscle contraction and relaxation and a consequent response with either fight (hitting the snake with a nearby stick) or flight (running away). **Scan QR code 8 to watch a video on the fight-or-flight response.**
6. Temperature Regulation: maintaining a constant body temperature is crucial for enzyme activity and metabolic processes. Homeostasis helps control body temperature and prevents the harmful effects of extreme heat or cold. Examples include sweating to cool the body when the weather is hot and shivering to produce heat when the weather is cold.

How the human body systems work together to maintain health and homeostasis

The human body consists of multiple interconnected systems, each with specific functions, but they work together to maintain homeostasis.

Here's an overview of how some of these systems collaborate:

Nervous System: the nervous system plays a crucial role in homeostasis. The brain receives sensory input from the body and initiates appropriate responses to maintain balance. For instance, if body temperature increases, sensory nerves detect the change and send signals to the brain, which triggers sweating to cool down the body.

Endocrine System: the endocrine system regulates homeostasis by releasing hormones. Hormones act as chemical messengers, communicating information to various organs and tissues. For example, insulin, produced by the pancreas, regulates blood glucose levels by signalling cells to take up glucose from the blood.

Respiratory System: the respiratory system helps maintain the balance of oxygen and carbon dioxide in the body. It facilitates gaseous exchange, supplying oxygen to the bloodstream and removing carbon dioxide. This helps regulate the pH of the blood, as carbon dioxide affects the acidity of the blood.

Circulatory System: the circulatory system transports oxygen, nutrients and hormones throughout the body. It also helps distribute heat and maintains fluid balance, ensuring that cells receive proper nourishment and also waste products are removed.

Digestive System: the digestive system breaks down food into nutrients, which are then absorbed into the bloodstream for distribution. This system helps regulate glucose levels, electrolyte balance and pH, ensuring a constant supply of energy and essential molecules to maintain homeostasis.

Pedagogical Exemplars

Collaborative Learning: Work in groups to establish the relationship between body systems in performing specific body functions (for example how the digestive system affects the muscle and skeletal systems). Learners contribute to the discussion by expressing their thoughts on the interconnectedness of the body systems among their peers in an environment that is free from fear or intimidation.

Activity-based learning: Create concept maps to link different body systems that work together to perform various functions. **(See an example in Fig. 17)**. Learners become creative by using the knowledge gained to create a concept map of the interconnectedness of the human body system. Refer to **Fig. 21** in Additional Reading as a guide to assess the concept maps of the learners.

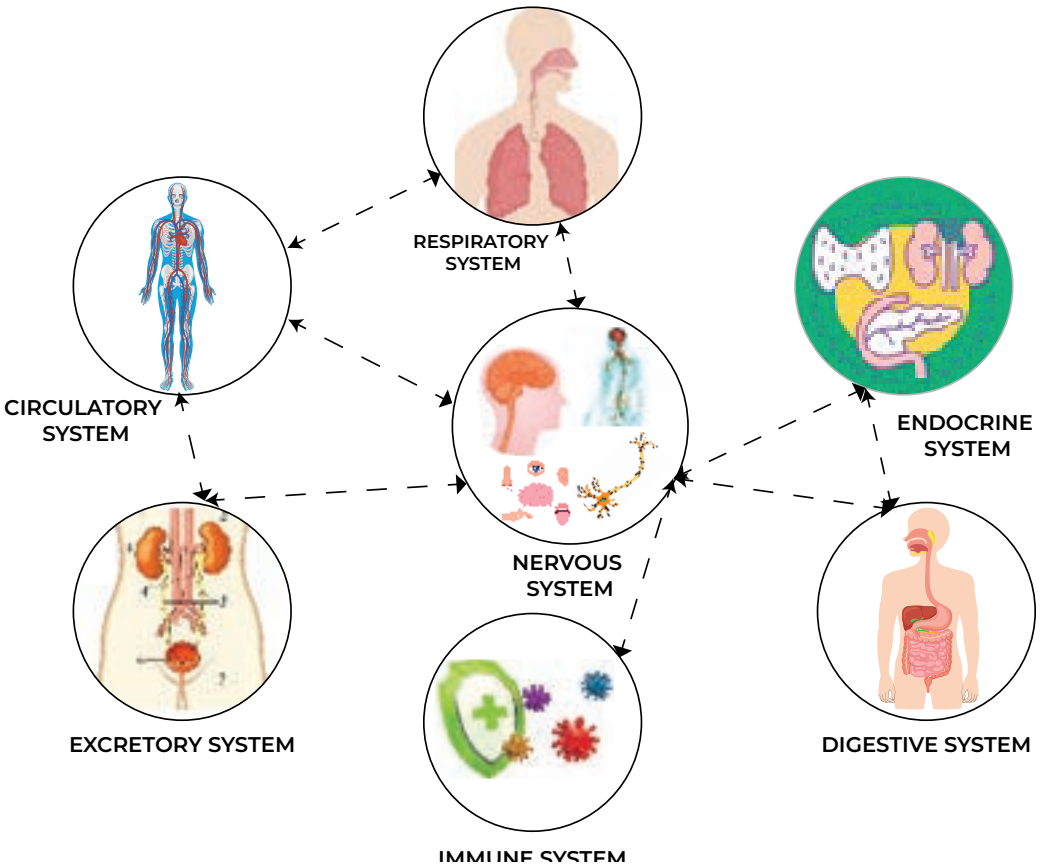

Fig. 17: *Concept map indicating interconnections of the human body system*

Initiating talk for learning: Engage learners in a whole class discussion to explain homeostasis and how the body achieves homeostasis. Learners identify systems working together to maintain the homeostasis and health of an individual.

Assessment

Level 1 (Recall):

1. What is homeostasis?
2. State three examples of homeostasis in humans

Level 2 (Conceptual Understanding):

1. Describe the maintenance of temperature as an example of homeostasis

Level 3 (Strategic Reasoning):

1. Describe the interconnections between three human body systems of your choice.
2. Identify any human body system and describe how it works to promote homeostasis and health.

Learning task for practice

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

1. Let about five learners hold hands in a row. Let another learner stand at one end of the row and pull the hand of the last person. Observe how this action can cause others in the row to be affected by the pull. This is to demonstrate that interconnection involves two or more connections and any influence on one can affect the other(s). This task also demonstrates the interconnections among society and within the human body. This task can be applied to how the nervous system triggers the feeling of hunger, encourages us to eat and the food is broken down by the digestive system which is absorbed and transported by the circulatory system to provide fuel for energy production.

2. Let a learner's volunteer to balance on an upturned pot, or brick or broken cement block using one leg with (i) eyes open and (ii) eyes closed. Learners are to share with the whole class the difficulty level(s) in balancing under these two conditions (with the eyes opened and with the eyes closed). This activity is to introduce learners to the concept of the interconnection between the nervous system (eyes and ears) and the musculoskeletal system for balancing. NOTE: It is easier to maintain balance with the eyes opened then with the eyes closed. (See Fig. 18, Illustration of the interconnectedness of the eyes, ears and muscles for balance). This is because the brain uses information from the inner ear AND the eyes to maintain balance. Cut out vision, and balance becomes more difficult.

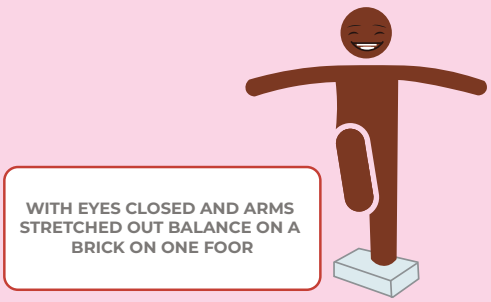

Fig. 18: *Illustration of the interconnectedness of the eyes, ears and muscles for balance*

3. Let learners stand in a circle at equal distances apart (See Fig. 19). Allow another learner to stand in the middle of the circle. Let the learner standing in the middle of the circle close their eyes. Signal any of the learners in the circle to clap their hands once, in turns from different directions. The learner standing in the middle of the circle is to determine the direction of the clap. The same process is repeated with the learner standing in the middle with eyes opened. NOTE: It is easier to determine the direction of the clap with higher accuracy when the eyes are opened than when they are closed. This task is to demonstrate how the eyes and ears coordinate to determine the direction of sound. Additionally, this task demonstrates how the position of the human ears limits our ability to determine the direction of sound without the aid of the eyes.

Keep in mind, having TWO ears enables us to detect the DIRECTION from where the sound is coming. But if the sound comes from directly in front of us, or directly behind, the sound reaches both ears at the same time, and it becomes very difficult to tell whether the sound is from the front or from behind.

Fig. 19: *Illustration of the interconnectedness of the eyes and the ears for determining the direction of the sound*

Conclusion

The concept of the interconnection between the human body systems defines how the different human body systems coordinate their functions to maintain life. The knowledge of the relationship between the human body systems defines homeostasis. Homeostasis refers to the ability to maintain internal stability in an organism in response to environmental changes.

Week 9

Learning Indicator(s): *Evaluate how the interconnections and interactions of multiple body systems are necessary for life*

Theme/Focal Area (s)1: Discuss how the Interconnections of the human body systems support life.

The interconnection of the human body systems is vital for supporting and sustaining life. These interconnected systems work together in harmony to ensure the body functions properly and maintains homeostasis.

The discussion on how the interconnectedness of the human body systems supports life can be guided by the following key points:

1. Energy Production and Distribution: the respiratory system provides oxygen to the circulatory system, which transports it to cells throughout the body. The cells then utilise oxygen in cellular metabolism to generate energy. Also, the digestive system breaks down food into nutrients that are absorbed and transported by the circulatory system to provide fuel for energy production.
2. Waste Removal: the circulatory system, along with the respiratory system, eliminates waste products like carbon dioxide, a by-product of cellular respiration. Again, the circulatory system and the urinary system work together to produce and eliminate urine. The circulatory system transports blood to the kidneys. Within the kidneys, blood is filtered through nephrons, tiny filtering units, where waste products (urea, creatinine, ammonia, uric acid), excess ions, and water are removed to form urine. The circulatory system then carries the urine, containing waste products away from the kidneys for excretion. The digestive system eliminates solid waste through the excretion of faeces. The integumentary system removes waste (water, electrolytes, urea and ammonia) through sweating. Sweating is triggered by the nervous system when the body is hot to cool the body.
3. Defence against Disease and Infections: the immune, lymphatic, circulatory, digestive, respiratory and integumentary systems (skin) work together to defend the body against diseases and infections. The immune system identifies and neutralises pathogens, while the lymphatic system circulates immune cells and fluids throughout the body to target and eliminate pathogens. The integumentary system (skin) acts as a physical barrier against pathogens, preventing their entry into the body. White blood cells, including lymphocytes (B and T cells), neutrophils, monocytes, and macrophages, which form part of the circulatory system are key players in the immune response. They identify and destroy pathogens, produce antibodies, and coordinate immune responses. The respiratory system which includes the nose, trachea, and lungs, which acts as a barrier against inhaled pathogens. Mucus and cilia in the respiratory tract trap and remove foreign particles and pathogens, preventing them from reaching deeper tissues. The digestive system plays a role in defence by preventing the entry of pathogens through the gastrointestinal tract. Stomach acid, digestive enzymes and gut-associated lymphoid tissue (GALT) help destroy or neutralise ingested pathogens. The nervous and endocrine systems modulate immune responses through neuroendocrine signalling and hormone production respectively. They influence inflammation and immune cell activity as well as regulate immune function by modulating the body's response to infections and inflammation. These defence mechanisms are vital for the survival and well-being of the organism.
4. Communication and Coordination: the nervous system acts as the communication network, transmitting signals to and from various body parts. It coordinates the functions of all the other systems, allowing them to work in synchronisation. Hormones, produced by the endocrine system, act as chemical messengers that regulate and coordinate activities across different

systems. It enables quick responses to changes in the environment and helps maintain internal balance.

5. Temperature Regulation: the interplay of various body systems, such as the nervous, circulatory, and integumentary systems, allows for effective temperature regulation **(See Figure 20).** When the body temperature deviates from the set point, these systems collaborate to restore it, preventing overheating (hyperthermia) or cooling (hypothermia), both of which can be life-threatening. The nervous system, particularly the hypothalamus, serves as the body's thermostat. It monitors the core body temperature and initiates responses that will maintain normal body temperature. When the weather is hot, sweat glands in the integumentary system (skin) produce sweat, which evaporates from the skin's surface, thereby, dissipating heat and cooling the body. In colder weather, hairs stand up, the body shivers and the arrector pili muscle contracts (goosebumps) to trap air near the skin surface to provide insulation and retain body heat. Blood vessels (which form part of the circulatory system) in the skin can dilate or constrict in response to temperature changes. Vasodilation increases blood flow to the skin, facilitating heat loss, while vasoconstriction reduces blood flow to conserve heat.

6. Reproduction: the reproductive system is essential for the continuation of the species, and it relies on hormonal signalling from the endocrine system to regulate reproductive processes. The nervous system also plays a role in sexual arousal and response. The circulatory system ensures adequate blood flow to the reproductive organs. The respiratory and digestive systems provide oxygen and nutrients necessary for gamete production and foetal development. The immune system plays a role by protecting the reproductive organs and foetus against infections that could affect fertility or pregnancy outcomes. It also plays a role in the acceptance of a developing foetus by preventing immune rejection during pregnancy. Musculoskeletal structures are also involved in sexual activity and childbirth. Muscles in the pelvic floor are important for sexual function and childbirth, while the skeletal structure provides support for the growing foetus during pregnancy and facilitates childbirth.

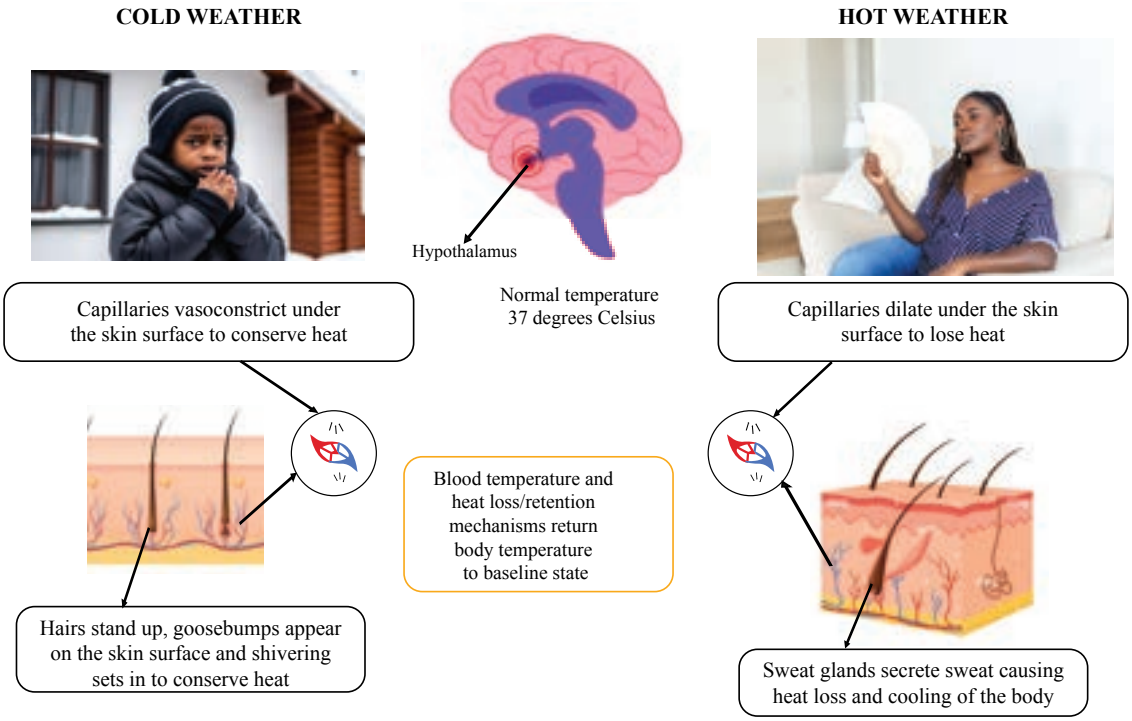

Fig. 20: *The interconnectedness of the human body systems for thermoregulation*

Pedagogical Exemplars

Initiating-talk for learning: Guide learners to identify the human body systems involved in various life activities such as energy production and distribution, waste removal, defence and immunity.

Project-Based Learning: Learners work in mixed-ability groups to explore how interconnections of the human body systems support life activities as their group project.

The objective of this project is to visually represent how different body systems work together to maintain overall health and function. This project is to help learners gain a deeper understanding of how the various body systems work together to support life and promote health. It will also improve learners' communication skills (visual and verbal) and ability to explain complex concepts.

Assessment

Level 1 (Recall): Identify at least two of the human body systems that are involved in any of the following life processes; energy production, waste removal, temperature regulation, reproduction and communication and coordination.

Level 4 (Extended critical thinking and reasoning): Discuss how the systems mentioned are interconnected in function to bring about the operation of the human body.

Learning Task for Practice

Materials needed for this task are poster board or cardboard, markers, coloured pencils, images or illustrations of body systems (can be printed or drawn), labels or captions to identify each body system and its components.

Guide learners to follow the steps:

1. Select a life process (such as energy production and distribution, waste removal, defence and immunity, communication and coordination, temperature regulation and reproduction).
2. From previous knowledge, guide learners to identify the interconnections between the systems and create a visual representation using images, illustrations or diagrams of each body system with a description of the interconnections between the body systems on a poster board.
3. Present your poster to the class and explain how the body systems work to support your chosen life process.

Encourage discussion and questions to deepen understanding. Guide learners to reflect on what they have learnt through the project.

Conclusion

The human body as a whole depends on the interconnection of the body systems for sustaining life. The interconnected systems must work together in harmony to ensure the body functions properly and maintains homeostasis. The importance of the interconnectedness of the body systems is to sustain life and maintain health through the different life processes.

SECTION 3: REVIEW

This section is a review of all the lessons taught for the last 3 weeks and a summary of what the learner should have learnt.

1. What are anatomy and physiology?
2. Identify the human body systems necessary for life.
3. Describe the human body systems, the components of these systems and their functions.
4. Explain homeostasis and how the human body systems work together to maintain health.
5. What is homeostasis?
6. What is the importance of homeostasis?
7. Identify the interconnections between the human body systems.
8. How do the interconnections between the human body systems work to support life?

The human body system comprises different systems working together in a coordinated fashion to promote growth and maintain life. The interconnections between the systems determine how the systems influence one another to maintain life. The ability of the human body to maintain internal stability despite the changing external conditions is important to the body's sustainability.

Additional Reading/ Resources

QR Code 5: Human body system

QR Code 6: Human body system

QR Code 7: Model of the respiratory system

QR Code 8: Fight-or-flight response

System	NERVOUS	DIGESTIVE	CIRCULATORY	IMMUNE	LYMPHATIC
Interactions with other systems w/ = with	Controls all other systems Hypothalamus - maintains homeostasis by working with all systems	1. w/circulatory - absorbs & deliver the digested nutrients to the cells 2. w/muscular - control the contractions of many of the digestive organs to pass food along 3. w/nervous- hypothalamus maintains homeostasis by triggering appetite (stomach growling), digest.	1. w/respiratory - deliver 02 from lungs to cells to lungs 2. w/digestive - absorb and deliver digested nutrients to cells 3. w/excretory - kidney filter cellular waste out of blood for removal 4. w/lymphatic - both transport things to and from cells 5. w/immune - transports WBCs throughout body to fight diseases	1. w/circulatory - transports WBCs to fight invaders 2. w/lymphatics - has lots of WDCs to fight invaders, spleen filters bacteria/viruses out of blood 3. w/skeletal - WBCs made in bone marrow 4. w/integumentary - prevents invaders from getting in	1. w/immune - holds lots of WBCs to fight pathogens 2. w/circulatory - to transport materials to and from cells

System	EXCRETORY	RESPIRATORY	MUSCUSKELETAL	ENDOCRINE	INTEGUMENTARY
Interactions with other systems w/ = with	1. w/circulatory - filters waste out of blood 2. w/lungs - removes excretory waste 3. w/integumentary - removes excretory waste	1. w/circulatory - takes in 02 for delivery to cells and removes CO2 brought from cells 2. w/excretory - removes excretory waste 3. w/nervous - controls breathing 4. w/muscular - diaphragm controls breathing	1. w/circulatory - produce blood cells 2. w/immune - producewhite blood cells 3. circulatory and respiratory - protects it's organs 4. w/digestive - allows organs to contract to push food through 5. w/respiratory - diaphragm controls breathing 6. w/circulatory - controls pumping of blood (heart) 7. w/nervous - controls all muscle contractions	1. w/circulatory - transports hormones to target organs 2. w/nervous - maintain homeostasis, hormone release 3. w/reproductive - controlled by hormones 4. w/skeletal - controls growth of bones	1. w/excretory - removes cellular waste 2. w/nervous - controls body temperature (sweating, goose bumps) 3. w/immune - prevents pathogens from entering

System	REPRODUCTIVE
Interactions with other systems w/ = with	1. w/endocrine - controls production of sex cells 2. w/muscular - uterus contracts to give birth - controlled by hormones

Fig. 21: *Interconnectedness of the various human body systems*

SECTION 4: DISEASES AND DISORDERS

Strand: **Human Body Systems**

Sub-Strand: Diseases and Disorders

Learning Outcome: *Explain what a disease is with examples, identify the symptoms of common diseases and illustrate how the symptoms of diseases lead to diagnosis*

Content Standard: Show an understanding of common diseases and conditions that can disrupt the functioning of cells, tissues and organs within the body.

INTRODUCTION AND SECTION SUMMARY

In this section, learners are introduced to the concepts of diseases and disorders by defining what a disease is and what a disorder is. The categories and examples of diseases and disorders examples are explained in this section. Additionally, learners identify the symptoms of the disease and appreciate how the knowledge of the symptoms supports the diagnosis of the disease. The section also explains what a symptom is, its importance and how they are applied in healthcare delivery. The section concludes with a discussion of common diseases and conditions that can disrupt the normal functioning of cells, tissues and organs within the human body.

The weeks covered by the section are

***Week 10**: Demonstrate an understanding of what a disease is and give examples.*

***Week 11**: Explore how initial symptoms of an illness lead to diagnosis and treatment.*

***Week 12**: Explore the symptoms and factors that contribute to sickle cell disease and how to curtail it in humans.*

SUMMARY OF PEDAGOGICAL EXEMPLARS

To achieve the content standard for this section, the following pedagogical exemplars are recommended. Using managing talk for learning and activity-based learning strategies, learners share their experiences on the concepts of disease, disorder and symptoms and engage in learning tasks that allow them to identify diseases and disorders based on symptoms. Through demonstrative and exploratory learning strategies, learners role-play on diagnosis and treatment. To promote learners' ability to search for information, let learners research from other resources on some common diseases and disorders through an inquiry-based learning strategy.

SUMMARY OF ASSESSMENT

To appraise learners' ability to show an understanding of common diseases and conditions that can disrupt the functioning of cells, tissues and organs within the body, levels 1,2,3 and 4 assessments are recommended. Using DOK level 1 assessment, learners' ability to recall knowledge shared on disease, disorder and symptoms is assessed. Learners' conceptual understanding is assessed on how symptoms are applied in healthcare delivery using DOK level 2 assessment strategies. Using DOK level 3 assessment, learners' strategic reasoning abilities are assessed on how a disease develops, its diagnosis, treatment and management.

Week 10

Learning Indicator(s): *Demonstrate an understanding of what a disease is and give examples*

Theme/Focal Area(s) 1: Introduce learners to the Concept of Diseases and Disorders and establish the relationship between them.

What is a Disease?

A disease is a pathological condition of an organism that impairs its normal physiological functioning.

Key Facts about Diseases

a. Diseases can be caused by Pathogens such as Bacteria, Viruses, Fungi and Protozoa.

b. Diseases are typically characterised by specific Symptoms, Signs and Abnormal changes in the Body's Structure or Function.

c. Symptoms of diseases can manifest in different ways, ranging from mild to severe. It can last for a short period (acute) or be life-long (chronic).

d. Diseases can affect any part of the body, including organs, tissues, cells and even the entire organism.

What is a Disorder?

A Disorder is a broad term sometimes used to describe any abnormal condition or deviation from the normal functioning or in the structure of the body.

Key Facts about Disorders

a. It can refer to physical, mental, or emotional disruptions that deviate from typical patterns of health and well-being.

b. Disorders can manifest in various forms and severity levels, ranging from mild to severe.

Discuss the types of Diseases with examples

Diseases can be classified based on different criteria.

Here are some common types of diseases along with examples:

1. **Infectious or Communicable Diseases:** these diseases are mostly caused by pathogens and some of these can be transmitted from one individual to another like Tuberculosis

   (Air-Borne) and HIV/AIDS (Sexually Transmitted).

   Examples of Infectious Diseases

   a. Bacterial Infections: Tuberculosis, Streptococcal Infections, Typhoid Fever, Pneumonia.
   b. Viral Infections: Influenza (Flu), HIV/AIDS, COVID-19, Hepatitis.
   c. Fungal Infections: Ringworm, Athlete's Foot, Candidiasis (Yeast Infections).
   d. Vector-borne parasitic Infections: Malaria, African *trypanosomiasis* (sleeping sickness), Head Lice Infection, *Filariasis* (Elephantiasis), *Schistosomiasis* (Bilharzia).

2. **Non-Communicable Diseases:** these are usually conditions that are non-infectious and not transmissible from affected individuals to others. These conditions result in long-term health consequences creating the need for long-term treatment and management.

Examples of Non-communicable Diseases

a. Cardiovascular Diseases: Coronary Artery Disease (CAD), Hypertension (High Blood Pressure), Stroke.
b. Cancer: Breast Cancer, Lung Cancer, Prostate Cancer.
c. Respiratory Diseases: Asthma, Chronic Obstructive Pulmonary Disease (COPD).
d. Musculoskeletal Diseases: Osteoarthritis, Rheumatoid Arthritis.

Discuss the types of disorders with examples

1. **Genetic Disorders**: these are caused by genetic mutations, inherited from one or both parents. For example, Sickle Cell Disease, Haemophilia, Down Syndrome and Cystic Fibrosis.
2. **Metabolic Disorders:** the condition where normal metabolism is disrupted due to the body's inability to turn food into energy and get rid of waste. Examples are Diabetes (Type 1 and Type 2) and Obesity.
3. **Neurological Disorders**: disorders affecting the brain, spinal cord and nerves constitute neurological disorders. They result from structural, chemical or electrical abnormalities within the nervous system. Examples include Autism, Cerebral Palsy, Multiple Sclerosis, Alzheimer's Disease, Parkinson's Disease and Epilepsy.
4. **Mental Health Disorders:** with a range of conditions these disorders affect mood, thinking and behaviour. Some examples are Depression, Anxiety Disorders, Schizophrenia and Bipolar Disorder.
5. **Lifestyle-Related Disorders:** due to poor diet, lack of exercise and smoking lifestyle-related disorders are inevitable. Type 2 Diabetes and hypertension are examples.

Discuss Symptoms Associated with Diseases and Disorders.

A symptom is a subjective indication or sign of a disease or disorder experienced or noticed by the affected individual. Symptoms are typically reported by the person experiencing them and may not always be visible to others. They can be physical, emotional, or cognitive and they vary depending on the specific condition.

Below are some common diseases and their associated symptoms:

1. **Influenza (Flu):** High fever, muscle aches, chills, fatigue, headache, sore throat, runny or stuffy nose, cough.
2. **COVID-19:** Fever, cough, shortness of breath or difficulty breathing, fatigue, muscle or body aches, loss of taste or smell, sore throat, congestion or runny nose, nausea or vomiting, diarrhoea.
3. **Diabetes (Type 1&2):** Increased thirst, frequent urination, fatigue, blurred vision, slow-healing wounds or sores, tingling or numbness in hands or feet, unexplained weight loss.
4. **Malaria:** loss of appetite, hot and cold chills, fatigue or loss of energy, headaches, fever, nausea and vomiting, anaemia (in severe cases).
5. **Asthma:** Shortness of breath, wheezing (high-pitched whistling sound during breathing), coughing, especially at night or early morning, chest tightness or pain.
6. **Cardiovascular Disease (coronary artery disease):** Chest pain or discomfort (angina), shortness of breath, fatigue, rapid or irregular heartbeat, dizziness or light-headedness.
7. **Common Cold:** Runny or stuffy nose, sneezing, sore throat, cough, mild fatigue, mild headache.

Discuss how the human body responds to infection to include:

1. First line defence mechanisms like skin, stomach acid, mucus and cilia in the lungs, tears
2. The immune system with an understanding of the terms antigen and antibody
3. The cells of the immune system: lymphocytes and macrophages and how they work
4. T-lymphocytes and B-lymphocytes and the different ways they operate
5. The concept of self and non-self markers
6. The autoimmune response and problems which arise from it

Discuss how humans develop 'herd' resistance to transferable diseases

The development of resistance to infectious and transferable diseases in a community is called herd immunity or community immunity. According to the World Health Organisation (W.H.O.), herd immunity occurs when a significant proportion of the population becomes immune to a particular infectious disease, either through vaccination or previous infection (W.H.O., 2020). The spread of infection is significantly reduced providing indirect protection to individuals who are not immune when herd immunity is achieved. This also protects vulnerable individuals who cannot be vaccinated (new-borns) or have weakened immune systems in the community.

Here are the ways through which herd/community immunity is achieved:

1. Vaccination: When enough people have been vaccinated against a disease their immune system develops antibodies against future infections. This creates immunity without causing the disease. An example is the controlled spread of polio and smallpox through vaccination of infants.
2. Immune Memory Response: After infection and recovery, immune memory protects against the same infection when an individual is exposed again to the pathogens causing the same infection. This makes it difficult for the pathogen to infect hosts, limiting its ability to spread.

Overall, as the transmission chain of the disease is broken due to high immunity in the population, even individuals who cannot be vaccinated or are at higher risk of severe illness are indirectly protected.

Pedagogical Exemplars

Managing Talk for Learning: Learners share their experiences of diseases they know and might have experienced. Let learners watch a video on the different types of diseases and write down key observations. Scan **QR Code 9** to watch "Symptoms of Flu". Learners contribute to the discussion by expressing their thoughts among their peers in an environment that is free from fear or intimidation.

Activity-Based Learning: Learners work in mixed-ability or mixed-gender groups to choose a disease or disorder from a list of diseases or disorders provided through a random ballot. In their groups, learners are to categorise their chosen diseases or disorders, the causes and the list of symptoms associated with their chosen diseases or disorders. Learners become creative by using their knowledge to create posters on diseases.

Assessment

Level 1 (Recall):

1. What are diseases?
2. What are the symptoms of diseases?

Level 2 (Conceptual Understanding):

1. Identify the various types of diseases.
2. Give two examples of the various types of diseases.

Level 3 (Strategic Reasoning):

1. Describe how the immune system might react to the invasion of the 'flu virus

Learning Task for practice

In mixed-ability groups, provide learners with a list of diseases and disorders (the list should include a variety of diseases from different categories of diseases and disorders). Each group randomly chooses a disease or disorder from the list through a ballot. Based on the disease/ disorder chosen, each group should provide the following information:

a. Type of disease or disorder (that is, infectious, non-communicable or disorder).

b. Causative agent of disease (bacteria, fungi, virus, vector-borne parasitic infection) or risk factors for disorders.

c. Symptoms of the disease and disorders.

Conclusion

A disease can be described as a condition caused by a microorganism, whereas a disorder describes a deviation of the body's function or structure from the normal function or structure. Diseases and disorders are characterised by symptoms, signs and abnormal changes in the body's function and process. The body can defend itself from infectious diseases in a wide variety of ways, and we can protect individuals and populations by vaccination programmes and public health interventions.

Week 11

Learning Indicator(s): *Explore how initial symptoms of an illness lead to diagnosis and treatment.*

Theme/Focal Area(s) 1: Introduce learners to the importance of the symptoms of diseases to diagnosis along the following points;

Symptoms of diseases are vital clues that aid healthcare providers in identifying, localising, evaluating and managing various health conditions.

Symptoms also serve as the cornerstone of the diagnostic process, guiding further evaluation and treatment decisions to promote optimal patient outcomes and well-being.

Symptoms provide valuable information to healthcare professionals, helping them identify the underlying condition and develop appropriate treatment plans.

However, it is important to note that symptoms alone may not be enough for a definitive diagnosis and further medical tests and examinations may be necessary to confirm the cause of the symptoms.

Here are some ways of using symptoms for healthcare delivery:

1. Diagnosis: symptoms are the primary indicators that prompt health workers to consider potential illnesses or conditions affecting a patient. By carefully listening to a patient's symptoms and conducting a thorough examination, health workers can narrow down the list of possible diagnoses and arrive at the most likely explanation for the patient's health issue.
2. Treatment Planning**:** the symptoms provide critical information for designing an effective treatment plan. Different diseases and conditions may require specific interventions, medications, or therapies. Understanding the symptoms helps health workers tailor treatment to address the underlying cause of the illness.
3. Monitoring Progress: after initiating treatment, health workers monitor the patient's symptoms to assess the response to treatment and make necessary adjustments if needed. Improvements or worsening of symptoms provide valuable feedback on the effectiveness of the chosen treatment approach.
4. Early Detection: some diseases may present with subtle or non-specific symptoms initially. Health workers who recognise early signs and symptoms can expedite the diagnosis and treatment, leading to better outcomes and potentially preventing the progression of serious illnesses.
5. Public Health Surveillance: identifying and monitoring specific symptoms in a population can be an essential tool for public health surveillance. It allows health authorities to detect outbreaks or trends in diseases, implement appropriate public health measures, and allocate resources effectively.

Discuss how diagnosis and treatments are deduced from the initial symptoms of an illness.

Introduction

Diagnosis refers to the process of identifying a disease or disorder based on the evaluation of symptoms, signs, medical history, physical examinations, and diagnostic test results. A proper diagnosis is essential for understanding the underlying cause of a patient's condition and determining the most appropriate course of action.

Diagnosis and treatment of illnesses (diseases and disorders) based on initial symptoms are crucial aspects of medicine. Physicians use a systematic approach (scientific method) to assess a patient's

symptoms, medical history, physical examination, and sometimes additional diagnostic tests to arrive at a diagnosis and recommend appropriate treatments.

Discussions on how diagnosis and treatments are deduced from initial symptoms should be based on the following:

1. Patient History: the first step in the diagnostic process is gathering information about the patient's medical history. This includes asking questions about the patient's current symptoms, the duration and progression of the symptoms, any past medical conditions, family history of illnesses, medications, and lifestyle factors. The patient's history often provides important clues that can guide the diagnosis.
2. Major Complaint: A major complaint is the primary reason that will cause a patient to seek medical attention. Healthcare professionals focus on understanding the specific symptoms that are most troublesome to the patient (such as stomach ache and headache) and use this information as a starting point for further investigation.
3. Open-Ended Questions: Healthcare providers often ask open-ended questions to allow the patient to describe their symptoms in their own words. This approach helps in understanding the nature, duration, and severity of the symptoms without leading the patient to specific responses.
4. Review of Systems (ROS): ROS is a systematic approach where the healthcare professional asks questions about various body systems to identify any other symptoms that the patient may not have mentioned initially. This helps uncover additional clues to potential underlying conditions.
5. Physical Examination: A thorough physical examination is conducted by the healthcare provider to assess the patient's vital signs and examine specific areas related to the reported symptoms. This hands-on evaluation helps identify physical abnormalities and further narrows down potential diagnoses.
6. Additional Diagnostic Tests: depending on the suspected conditions from the history, the physician may order additional tests. These tests can include laboratory tests (for example blood tests, urine tests), imaging studies (for example X-rays, CT scans, MRIs), biopsies, or other specialised tests to obtain more detailed information about the patient's condition.
7. Refining the Diagnosis**:** once the results of the additional tests are available, the physician can refine the diagnosis and eliminate some possibilities while strengthening others. This helps them arrive at a more accurate diagnosis (draw conclusion).
8. Treatment Decision: with a confirmed diagnosis, the physician can develop an appropriate treatment plan tailored to the patient's specific condition. Treatment may involve medication, surgery, lifestyle changes, physical therapy, or other interventions depending on the illness and its severity.
9. Monitoring and Adjusting: Throughout treatment, the patient's response is closely monitored. If necessary, the treatment plan can be adjusted based on the patient's progress or any changes in their condition.

Pedagogical Exemplars

Demonstrative Learning: Learners do a role play on the diagnosis and treatment of illness. Learners embrace diversity and practice inclusion as they practise diagnosis and treatment of illness. Learners create and share tasks and responsibilities among themselves as they work in groups.

Exploratory learning: Learners after the role-play, are put in groups to review the whole process of how diagnosis and treatments are deduced from initial symptoms. Learners are made to further research and also share their personal experiences on how this is done in real-life settings with their

group members and present their findings to the class. Learners use technological tools to research and prepare their presentations to gain experiential training on how illnesses are diagnosed and treated.

Assessment

Level 1 (Recall):

1. Define what a symptom is.
2. Mention at least two importance of symptoms of diseases.

Level 2 (Conceptual Understanding):

1. What is the significance of the patient's chief complaint in determining the potential underlying cause of the illness?
2. How does the review of systems (ROS) help healthcare providers identify additional symptoms that might be relevant to the initial presentation of the illness?
3. What role does the physical examination play in deducing possible diagnoses from the initial symptoms reported by the patient?

Level 3 (Strategic Reasoning): Explain the importance of symptoms to healthcare workers.

Level 4 (Extended critical thinking and reasoning): In cases where the initial symptoms are vague or non-specific, how do healthcare professionals navigate the diagnostic process to reach an accurate diagnosis and initiate appropriate treatment?

Learning Task for Practice:

The objective of this task is to engage learners in active learning and help them understand the complex concept of how initial symptoms can lead to the diagnosis and treatment of illnesses.

Let learners act out a role play on how initial symptoms can lead to the diagnosis and treatment of illness (for example malaria, flu). Assign roles of a doctor, nurse and patient to the learners.

Their expected responsibilities are as follows:

Doctor: Responsible for diagnosing and prescribing treatment.

Patient: Presents with symptoms and answers questions from the doctor.

Nurse/Assistant: Supports the doctor and patient and takes notes.

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

a. What symptoms did the patient present with?

b. What questions did the doctor ask to diagnose the illness?

c. How was the diagnosis confirmed?

d. What treatment was prescribed and why?

Conclusion

Symptoms are important indicators for patients and healthcare workers. The ability to detect a symptom at an early stage is important for early diagnosis, treatment and management. Without symptoms, diseases may go undetected, undiagnosed, or untreated and may lead to the sudden death of an individual.

Week 12

Learning Indicator(s): *Explore the symptoms and factors that contribute to sickle cell disease and how to curtail it in humans.*

Theme/Focal Area(s) 1: Genetics and Heredity

All organisms inherit the genetic makeup of their parents. The genetic makeup determines the structure and functions of the cells of an organism. Through heredity, particular characteristics or traits of parents are passed on to their offspring provided the traits are determined by the genetic code. Among the many traits that can be inherited by offspring is sickle cell disease.

What is Sickle Cell Disease?

Sickle Cell Disease (SCD), or Sickle Cell Anaemia, is a major genetic disease characterised by a distortion in the shape of the red blood cell. Haemoglobin is a protein in red blood cells responsible for carrying oxygen throughout the body. Normally, red blood cells are flexible and concave, allowing them to flow smoothly through blood vessels **(See Fig. 22).** However, in individuals with sickle cell disease, the haemoglobin is sickle-shaped, causing red blood cells to become rigid and take on a crescent or "sickle" shape. These abnormal cells can get stuck in small blood vessels, leading to various complications **(Fig. 22).**

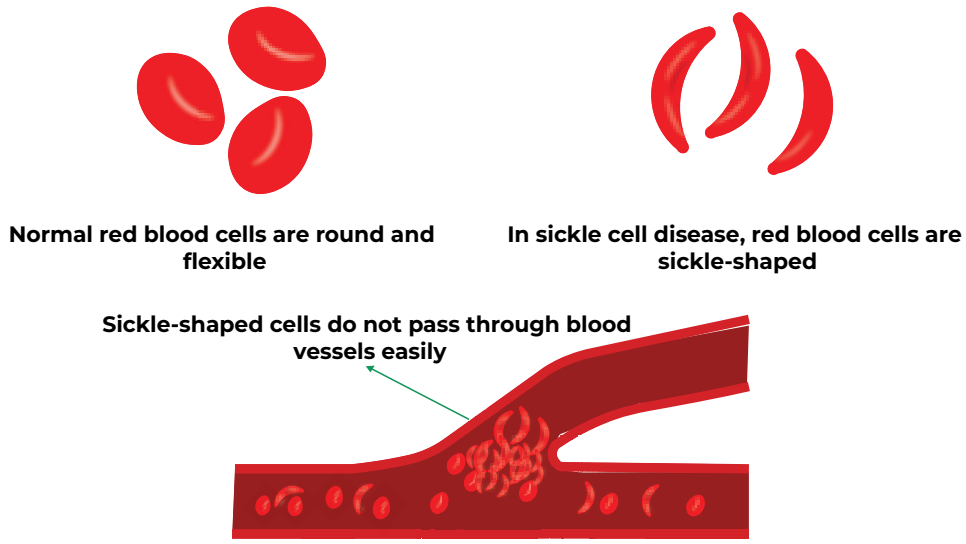

Fig. 22: *Normal red blood cell and a sickle-shaped red blood cell*

Discuss the Symptoms of Sickle Cell Disease along these points;

Sickle Cell Disease can cause a wide range of symptoms and the severity and frequency of these symptoms can vary from person to person.

The most common symptoms and complications of sickle cell disease include:

1. Painful Crises: pain crises are one of the hallmark symptoms of sickle cell disease. These episodes are characterised by severe and acute pain that can occur in various body parts, such as the chest, abdomen and joints. Pain crises may be triggered by factors like infection, dehydration, cold weather, stress, or high altitudes.
2. Anaemia: Sickle cells have a shorter lifespan than normal red blood cells, leading to chronic anaemia. Anaemia can cause fatigue, weakness, and paleness.

3. Fatigue: SCD can lead to persistent fatigue and lack of energy. This is because of the reduction in the surface area of the red blood cell which makes it impossible for enough oxygen to be carried by the red blood cell.
4. Swelling of Hands and Feet: sickle cells can block blood flow in small blood vessels, causing swelling in the hands and feet, particularly in infants and young children.
5. Frequent Infections: sickle cell disease weakens the immune system, making individuals more susceptible to infections, particularly those caused by bacteria.
6. Delayed Growth and Development: Children with sickle cell disease may experience delayed growth and development compared to their peers.
7. Jaundice: Sickle cell disease can cause the breakdown of red blood cells, leading to an increased level of bilirubin in the blood. This can result in jaundice, which is characterised by yellowing of the skin and eyes.
8. Organ Damage: repeated sickling and blood vessel blockages can lead to the damaging of various organs, including the spleen, liver, kidneys and lungs. This can result in organ dysfunction and long-term complications.
9. Acute Chest Syndrome: this is a severe and potentially life-threatening complication of sickle cell disease, characterised by chest pain, fever and difficulty in breathing. It is often caused by infection or blockage of blood vessels in the lungs.
10. Stroke: in children with sickle cell disease, there is an increased risk of stroke due to blood vessel blockage in the brain.

Explain how sickle genes are transferred from parents to offspring through cross-mapping

Cross mapping, also known as Punnett square analysis, is a simple genetic tool used to predict the possible genotypes (genes) and phenotypes (expression of the genes) of offspring when two parents with known genetic traits reproduce. In the case of SCD, it helps to understand how sickle cell genes are transferred from parents to their children.

We have two genes for ever characteristic, which may be dominant or recessive. The gene for SCD is recessive. This means that if you only have one SCD gene it does not express itself because it is hidden by the normal dominant gene, and you appear to be perfectly healthy. But you are a carrier of the gene, and this is potentially dangerous for your children.

The only way to get SCD is to have both recessive genes. As we get one gene from each parent, this means that both parents must be a carrier of the recessive gene before you can get the disease. If both parents carry the recessive gene there is a 25% chance of you getting the disease.

This can be seen in the table below.

In the cross below, both parents are carriers of the SCD gene > HbS The normal gene is HbA

A Punnett square is used to determine the possible genotypes of their offspring:

Punnett square for Parent 1 (HbA/HbS) and Parent 2 (HbA/HbS):

	HbA	**HbS**
HbA	**HbA/HbA**	**HbA/HbS**
HbS	**HbA/HbS**	**HbS/HbS**

The Punnett square shows the four possible combinations of genotypes that their offspring can inherit from the parents:

1. **HbA/HbA:** This genotype means the child inherits a normal haemoglobin gene from each parent. The child does not have sickle cell disease and is NOT a carrier of the gene
2. **HbA/HbS**: This genotype means the child inherits one normal haemoglobin gene from Parent 1 and one sickle haemoglobin gene from Parent 2. The child is a carrier of the sickle cell trait but does not have sickle cell disease.
3. **HbS/HbA:** This genotype means the child inherits one sickle haemoglobin gene from Parent 1 and one normal haemoglobin gene from Parent 2. Like the HbA/HbS genotype, the child is a carrier of the sickle cell trait but does not have sickle cell disease.
4. **HbS/HbS:** This genotype means the child inherits a sickle haemoglobin gene from each parent. Therefore, the child has sickle cell disease.

You can see from the table that there is a 50% chance their child might be a carrier, a 25% chance their child will be totally normal, and NOT a carrier, and a 25% chance their child will have SCD. This is pure chance, like tossing a coin. It does not mean that if the parents have four children there will be one normal, two carriers and one with SCD, any more than tossing a coin four times guarantees two heads and two tails. The table only predicts the likely outcome.

Cross-mapping through the Punnett square analysis allows us to understand the probabilities of different outcomes in terms of genotypes and phenotypes for the offspring when considering specific genetic traits. This information is valuable in genetic counselling and family planning to help individuals and couples make informed decisions regarding the risk of passing on inherited conditions like sickle cell disease to their children.

How the Sickle Cell Disease can be Curtailed in Humans.

Here are some ways to curtail the impact of sickle cell disease in humans:

1. Early Detection and Screening: early detection through new-born screening programs can help identify infants with sickle cell disease so that appropriate medical care and interventions can be initiated early on.
2. Comprehensive Medical Care**:** regular medical check-ups and ongoing care by a specialised healthcare team experienced in treating sickle cell disease are essential. This team may include haematologists, paediatricians, and other specialists. Also, the provision of drugs such as hydroxyurea can help increase foetal haemoglobin levels and reduce the frequency of pain crises and complications in some individuals with SCD.
3. Blood Transfusions: In severe cases of sickle cell disease, regular blood transfusions may be required to increase the number of healthy red blood cells and prevent complications.
4. Stem Cell Transplantation**:** For eligible patients, a stem cell or bone marrow transplant from a matched sibling donor can be a potential curative treatment. However, this option is not suitable for everyone due to the risks involved and the need for a suitable donor.
5. Avoiding Triggers: Individuals with SCD should avoid triggers that may precipitate a pain crisis, such as extreme temperatures, dehydration, stress, and high altitudes.
6. Vaccinations and Infection Prevention: keeping up with vaccinations and taking measures to prevent infections is essential for individuals with sickle cell disease, as infections can exacerbate the condition.
7. Genetic Counselling: Genetic counselling can help individuals and families understand the inheritance pattern of sickle cell disease and make informed decisions about family planning.

Pedagogical Exemplars

Inquiry-based learning: In groups, research from various sources about how sickle cell disease occurs in humans and the symptoms of the disease. Learners can contribute their knowledge on how sickle cell disease spreads and how it can be reduced drastically.

Activity-based learning: Learners undertake the cross-mapping for the sickle genes to show how it is transferred from parents to offspring. Based on the crossings, deduce how the disease can be curtailed in humans. Learners understand and embrace people living with sickle disease and the lifestyle of the sickle cell disease patient.

Assessment

Level 1 (Recall):

1. What is sickle cell disease?
2. Indicate if each of the following statements is true or false:
3. Sickle cell disease is a genetic disorder caused by a mutation in the haemoglobin gene.
4. Sickle cell disease primarily affects the red blood cells, causing them to change shape and become rigid, leading to blockages in blood vessels.
5. Sickle cell disease is inherited in an autosomal recessive pattern, meaning both parents must carry the sickle cell gene for their child to have the disease.

Level 2 (Conceptual Understanding): List the symptoms of a sickle cell patient and factors that contribute to sickle cell disease.

Level 3 (Strategic Reasoning): Identify and discuss the genetic cross mapping between sickle cell patient, carrier and normal person as they interbreed between any of the two involved.

Level 4 (Extended Critical Thinking and Reasoning):

1. With the knowledge gained in the cross mapping suggest the advocacy support that must be given to couples on the possibilities of their children getting the sickle cell disease or not.
2. With the knowledge acquired about the living condition of a sickle cell patient and as a learner what are some of the measures that you would put in place for the sickle cell patient in order for the patient to live longer?

Learning Task for Practice

The objective of this activity is to help learners understand the inheritance patterns of sickle cell disease through a hands-on cross-mapping activity.

Begin the activity by providing a brief overview of the genetic basis and inheritance patterns of sickle cell disease to learners. Explain the concept of genotypes and how they are inherited from parents. Review the basics of Punnett squares and how they are used to predict the outcomes of genetic crosses.

In groups, assign each group with a scenario involving the inheritance of sickle cell disease from parents to offspring. Scenarios can vary in complexity, such as:

a. One parent with sickle cell disease and one parent with normal haemoglobin.

b. Two parents who are carriers of the sickle cell trait.

c. Two parents with sickle cell disease.

Instruct students to use Punnett squares to cross-map the alleles from the parents and predict the genotypes of their offspring.

Encourage students to use different colours to represent normal haemoglobin genotype (HbA) and sickle cell alleles (HbS) in the Punnett squares.

Conclusion

In this lesson, the concepts of genetics and heredity are introduced to learners. Based on the introduction, SCD, a genetic disorder is explored. The symptoms and ways to curtail SCD are also explained. The process by which SCD is transferred from parents to offspring is described using the cross-mapping method.

Section 4 Review

Additional Readings

QR Code 9: Symptoms of Flu

(https://www.youtube.com/watch?v=RvN2upZYBOs)