MINISTRY OF EDUCATION

GHANA ASSOCIATION OF SCIENCE TEACHERS

(GAST)

# Biomedical Science

## for Senior High Schools

Year 2


Dr. Daniel Akwei Addo

Susuana Nyankom

Davidson Addo

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# Contents

# FOREWORD

Ghana's new Senior High School Curriculum aims to ensure that all learners achieve their potential by equipping them with 21st Century skills, knowledge, character qualities and shared Ghanaian values. This will prepare learners to live a responsible adult life, progress to further studies and enter the world of work. This is the first time that Ghana has developed a Senior High School 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.

The Ministry of Education is proud to have overseen the production of these Learner Materials which can be used in class and for self-study and revision. These materials have been developed through a partnership between the Ghana Education Service, teacher unions (Ghana National Association of Teachers- GNAT, National Association of Graduate Teacher -NAGRAT and the Pre-Tertiary Teachers Association of Ghana- PRETAG) and National Subject Associations. These materials are informative and of high quality because they have been written by teachers for teachers with the expert backing of each subject association.

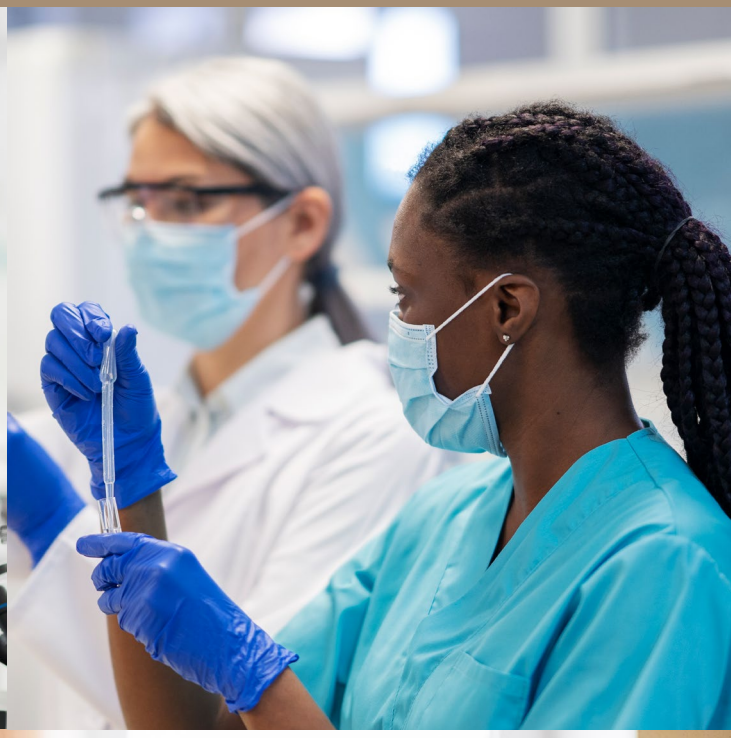
I believe that, if used appropriately, these materials will go a long way to transforming our Senior High Schools and developing Ghana so that we become a proud, prosperous and values-driven nation where our people are our greatest national asset.

**Haruna Iddrisu MP**
*Minister for Education*

SECTION

1

# CAREERS IN BIOMEDICAL SCIENCE



# BIOMEDICAL SCIENCE IN SOCIETY

## Biomedical Science In Practice

## INTRODUCTION

In the world of healthcare, various professions collaborate to protect community health. This section allows you to explore careers in biomedical science that are crucial for preventing, diagnosing, and treating diseases. You will learn about the roles of research scientists, who study disease causes, and medical laboratory technicians, who conduct essential diagnostic analyses. You will also discover the contributions of biomedical science professionals in forensic investigation, where scientific methods are applied to crime-solving, highlighting the intersection of biomedical sciences and law enforcement.

This section serves as a comprehensive guide, highlighting not only the impact of these careers on public health but also the academic pathways and professional responsibilities associated with each. You will have a clearer understanding of the wide array of biomedical careers and how they contribute to enhancing healthcare outcomes. This knowledge will help you find potential career paths that align with your interests and aspirations. Let us get started!

### Key Ideas

- Biomedical forensics is important for solving crimes and diagnosing diseases.
- Biomedical science supports forensics with techniques like fingerprint and DNA analysis, blood spatter analysis and toxicology, aiding in victim identification and understanding causes of death.
- Careers in biomedical science, such as microbiology, immunology, and clinical and forensic science, are interconnected and focus on understanding disease mechanisms, developing treatments, and enhancing overall healthcare through innovative solutions.
- Clinical professionals work directly with patients, while research professionals focus on understanding diseases and finding cures.
- Fingerprint analysis is a crucial technique in forensic science which allows investigators to collect and examine unique patterns that can link suspects to crime scenes.
- Techniques like blood spatter analysis and toxin testing provide key information about crime scenes.

# BIOMEDICAL SCIENCE CAREERS FOCUSING ON PREVENTING, DIAGNOSING, AND TREATING DISEASES

Biomedical science careers focus on preventing, diagnosing, and treating diseases. Professionals in this field use research and technology to improve health outcomes. They play a crucial role in advancing medical knowledge and public health.

## Careers Involved in Preventing and Diagnosing Diseases

Biomedical scientists are superheroes in our healthcare system, tirelessly working to prevent, diagnose, and treat diseases that impact people. Can you imagine being at the forefront of medical breakthroughs, analysing data and testing new medications that could save lives? These scientists dive into fascinating specialties, from creating innovative diagnostic tools to unravelling the mysteries of disease causes, with the aim of improving health outcomes. With their advanced technology, they analyse blood and tissue samples to find illnesses, making a real difference in patients' lives. Their incredible work helps individuals and drives the mission for better health for everyone.

## Exploring the key careers in Biomedical Science focusing on prevention and diagnosis

1. **Biomedical Scientists:** They conduct experiments on samples to research causes and improve the diagnosis of both common and rare diseases. They also play a key role in preventive healthcare, such as health screenings and vaccinations.
2. **Microbiologists:** These scientists study microorganisms to understand their effects on diseases, including research into antibodies and vaccine production.
3. **Immunologists:** They focus on the immune system's role in fighting diseases and analyse blood and other fluids to help diagnose conditions like haemolytic anaemia.
4. **Genetic Counsellors:** They help individuals and families understand genetic diseases and their risks. They also advise on necessary genetic tests, such as prenatal tests for conditions like Down syndrome.
5. **Epidemiologists:** These professionals study disease causes, patterns, and effects in populations to help prevent future outbreaks. Their work involves surveys and analysing large data sets.

Preventing diseases keeps people healthy, and correct diagnoses are essential for understanding health problems. This knowledge informs healthcare decisions.

## Exploring Careers Involved in Treating Diseases

In addition to prevention and diagnosis, treating diseases is vital for improving health. Have you ever been to the hospital before? What form of treatment did you receive? Treatment can include medications, therapy, or surgery. Some biomedical scientists

also work on developing new treatments or improving existing ones. Let us explore treatment-related careers in biomedical science:

1. **Biotechnologists:** They use their knowledge of biology and technology to create new products or enhance existing treatments for diseases.
2. **Medicinal Chemists:** They design and synthesise chemical compounds that positively affect health using their chemistry skills.
3. **Pharmaceutical Scientists:** They focus on creating new and effective medicines by finding potential new drugs through research and testing.
4. **Bioinformaticians:** They analyse biological data using computational tools, helping medical teams make informed decisions and develop targeted drugs.
5. **Clinical Scientists:** These healthcare experts perform laboratory tests and research to diagnose, prevent, and treat diseases using samples like blood or tissue.

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

Bingo! So, what part of the biomedical science career excites you the most? Ready for a fun activity on biomedical science careers? Let us dive right in!

## Activity 1.1 Virtual Field Trip – Discover Ghanaian Biomedical Heroes

**What to do:**

1. Pick one biomedical career from the following options: Microbiologist, Epidemiologist, Immunologist, Pharmaceutical Scientist, Genetic Counsellor, etc.
2. Search for a video or image that shows how your chosen professional works.
3. While watching or searching, grab a notebook and jot down:
   a. tools and equipment they are using for work,
   b. how they help prevent, diagnose, or treat diseases,
   c. anything surprising or new you learnt?
4. Create a simple poster or infographic in your notebook showing the main duties of this professional, the tools they use, and why they are important. Make it colourful and fun!

## Activity 1.2 Field trip to a local healthcare facility 🥼💡

(Discuss with your teacher, parents, or guardian to plan for this activity).

1. Embark on a field trip to see selected biomedical scientists (those related to the prevention, diagnosis, and treatment of disease such as pharmacists, radiologists, community health nurses, etc.) at work.
2. Choose a healthcare facility that has diverse departments related to biomedical science, like:
    a. University Teaching Hospitals
    b. Research centres (e.g., Noguchi Memorial Institute for Medical Research)
    c. Diagnostic Laboratories
3. Prepare a list of expectations for the trip, such as:
    a. Understanding how biomedical scientists contribute to disease prevention, diagnosis, and treatment.
    b. Observing the daily tasks and challenges of professionals like laboratory scientists, microbiologists, clinical researchers, etc.
4. Create a set of guiding questions such as:
    a. What is the primary role of each biomedical professional?
    b. What tools and technology do they use in their daily work?
    c. How do they collaborate with doctors and other healthcare professionals? Etc.
5. Draft a report upon your return and share it with a friend or family.

## Activity 1.3 Biomedical Science Career Podcast (Role-play) 🥼💡

**What to do:**

1. Select one of the biomedical science careers mentioned (e.g., microbiologist, genetic counsellor, immunologist). Research information about the chosen career, including:
    a. Daily responsibilities.
    b. Importance in disease prevention or treatment.
    c. Required education and skills.
2. Write a short script outlining what you will say. Include an introduction, main points about the career, and a conclusion.
3. Use a smartphone or computer to record your podcast. Aim for 3-5 minutes in length.

4. Share your podcast with friends or family or post it online in a safe environment to educate others about the career. *(Repeat this activity for other careers if you can).*

## Activity 1.4 Be the Scientist in the laboratory 🥼 💡

**What to do:**

1. Pick one health problem affecting people in Ghana. Some examples:
   a. Malaria outbreak
   b. Typhoid in a local community
   c. Sickle Cell Disease risk
2. Imagine you are the scientist responsible for solving this problem. Which profession(s) would be best suited for the job? Choose from: Microbiologists, Epidemiologists and Pharmaceutical Scientists.
3. Write down a short plan of how you will go about solving the problem including:
   a. Tools, methods and tests you will use.

**Hint:** Here is a template to guide you about tools and tests: Search further!

   i. Health problem: [State the health problem you have chosen]
   ii. Tools and Methods: [Depends on the health problem]
   iii. For Malaria: Use rapid diagnostic tests (RDTs) and microscopic examination of blood
   iv. smears to detect malaria parasites in blood samples. These tests can provide results in about 15-20 minutes.
   v. For Typhoid: Utilise blood cultures and Widal tests to find the presence of *Salmonella typhi* in the bloodstream. You can also use polymerase chain reaction (PCR) tests for faster results.
   vi. For Sickle Cell Disease: Implement haemoglobin electrophoresis to figure out the types of haemoglobin present in blood samples.

   b. How you will communicate your findings to the community.
4. Act it out: If you have access to a mirror or a friend, practice explaining your role as if you were presenting to a group.

## Self-reflection

1. Write a few sentences about your experience. Did you enjoy being a scientist?
2. What challenges did you face, and how would you overcome them?

# HOW BIOMEDICAL SCIENCE IS USED IN FORENSICS

What if science held the key to solving mysteries and catching criminals? Biomedical science professionals in forensics do just that, using innovative techniques to analyse evidence and reveal hidden truths in criminal investigations.

The world of biomedical science is expanding rapidly, creating exciting job opportunities in various fields! Have you ever wondered how science can help solve crimes? Forensic science combines biology, chemistry, physics, and other disciplines to crack cases and support legal investigations. Each specialisation within forensic science plays a unique role in uncovering the truth. Forensic science uses various biomedical methods to investigate crimes. Here are some interesting specialisations:

1. **Forensic odontology:** Also known as forensic dentistry, this field identifies individuals by examining their teeth. Teeth are incredibly durable and can survive extreme conditions, making them valuable for finding victims in disasters like fires. Is it not fascinating that teeth can survive fires or crashes?

**Figure 1.2:** Forensic odontologist examining the teeth of a lower jaw.

2. **Forensic toxicology:** This area analyses body fluids and tissues to detect poisons and drugs. A common example is measuring blood alcohol levels to decide how alcohol may have affected a person's behaviour.
3. **Forensic pathology:** Have you ever thought about what happens during an autopsy? Forensic pathologists act as medical detectives, figuring out the cause and manner of death through autopsies. Autopsy involves closely examining bodies for injuries or signs of poisoning and often collaborates with toxicologists to analyse tissue samples.

**Figure 1.3:** Forensic pathologist at work.

4. **Forensic serology:** Focuses on analysing blood serum to gather evidence. Forensic serologists find blood types and can decide the presence of substances like semen or saliva, which can be crucial in investigations.

**Figure 1.4:** Forensic serologist picking blood sample for analysis.

## Exploring Other Disciplines of Forensic Science

**Forensic psychology:** This field assesses whether individuals are mentally fit to stand trial. Forensic psychologists help understand a person's mental state, which can inform legal defences and aid in crime scene reconstruction.

**Forensic anthropology:** Like archaeologists, forensic anthropologists study bones to identify individuals and understand the cause of death.

**Figure 1.5:** Examination of bones to find the individual and cause of death.

**Forensic Engineering:** This discipline uses principles of engineering to investigate accidents and crimes. Forensic engineers analyse evidence such as skid marks and road conditions to decide what happened during incidents like car crashes.


**Figure 1.6:** Investigation of accident and crimes

So, which area of forensic science intrigues you the most, and how do you think these scientists make a difference in our world?

## Exploring the Applications of Biomedical Science in Forensics

Biomedical science is essential in forensics, especially when it comes to analysing biological evidence. This specialised area, known as biomedical forensics, plays a crucial role in criminal investigations. Did you know that DNA analysis can not only find suspects but also exonerate innocent people? Imagine the impact that can have on someone's life! But the work of biomedical forensic scientists goes beyond solving crimes; it also helps diagnose and treat diseases in the medical field. They analyse a wide range of evidence, making connections that can change the course of an investigation or a patient's treatment

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

1. **Biological evidence:** Hair follicles and bodily fluids can provide DNA information.
2. **Chemical evidence:** Drugs and other substances found at crime scenes are analysed to piece together events.
3. **Physical evidence:** Fibres from clothing and fingerprints are examined using biomedical techniques.

You have explored the key role that biomedical science plays in forensic investigations, displaying its essential contributions and powerful techniques for analysing evidence.

Now, let us dive deeper into **three fascinating examples of how biomedical science enhances forensic investigations and helps uncover the truth**:

1. **DNA analysis:** Fingerprints have unique patterns that are formed before birth and remain unchanged throughout life. It is made of unique instructions inside your cells called deoxyribonucleic acid (DNA). DNA, which carries individual genetic information, can be extracted from crime scene evidence like hair or blood. By comparing this DNA with that of a suspect, investigators can link or rule out individuals in crimes.

**Figure 1.7:** Forensic examiner observing for fingerprint, poison, and toxins on a glass

2. **Identifying toxins and poisons:** Some harmful substances may not be at once visible. Biomedical forensic scientists use specialised techniques to analyse body fluids for toxins, helping to decide if these substances contribute to illness or death.
3. **Using blood spatter analysis to reconstruct crime scenes:** The patterns of bloodstains at a crime scene can reveal crucial information. Forensic scientists analyse the size and shape of the stains, using physics and biology to reconstruct the events of the crime, including the positions of the victim and perpetrator.

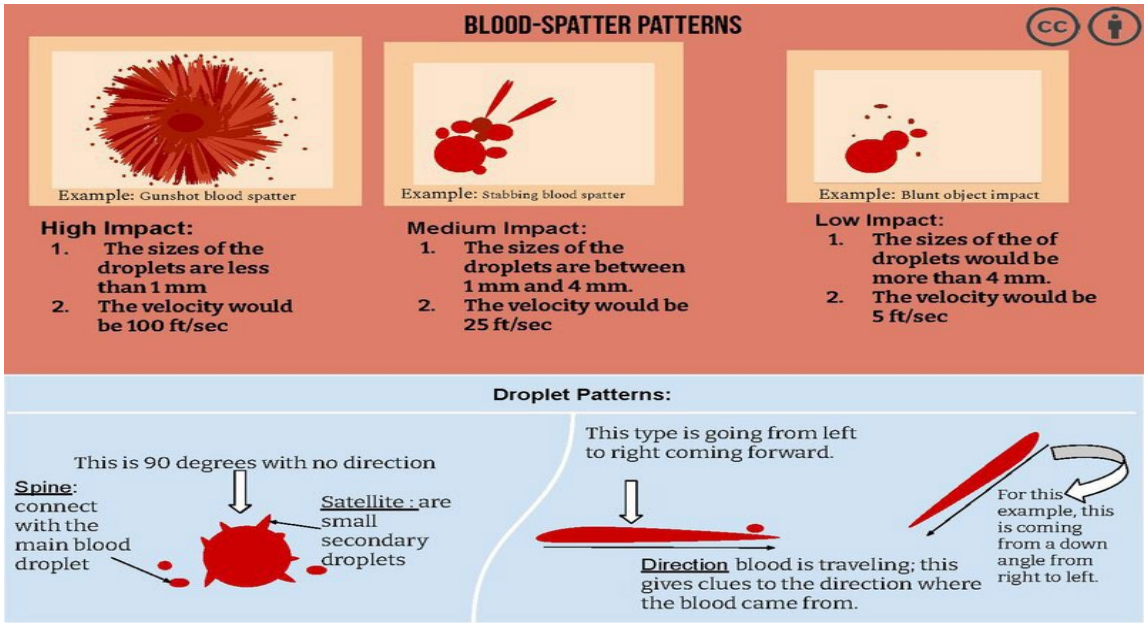



**Figure 1.8:** Blood spatter analysis.

Well done! Now get ready to explore further with some intriguing activities. Let us kick off!

## Activity 1.5 Fingerprinting Art Gallery

**Materials needed:** coloured dye or ink pads (diverse colours), white paper or cardstock, markers or pens, tape or glue, and a designated wall or board for the gallery display.

**What to do:**

1. Find a clean, flat surface to work on. Lay down some newspaper or a plastic sheet to protect the area from any ink spills.
2. Select a few distinct colours of dye or ink pads. Dip your fingertip into the coloured dye or ink pad. Ensure it is evenly coated but not dripping.
3. Press your inked finger firmly on the paper or cardstock to create a clear fingerprint.
4. Repeat this process with different fingers or colours to create a unique design.
5. Once the prints are dry, use markers or pens to label each fingerprint with your name. Feel free to add any fun facts about yourself or what the fingerprints stand for.
6. Use tape or glue to secure the prints in an organised manner, creating an art gallery feel.
7. After the gallery is set up, talk to a friend or family about the uniqueness of fingerprints, how they are used in forensic science, and why they are important for identification.
8. Walk around the gallery with the friend or family.

## Self-reflection

After the activity, write a short reflection on what you learned about fingerprints and their role in forensic science. Why are fingerprints used for identification?

## Activity 1.6 How Crimes are solved using Fingerprints | Fingerprint Forensics

1. Search videos online (Click here and here) on fingerprint detection and analysis.
2. As you watch, take notes on important points, techniques shown, and any interesting facts you notice.
3. After watching the videos, write a summary of what you observed. Focus on:
   a. how fingerprints are collected and analysed.
   b. why fingerprints are important in solving crimes.
   c. any specific cases or examples mentioned in the videos.
4. Share your observation with a friend or family and let them know why fingerprint detection is possible.

## Activity 1.7 Forensic scientist at work

Search a video on virtual forensic scientists (or pay an in-person visit to the workplace of forensic scientists). (After, click here to watch another video).

1. Make observations on the roles of biomedical scientists in the field of forensic science.
2. Write down the various tools and techniques used, as you watch the video.
3. Share your findings with friends or family members.

## Activity 1.8 Crime scene investigations with word puzzles

**A** **B**

**Figure 1.9:** Crime Scene A and Crime Scene B

Click here crime scene A and here crime scene B to find a wordlist that describes the images from each crime scene in Figure 1.9 A and B, respectively. Enjoy your puzzle-solving!

**What to do:**

1. Copy into your note (or print) the puzzle grid or play online.
2. Have a pencil or pen ready if it is a printed or copied puzzle.
3. Look at the word list to understand the words you need to find.
4. Scan the puzzle grid for the first word on your list. (Note that words can be arranged horizontally, vertically, or diagonally, and may be forwards or backwards).
5. When you find a word, circle it, or highlight it to keep track of your progress. You may want to cross it off the word list as you find it.
6. Take your time to carefully search for each word. If you get stuck, move on to the next word and come back later. Review the puzzle to ensure every word is circled or highlighted.
7. After completing the puzzle, share your experience with friends or family.

## Activity 1.9 Create a Forensic Science News Report

**What to do:**

1. Create a fictional crime scene. This could involve a missing person, a mysterious death, or a robbery.
2. Look for real biomedical science techniques that could be used in your scenario, such as DNA analysis, toxicology tests, or blood spatter analysis.

3. Draft a news article or script for a video news segment that includes:
    a. A summary of the crime.
    b. The forensic evidence collected.
    c. The techniques used to analyse the evidence.
    d. Leads or conclusions.
4. Record yourself reading the news report or create a digital presentation to share with family or friends.

## Activity 1.10 Forensic Science Role-Play

**How to go about it:**

1. Choose various roles involved in a forensic investigation, such as a forensic pathologist, toxicologist, or forensic engineer.
2. Create short scenarios for each role. For example, the forensic pathologist could explain the findings from an autopsy, while the toxicologist discusses the results of a drug test.
3. If possible, ask a family member or friend to play different characters. Alternatively, you can perform both roles by switching back and forth.
4. After the role-play, write a brief reflection on what you learned about each role and how they contribute to solving crimes.

## Activity 1.11 Build a Forensic Science Toolkit

1. Research common tools used in forensic science, such as DNA testing kits, blood spatter analysis tools, and microscopes.
2. Build your toolkit:
3. Physical Version: Use a box or a small container to gather items that stand for each tool (e.g., a magnifying glass, a notebook for notes, etc.). ***You can use pictures or drawings if you do not have the actual items.***
4. Use a digital presentation tool (like PowerPoint or Google Slides) to create a virtual toolkit that includes images and descriptions of each forensic tool and its purpose.
5. Share your toolkit with family or friends, explaining the significance of each item and how it is used in forensic investigations.

**Self-reflection**

1. What did you learn about how fingerprints and other forensic techniques are used to solve crimes, and why is biomedical science important in this process?
2. In what ways can you apply this knowledge in real-world situations or your future studies?

# CLINICAL AND RESEARCH CAREERS IN BIOMEDICAL SCIENCE

## Exploration and Description of Different Career Fields in Biomedical Science Related to Clinical or Research Studies

Have you ever wondered how scientists discover new treatments or diagnose complex diseases? Biomedical science offers a range of career options that are vital for advancing healthcare and improving lives. Whether in clinical settings or research environments, professionals in this field make significant contributions to understanding health and treating diseases. By exploring these careers, you will gain insights into the various pathways available in biomedical science and consider how you might contribute to this important field.

Clinical and research careers in biomedical science are interconnected, much like two sides of a coin. Clinical careers focus on diagnosing, managing, and treating diseases, while research careers investigate scientific questions and develop new therapies. Below, you will examine the similarities and differences between these two areas.

### Clinical Professionals and Patient Interaction

Did you know that clinical professionals, like medical doctors and clinical scientists, do more than just study diseases? They also work closely with patients! In many cases, when testing new treatments (like a new drug for Alzheimer's, which affects memory), these professionals have two big responsibilities:

1. **Research and track progress**: Clinical scientists design and carry out clinical trials, where they check how a treatment is affecting patients who volunteer to take part. This means they are actively involved in studying the results and making sure everything is safe and effective.
2. **Provide patient care**: While doing research, they also get to care for the patients, giving advice, and supporting them throughout the study.

Some specialised doctors, like **cardiologists** (heart specialists) and **oncologists** (cancer specialists), also combine research with patient care, helping improve treatments and directly supporting those in need.

## Research Professionals and New Treatment Development

Research professionals in biomedical science are like detectives for diseases! They help us understand health problems better and find new ways to diagnose and treat them.

They are crucial for expanding scientific knowledge and developing new diagnostic methods and treatments. Here is how they do it:

1. **Investigate diseases**: They follow the scientific process to study the main causes of diseases. This includes looking at how a disease works in the body and how things like environment, lifestyle, or diet might make it worse or better.
2. **Develop new tests and treatments**: Biomedical scientists work with other scientists and healthcare experts to create new tests or improve existing ones. This helps doctors diagnose diseases more accurately and find better ways to treat them.

Clinical biomedical scientists focus on research rather than patient care, collaborating with others to develop new diagnostic tests that improve disease detection.

How would it feel to help discover new treatments and get to care for patients?

# EXPLORING A CHOSEN CLINICAL OR RESEARCH FIELD

Get ready to explore how professionals in this area contribute to healthcare and scientific discovery by bridging the gap between the theoretical and the practical parts of biomedical science.

## What Unique Contributions Does a Particular Field Bring to Biomedical Science?

Exploring the unique aspects and effects of different fields within biomedical science reveals how each specialty plays a vital role in advancing healthcare and scientific knowledge.

People from different educational backgrounds, not just those in biology, can pursue careers in this sector. For example, biostatisticians are essential for analysing and interpreting data from biomedical research. They design experiments and clinical trials, helping to clarify disease understanding. Robotic engineers and manufacturing engineers create assistive devices like prosthetics and orthotics for amputees, while computer scientists develop tools for analysing medical images and managing electronic health records, which enhances patient care.

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

Let us look at two chosen careers in biomedical science: neuroscientists and dietitians.

**Neuroscientist:** Neuroscientists study the nervous system to uncover how it functions and to develop solutions for related disorders. To become a neuroscientist, you typically need a bachelor's degree in psychology or biology, a pure research Doctor of Philosophy Degree (Ph.D.) focused on the nervous system, and a license to practice in a clinical setting.

*Daily tasks might include:*

1. staying updated on the nervous system's development,
2. designing experiments to investigate neurological disorders,
3. researching treatments using genetically modified animal models.

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

**Dietitian:** Dietitians specialise in nutrition and educate clients on healthy eating. To work as a dietitian, a bachelor's degree in Dietetics is needed.

*Daily responsibilities include:*

1. planning nutritional therapies for conditions like diabetes,
2. preparing meals for clients with special dietary needs, and
3. promoting awareness of healthy eating habits.
4. assessing clients' nutritional and health needs to support healthy living.

Dietitians provide evidence-based recommendations on the nutritional and health needs of clients to enhance their lifestyles, not.

Splendid work for completing section 1! It is now time to delve into some activities. Remember to crown it all by solving the review questions. Keep exploring with the extended reading.

### Activity 1.12 Career Detective Research

**What to do:**

1. Choose one clinical (e.g., Clinical Laboratory Technician) and one research-based career (e.g., Biotechnologist). Write it down.
2. Use textbooks, reputable websites like MedlinePlus, google scholar or career sites like My Next Move to find out what these professionals do daily. Jot down:

   a. Core responsibilities (e.g., diagnosing diseases, researching new therapies).
   b. Skills needed (e.g., attention to detail, research skills).
   c. Educational pathway (e.g., bachelor's degree, advanced certifications).
3. Assume you are preparing for a TV show interview. Create a short career profile for each.
   a. Use catchy headings like "The Day in the Life of a Lab Technician!" or "Meet the Biotech Genius!"
   b. Use images and bullet points to keep it visually engaging.
4. Summarise your findings on a career comparison chart. Make sure to include at least three similarities and three differences between the roles. Share your findings with friends or family.

## Activity 1.13 Create a Career Map of Biomedical Science

**Guidelines:**

1. Choose three biomedical careers (e.g., Microbiologist, Toxicologist, and Clinical Biomedical Scientist). For each one, find:
   a. Their core duties (e.g., testing for pathogens, analysing chemical substances).
   b. Skills needed (e.g., lab techniques, problem-solving).
   c. Educational path (e.g., degrees, certifications).
2. Use tools like Mind Meister (online) or paper and coloured pens. Start with a central node labelled "Biomedical Careers" and branch out to each profession. Add images, icons, or symbols (e.g., test tubes for a scientist) to stand for each career. Colour-code the roles (e.g., green for clinical, blue for research).
3. Present It: Share your mind map with a family member or friend. Walk them through it and explain how these roles work together to solve real-life health challenges.
4. Bonus Challenge: Add a "career growth" branch showing future opportunities in each field!

## Activity 1.14 Career Path Interview - Become a Biomedical Journalist

**What to do:**

1. Find a biomedical professional in your community (e.g., a laboratory technician or healthcare worker). Prepare 5–7 interesting questions such as:
   a. What does a typical day look like in your job?

   b. What inspired you to choose this career?
   c. What challenges do you face?
   d. What advice would you give to someone interested in this field? Etc.
2. Conduct the interview in person or through a video call. Take notes or record (with permission). If you cannot reach a professional, use video interviews online noting key points.
3. Summarise your interview findings into a mini-news article titled: "A Day in the Life of a [*Write Career Name*]"
4. Include quotes from the interview and add a short reflection on what you learned and how it changed your belief about the career. Share your mini-news article.

## Activity 1.15 Role-Playing and Presentation - Career Drama!

**Steps:**

1. Pick two biomedical careers (e.g., a forensic scientist and a dietitian). Write a short script where these professionals collaborate on a case. Imagine a scenario like a food poisoning outbreak:
   a. The forensic scientist finds the toxins in the food.
   b. The dietitian explains how the food might have affected the victims and advises on a recovery diet plan.
2. Create a small stage setup (e.g., a laboratory table for the scientist, and a consultation room for the dietitian).
3. Use props like empty medicine bottles, food trays, or laboratory tools to make it feel realistic.
4. Present your role-play to a friend, classmate, or teacher. After the role-play, discuss how the careers overlapped, what skills were used, and the impact of each profession on public health.

## Activity 1.16 Create and Play Biomedical Science Bingo

**Materials needed:** Access to the internet or your learner's material, notebook, a blank bingo card, pen, or marker.

**Steps:**

1. Search for a list of terms and roles related to biomedical science clinical and research careers and check any that you are unfamiliar with.

2. **Create your Bingo card like this:**

| Term | Term | Term | Term | Term |
|---|---|---|---|---|
| Term | Term | Term | Term | Term |
| Term | Term | **FREE** | Term | Term |
| Term | Term | Term | Term | Term |
| Term | Term | Term | Term | Term |
| Term | Term | Term | Term | Term |

3. Write 24 terms from the list on your Bingo card, one in each square. Leave the middle square blank (that is your free spot).
4. Write the meaning of each word on a separate paper. Invite a friend or a family member to call out the meaning of the words.
5. When a term is described, mark it on your card if you know it. Try to get five in a row to win!

## Self-reflection

How did the activities aid your understanding of the careers in Biomedical science?

## EXTENDED READING

- Click here to read more on medical scientists
- For further information on medical laboratory technologist, their skills and work, click here
- Click the link to search various careers in Biomedical science by using keywords.

# REVIEW QUESTIONS 1.1

**Read each case study and answer the question(s) that follow**

## 1. Case Study: Microbiologist's Role in a Malaria Outbreak 🌍🔬

**Scenario**

A community in the northern part of Ghana experiences a sudden spike in malaria cases, especially after a rainy season. The local clinic brings in a **microbiologist** to find the cause of the outbreak. The microbiologist collects **blood samples** from affected individuals and uses a **microscope** to detect ***Plasmodium* parasites** in the blood. After confirming the presence of the parasite, the microbiologist collaborates with public health officials to **educate the community** on preventive measures, such as using mosquito nets and removing stagnant water where mosquitoes breed.

**Questions:**

a. What tool did the microbiologist use to detect the malaria parasite?

b. Explain why the microbiologist collected blood samples from affected individuals.

c. Suggest two other actions the microbiologist can take to help prevent future malaria outbreaks in the community.

## 2. Case Study: Epidemiologist Investigating a Typhoid Fever Outbreak 🏥📊

**Scenario**

An epidemiologist is called to investigate an outbreak of **typhoid fever** in a town in the Ashanti Region. They begin by **collecting data** on reported cases and tracing it back to a **water source** that supplies several homes. After conducting surveys and testing water samples, they discovered that a **contaminated well** is the probable cause. The epidemiologist recommends that the community **boil their water** before drinking and works with local authorities to ensure proper sanitation practices.

**Questions:**

a. What disease was the epidemiologist investigating?

b. Why did the epidemiologist test the water samples?

c. Propose a long-term solution the epidemiologist could recommend for preventing future outbreaks of typhoid in the town.

## 3. Case Study: Genetic Counsellor with a Family at Risk of Sickle Cell Disease

**Scenario**

A **genetic counsellor** in a hospital in Accra is working with a couple who both have the **sickle cell trait**. The couple is concerned about the risk of passing on **sickle cell disease** to their children. The counsellor explains the **genetics of the disease** and the **inheritance patterns**. Using a **Punnett square**, the counsellor shows that there is a **25% chance** for each child to have sickle cell disease, a **50% chance** to be a carrier like the parents, and a **25% chance** to have no trait at all. The counsellor advises the couple on available **testing options** and **family planning**.

**Questions:**

a. What condition is the genetic counsellor helping the family understand?

b. How does the genetic counsellor use a Punnett square in the session?

c. What recommendation can the genetic counsellor give to the couple to help them make informed decisions about family planning?

## 4. Case Study: Pharmacist's Role in Managing Chronic Diseases

**Scenario**

A **pharmacist** in a community hospital in Kwahu is working with patients who have been diagnosed with **hypertension** (high blood pressure). The pharmacist provides **medication counselling** and educates patients on the **importance of medication adherence** to control their condition. One patient mentions that they often forget to take their pills. The pharmacist suggests using a **medication reminder app** or setting a daily alarm on their phone. To ensure the treatment is effective, the pharmacist collaborates with the doctor to **check the patient's blood pressure** regularly.

**Questions:**

a. What health condition was the pharmacist helping to manage?

b. Why did the pharmacist suggest using a reminder app for the patient?

c. Describe one other method the pharmacist could use to support patients with chronic diseases like hypertension.

## 5. Case Study: Clinical Scientist Addressing Tuberculosis in a Mining Community

**Scenario**

A **clinical scientist** is assigned to a mining community in the Western Region of Ghana to investigate the high prevalence of **tuberculosis (TB)** among miners. The clinical scientist conducts **health screenings** using **chest X-rays and sputum tests**. The tests reveal that the miners are exposed to elevated levels of **silica dust**, which weakens their lungs and makes them more susceptible to TB. The clinical scientist recommends that the mine management implement **dust**

**control measures** and provide **protective masks** for the workers. Additionally, they suggest regular health screenings to catch any new TB cases early.

**Questions:**

a. What disease was the clinical scientist investigating?

b. Why were the miners more vulnerable to developing TB?

c. Propose two recommendations the clinical scientist could give to reduce the risk of TB among miners.

## 6. Case Study: Forensic Pathology in a Crime Scene Investigation

**Scenario**

A forensic pathologist is called to examine a body found at a crime scene. The first examination reveals a head injury and traces of a toxic substance in the victim's blood. The pathologist collaborates with forensic toxicologists to find the exact cause of death, taking samples for further analysis.

**Questions:**

a. What field of forensics handles deciding the cause of death?

b. Describe two methods that a forensic pathologist might use to find the cause of death.

c. Based on the findings (head injury and toxic substance), explain the potential causes of death, and suggest how the pathologist can decide which one is correct.

## 7. Case Study: Blood Spatter Analysis at a Crime Scene

**Scenario**

A forensic scientist is analysing blood spatter patterns found at a crime scene. The bloodstains on the wall are in a circular pattern, while stains on the floor are elongated. The scientist needs to reconstruct the sequence of events to figure out the position of the victim and the angle of impact.

**Questions:**

a. What is the term used for the study of blood patterns in forensic science?

b. Compare the difference between circular and elongated blood spatter patterns. What does each show?

c. Using the patterns described, infer the probable position of the victim, and explain how the blood spatter analysis can be used to understand the crime scene dynamics.

## 8. Case Study: Forensic Odontology and Victim Identification

**Scenario**

After a fire accident at a residential building, forensic odontologists are called to identify the victims. Most bodies were severely burned, but the forensic odontologist examines dental records and matches them with the teeth found at the scene. One victim is found through dental fillings and braces.

**Questions:**

a. What does a forensic odontologist use to identify victims?

b. State two reasons why teeth are useful for identifying victims in disasters.

c. How can a forensic odontologist use dental fillings or braces to confirm a person's identity? Explain the process.

## 9. Case Study: Forensic Psychology and Crime Reconstruction

**Scenario**

A suspect in a murder investigation claims they were not in a stable mental state during the crime. The court assigns a forensic psychologist to assess the suspect's mental health and decide if they were legally insane at the time of the offense.

How would the forensic psychologist evaluate the suspect's mental state and what methods might be used to prove if the suspect is legally insane?

**Rubric: Forensic Psychology**

| Criteria | 1 mark (Low quality) | 3 marks (Medium quality) | 5 marks (High quality) |
|---|---|---|---|
| Concepts | Limited understanding lacks clarity. E.g., Forensic psychology is about interviewing suspects. | Basic understanding with some relevant points but lacks depth. E.g., Forensic psychologists analyse mental state to figure out sanity. | Comprehensive understanding with clear identification of key concepts. E.g., Forensic psychologists assess mental conditions using professional Act. |
| Application and Analysis | No application or irrelevant analysis. E.g., Interview the suspect and see what they say. | Basic application but lacks depth. E.g., Review mental health history to understand if suspect was capable. | Excellent application connects theories to case. E.g., Use structured interviews and tests to assess mental and emotional state. |

| | | | |
|---|---|---|---|
| Depth of Reasoning | Superficial reasoning, little justification. E.g., Suspect is guilty because they were present. | Some reasoning but lacks clarity or supporting evidence. E.g., Since suspect has history, they may not have understood actions. | Strong reasoning, well-supported. E.g., Based on ***People v. Serravo,*** cognitive incapacity due to disorder can negate intent. |

## 10. Case Study: Forensic Engineering in a Building Collapse

**Scenario**

A building collapses, and forensic engineers are tasked with figuring out whether structural flaws or external factors caused the failure. They examine the building's design, material quality, and damage patterns.

**Question:**

Write a report analysing how the forensic engineers would investigate the building collapse, and name potential causes based on their findings.

**Rubric: Forensic Engineering**

| Criteria | 1 Mark (Low quality) | 3 Marks (Medium quality) | 5 Marks (High quality) |
|---|---|---|---|
| Concepts | Incorrect understanding. E.g., Engineers just check the site after an accident. | Basic understanding lacks depth. E.g., Forensic engineers look at the structure to see what caused the issue. | Detailed understanding, and correct terms used. E.g., Engineers assess design, material properties, and environmental factors. |
| Application and analysis | Minimal or irrelevant. E.g., The engineer should look around and decide what happened. | Applies basic principles but lacks depth. E.g., Review building structure and materials for faults. | Excellent application integrates principles. E.g., Analyse shear cracks and tensile stress to prove failure cause. |
| Depth of reasoning | Limited reasoning, vague conclusions. E.g., Collapse due to weak materials. | Some reasoning lacks evidence. E.g., the material might have been substandard, causing cracks. | Well-supported, detailed arguments. E.g., Concrete samples show lower compressive strength, confirming substandard material." |

| | | | |
|---|---|---|---|
| Structure | Disorganised, unclear language. | Some structure, with 1-2 parts missing | A well-organised, clear flow of ideas with all parts such as introduction, investigation steps, findings, and conclusion present |

## 11. Case Study: Clinical Trials by clinical scientist

**Scenario**

In Accra, Dr. Smith, a clinical scientist at the Korle Bu Teaching Hospital, is leading a **trial** for a new drug aimed at slowing the progression of Alzheimer's disease, which is becoming increasingly recognised in Ghana. During the trial, she interacts closely with a group of participants, including Mrs. Johnson, an 82-year-old woman from Osu, who is eager to contribute to research that could help future generations. Each week, Dr. Smith designs and conducts the trial **while** checking the effects of the medication on consenting patients. Patient consent is crucial, as it ensures that participants understand their rights and the potential risks involved in the study. The personal connections Dr. Smith builds with her patients **foster** a trusting atmosphere, which may enhance the quality of data collected and the overall experience of the participants.

**Questions:**

a. What is the primary goal of the clinical trial being conducted by Dr. Smith?

b. Why is patient consent considered important in the clinical trial process?

c. In what ways might the personal connections Dr. Smith build with her patients influence the outcomes of the clinical trial?

d. What specific role does Dr. Smith perform each week during the trial?

e. How might the dual role of clinical scientists affect the outcomes of clinical trials

**12.** Define forensic science and describe how biomedical science is used in forensic investigations.

**13.** Analyse the different careers in biomedical science that focus on diagnosing and treating diseases, discussing their roles and importance.

**14.** Discuss how forensic science incorporates biomedical science, detailing specific examples of its applications in investigations.

**15.** Formulate a comprehensive overview of the various careers in biomedical science that focus on diagnosing and treating diseases, including future trends.

**16.** Design a research project that explores the intersection of forensic science and biomedical science, outlining the method and expected outcomes.

SECTION 2

# BIOSAFETY

# BIOMEDICAL SCIENCE IN SOCIETY

## Biosafety

## INTRODUCTION

Welcome to another exciting section on biosafety. Here, you are going to explore the crucial features of biosafety levels and proper practices that ensure a safe laboratory environment. Understanding these concepts will help you protect yourself from biohazardous exposure. You will start by describing the four different biosafety levels, focusing on their specific features and the practices you need to follow at each level. Then, you will explore how to set up a Biosafety Cabinet (BSC) correctly, along with its surrounding environment, to ensure the best safety while you work. Next, you will show the proper methods for donning and removing personal protective equipment, including gloves, laboratory coats, eye protection, and respiratory protection. This is essential for keeping you safe while handling potentially hazardous materials.

Remember, working in a laboratory is about more than just conducting experiments; it requires strict adherence to standard operating procedures and safety rules. So, are you ready to enhance your laboratory skills and knowledge? Let us kick off!

### Key Ideas

- A biosafety cabinet (BSC) must be placed away from airflow disturbances, on a stable surface, with verified airflow, disinfected surfaces, organised materials, and regular cleaning for safety and containment.
- Biosafety levels (BSLs) range from BSL-1 to BSL-4 with BSL-1 handling minimal risk agents and BSL-4 managing the most dangerous pathogens requiring advanced containment and strict safety protocols.
- BSCs provide various levels of safety based on the biosafety level of pathogens, ensuring suitable precautions for various experiments.
- Each BSC class (I, II and III) has unique features designed for specific safety and contamination risks in laboratory tasks.
- Implementing biosafety measures helps safeguard both laboratory workers and the surrounding community from infections.
- Properly donning and doffing personal protective equipment (PPE) is crucial for ensuring safety when working in or around BSCs.

# THE IMPORTANCE OF KNOWLEDGE OF BIOSAFETY LEVELS IN THE LABORATORY

Just like your home has designated spaces for different activities—cooking in the kitchen, resting in the bedroom, and washing up in the bathroom—the laboratory has specific levels of biosafety to handle varying types of biological materials. Each biosafety level has unique features and practices to ensure safe handling and containment, protecting both the lab workers and the surrounding environment from potential hazards.

Imagine you are a microbiologist working in a laboratory every day, handling potentially harmful biological agents or toxins. Why is it crucial to know the standard operating procedures and precautions? Great! It is essential for keeping yourself and others safe. Now, let us consider some important questions:

1. Where in the laboratory would you complete your work?
2. What protective equipment and practices would you use?
3. How would you hold the microbe to limit contamination or accidental infection?

These are key questions you should consider before starting your work in the laboratory. When handling biological agents, it is vital to recognise their risk groups and the precautions necessary to avoid infections, limit contamination, and protect both the work environment and the community. This is the foundation of biological safety, or biosafety, rules developed for laboratory work.

## What is Biosafety?

Have you ever wondered how labs keep everyone safe from harmful biological agents and toxins? Biosafety is all about protecting people, animals, and the environment from these dangerous biological materials. Let us investigate how these practices work to ensure safety in laboratories!

Biosafety refers to applying safety precautions that help reduce the risk of exposure to infectious microorganisms and limit contamination in the laboratory, thereby protecting the surrounding community (Centre for Disease Control and Prevention, CDC, 2024).

Do you remember what you learned last year about the routes of exposure to pathogens and laboratory-acquired infections (LAIs)? You also explored biohazards, and the risk groups linked to different biological agents, including biosafety levels (BSLs) 1, 2, 3, and 4.

Here is a pictorial recap of the BSL levels:

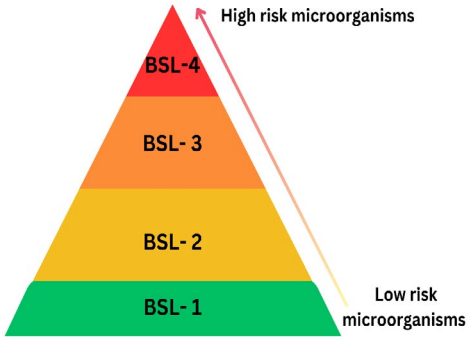



**Figure 2.1:** Biological Safety Levels 1-4

## The Biosafety Levels (BSL 1-4) and the Increasing Containment Measures Needed at Each Level

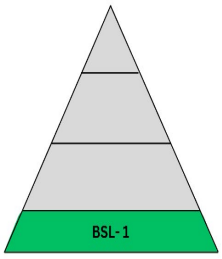
Understanding the different biosafety levels helps you know the containment measures needed at each level. The main goal of any biosafety rule is to hold potentially hazardous biological agents and toxins. Containment involves using primary and secondary barriers, safety equipment such as personal protective equipment (PPE), facility practices and procedures to manage the risks associated with handling and storing hazardous biological agents and toxins in a laboratory setting. The goal of containment is to reduce the danger of exposure to laboratory staff and the unintended release of hazardous biological agents or poisons into the surrounding environment and community (CDC & National Institute of Health, 2020).

Each biosafety level has specific controls based on factors like infectivity, severity of illness, and the type of work being done. It is also important to consider the origin of the microorganism and the route of exposure.

Let us examine the four biosafety levels:

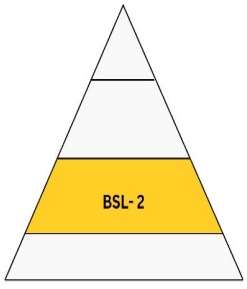
## Biosafety level 1 (BSL-1)

- **Risk level**: BSL-1 laboratories handle microorganisms that pose the lowest risk.
- **Examples**: Common examples include non-pathogenic microorganisms that do not cause disease in healthy people, such as certain strains of the bacterium *Escherichia coli* used in experiments.
- **Safety measures**:
    - Personal protective equipment (PPE) must be worn.
    - A sink with water for handwashing is needed to keep good hygiene.



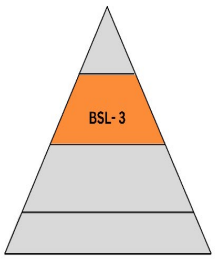

## Biosafety level 2 (BSL-2)

- **Risk level**: BSL-2 labs handle microorganisms that pose a moderate risk of infection or disease.
- **Examples**: Common pathogens at this level include:
  - *Staphylococcus aureus*: A type of bacterium that can cause skin infections and sometimes more serious illnesses if it enters the body.
  - *Salmonella typhi*: A bacterium that causes typhoid fever, spreading through contaminated food and water, leading to fever and stomach issues.
  - Human Immunodeficiency Virus (HIV): A virus that weakens the immune system, making it harder for the body to fight infections, and can lead to AIDS if untreated.
  - Hepatitis B and C viruses: Viruses that infect the liver, causing swelling and potentially serious health problems; they spread through infected blood and fluids.
  - Certain strains of influenza virus: Viruses that cause the flu, leading to symptoms like fever and cough, and spread easily, especially in crowded areas. Vaccines help prevent it.
- **Safety measures**:
  - Personal protective equipment (PPE) must be worn.
  - There should be a functioning sink for handwashing.
  - All procedures that might cause infection must be performed in a Biosafety Cabinet.



## Biosafety level 3 (BSL-3)

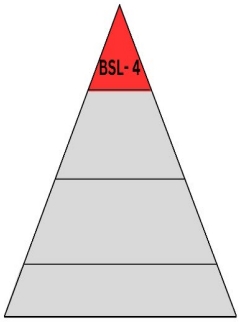
- **Risk level**: BSL-3 labs handle high risk that can cause serious diseases through inhalation.
- **Examples**: Microorganisms at this level include:
  - *Mycobacterium tuberculosis*: A type of bacterium that causes tuberculosis (TB), an infection that mostly affects the lungs and can spread through the air when an infected person coughs or sneezes.
  - SARS-CoV-2 (COVID-19): A virus that causes COVID-19, a respiratory illness that can lead to symptoms like fever, cough, and difficulty breathing. It spreads through respiratory droplets when an infected person talks, coughs, or sneezes.
  - Yellow fever: A viral disease spread by mosquito bites, causing fever, chills, and muscle pain. In severe cases, it can lead to serious liver problems and bleeding.
  - Dengue fever: A viral infection transmitted by mosquitoes, leading to high fever, severe headaches, joint and muscle pain, and rash. In severe cases, it can cause serious bleeding and organ damage.
  - Zika virus: A virus spread mainly by mosquito bites that can cause fever, rash, joint pain, and red eyes. While it often leads to mild symptoms, it can be serious for pregnant women, as it may affect the baby's development.
- **Safety measures**:
  - Laboratory staff must be under medical surveillance (monitoring) and immunised. Being immunised means that a person has been made resistant to a disease, usually by getting a vaccine. This helps the body recognise and fight off the biological agent that causes the disease, so the person is less likely to get sick.
  - Respirators must be worn along with PPE.
  - Access to BSL-3 labs is always restricted.




## Biosafety level 4 (BSL-4)

- **Risk level**: BSL-4 is the highest biosafety level, dealing with pathogens that pose the greatest risk of deadly infections for which there are no treatments or vaccines.

- **Examples**: Notable pathogens include:
  - Ebola virus: A virus that causes severe illness, leading to symptoms like fever, vomiting, and bleeding; it spreads through contact with infected bodily fluids.
  - Marburg virus: A virus similar to Ebola that causes severe viral bleeding fever, with symptoms including high fever, headache, and bleeding; it also spreads through contact with infected fluids
- **Safety measures**:
  - Individuals must change clothing before entering the lab.
  - Showering is needed after leaving the lab.
  - All materials must be decontaminated before exiting.
  - Work is done within a BSC while wearing a full-body air-supplied suit. A **full-body air-supplied suit** is a protective outfit that covers the entire body and provides clean air. It is used in dangerous environments to keep the wearer safe from harmful substances and ensure they can breathe safely.
  - All rules in BSL-3 are applied in BSL-4
  - BSL-4 labs are usually isolated from other buildings.




What safety practices do you think are most critical when working with the highest-risk pathogens in a BSL-4 lab, and why? In a BSL-4 lab, the most important safety practices are wearing airtight suits with their own air supply and carefully following strict entry and exit routines, including taking decontamination showers. These steps are crucial because BSL-4 labs work with the most dangerous biological agents which can cause deadly infections with no cure, so every layer of protection is needed to keep people safe.

## GENERAL BIOSAFETY PRINCIPLES THAT APPLY IN ALL LABORATORIES

Regardless of the biosafety level, all biological and biomedical laboratories follow standard safety practices. By adhering to these principles, you can significantly reduce the risk of laboratory-acquired infections and protect the community.

Here are some key general biosafety principles to keep in mind:

1. Handwashing procedures: Always wash your hands thoroughly.
2. Proper waste disposal: Dispose of waste safely and correctly into the right container.
3. Standard operating procedures: Follow rules like "No eating or drinking in the lab."

See **Table 2.1** for an overview of biosafety principles to be practised in all laboratories with the routes of exposure blocked when these principles are adhered to.

**Table 2.1:** General Biosafety Practices and Principles

| General Biosafety Practices | Routes of Exposure Blocked |
|---|---|
| Do not eat, drink, store foods, or smoke in the laboratory | Ingestion, Direct Contact with Skin, Inhalation |
| Use lab coats, gloves, safety eyewear, and other personal protective equipment. | Inhalation, Direct Contact |
| Wash hands after every laboratory activity, after removing gloves, and immediately after contact with an infectious biological agent or toxin | Direct Contact, Ingestion |
| Decontaminate work surfaces before and after use. When there are spills, clean and sterilise surfaces at once | Direct contact with Skin, Inhalation, Ingestion |
| Restrict the use of needles and syringes for trained personnel. Dispose of sharp objects in leak- and puncture-proof containers | Skin, Inhalation |
| Do not use your mouth to pipette liquids; always use a mechanical pipette or bulb for safety. | Inhalation, Direct contact with Skin, Ingestion |

Well done! Always remember that when you practise these principles, you help block routes of exposure to pathogens and create a safer lab environment. Explore further with the following activities

## Activity 2.1 Pathogen and Toxin Treasure Hunt

**Steps:**

1. Use your smartphone or a computer to research various pathogens that pose risks to humans.
2. Write down at least five pathogens and their associated risks.
3. Create a colourful poster highlighting these pathogens, including images and any interesting facts.
4. Once finished, present your poster to a family member or friend to share what you learned!

## Activity 2.2 Biosafety Level Sorting Game

1. Create flashcards for different pathogens and toxins, each labelled with their name and a brief description.
2. On a separate set of cards, write the biosafety levels (BSL-1, BSL-2, BSL-3, BSL-4).
3. Shuffle the cards and try to match each pathogen with the correct biosafety level.
4. Once you have matched them all, review your answers and see if you can explain why each pathogen fits its respective level.

## Activity 2.3 Flashcard Quiz Show

1. Make flashcards with a pathogen on one side and its biosafety level on the other.
2. Quiz yourself by flipping the cards and trying to guess the level before checking the answer.
3. Challenge a family member to quiz you too and keep score!

## Activity 2.4 Interactive Definition Challenge

1. Write down your own definition of “biosafety level” on a piece of paper.
2. Then, look up more information online to enhance your definition.
3. Create a short video (1-2 minutes) explaining your definition and its importance and share it with your classmates or family.
4. You can use props or drawings to make it more engaging!

## Activity 2.5 Diagrams and Justifications

1. Choose one biosafety level (BSL-1 to BSL-4) and research its features and safety practices.
2. Create a detailed diagram that stands for this biosafety level, including visuals and key characteristics.
3. Write a short paragraph justifying why you chose those features and how they contribute to safety in a lab.
4. Share your diagram with a peer and explain your reasoning.

### Activity 2.6 Lab Practice Role-Play with a Twist

1. Pick a biosafety level and imagine you are a lab technician working there.
2. Write a one-page script that describes a day in your life, focusing on the proper lab practices you follow for that biosafety level.
3. Perform the script in front of a mirror or record yourself. Use props or costumes if you have them to make it more fun!
4. Afterward, reflect on what you learned about the safety measures and how they protect you and others.

### Activity 2.7 Safety Dance Video

1. Write a short, catchy song or rhyme about the safety practices for one biosafety level (BSL-1 to BSL-4).
2. Create a fun dance to go along with your song.
3. Record yourself performing it and share it with friends or family!

### Self-reflection

What did I enjoy most about the activities? What new things did I learn? How can I apply this knowledge? What would I like to explore further?

# WHAT IS A BIOSAFETY CABINET (BSC)?

Have you ever seen a BSC and wondered how each part of its setup helps prevent contamination and protect lives? In laboratory settings, safety is paramount, especially when working with potentially hazardous microorganisms. Here, you will explore the different classes of BSCs and their functionalities.

## The Different BSC Classes and Their Functionalities

A BSC is a vital tool used in laboratories to work with infectious microorganisms safely. Its primary purpose is to protect laboratory personnel, the environment, and the samples from contamination. BSCs are classified according to the BSLs you explored earlier. Can you predict the types of BSCs? (see **Figure 2.2**).


**Figure 2.2:** Classes of Biosafety Cabinets. Image Source: Pro-Lab Diagnostics.

Let us explore the different classes of BSCs and their functions!

1. **BSC-I:** This is the most basic type of BSC. It provides protection for laboratory personnel and the environment but does not protect the biological samples from contamination. See **Figure 2.3** for an example of a Class I BSC.
   **Usage:** Typically used in BSL-2 laboratories.

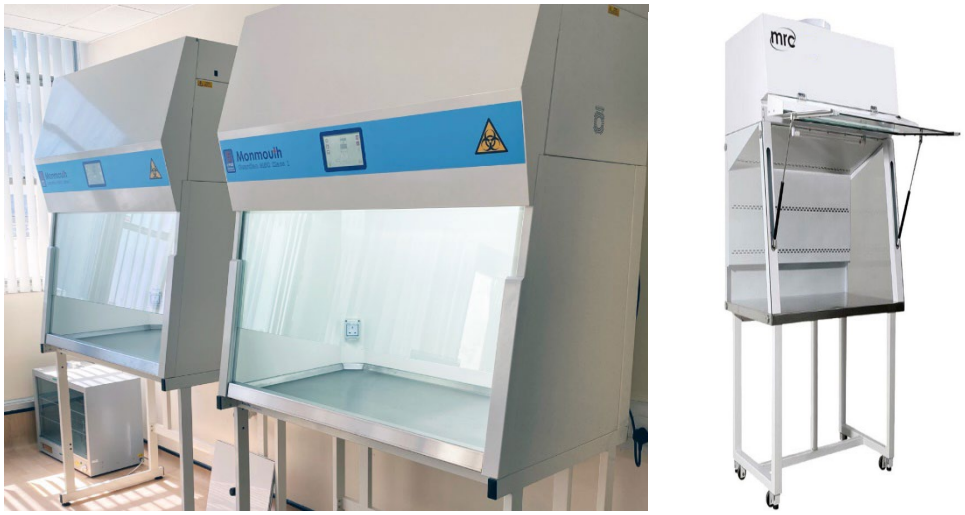


**Figure 2.3:** Class I Biological Safety Cabinet

2. **BSC-II:** This class offers protection for both laboratory staff and the biological samples being handled.
   **Types:** It includes subclasses A1, A2, B1, B2, and C1, each with different working mechanisms. See **Figure 2.4** for examples of Class II BSC. Check out the meaning of each of the subclasses:
   ***A1:*** offers basic protection with a steady airflow, suitable for low-risk biological work.
   ***A2:*** similar to A1 but with stronger airflow, allowing for handling a wider range of agents.

***B1:*** combines A features with a filtered exhaust for extra safety for both the user and the environment.
***B2:*** provides the highest protection with all air being filtered before it is released outside, ideal for high-risk materials.
***C1:*** a flexible cabinet that balances safety and accessibility for specific applications.
**Usage:** Commonly used in BSL-2 and BSL-3 laboratories.

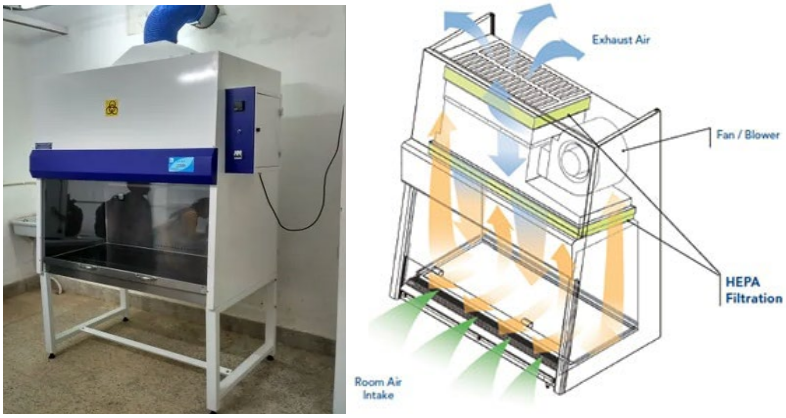



**Figure 2.4:** Class II Biological Safety Cabinet B2 (ESCO Lifesciences, 2020)

The key components highlighted in Figure 2.4 are:

a. Exhaust Air: The contaminated air from inside the cabinet is expelled through this exhaust.
b. Fan/Blower: This component creates the airflow within the cabinet.
c. HEPA filtration: The High-Efficiency Particulate Air (HEPA) filter purifies the air before it is either recirculated or exhausted.
d. Room Air Intake: The clean air from the room is drawn into the cabinet to create the desired airflow pattern.

3. **BSC-III:** BSC-III cabinets are fully enclosed and ventilated, ensuring that all air entering and leaving is filtered through a special filter. They are also called "**glove boxes**" because they have special rubber gloves attached for handling tasks inside the enclosure. See **Figure 2.5** for examples of a Class III BSC.

   **Usage:** Used in BSL-4 laboratories.


**Figure 2.5:** Class III Biological Safety Cabinet (BIOBASE, 2024)

# PROPER SETUP PROCEDURES FOR THE BSC AND ITS SURROUNDING ENVIRONMENT

Before you start working in and around BSCs, it is crucial to wear the right personal PPE, such as lab coats, gloves, hairnets, goggles, and nose masks.

## Key Steps for Proper Setup

1. **Checking airflow and alarms**
   a. Ensure the BSC is installed in a calm area, away from direct sunlight and drafts.
   b. Connect it to a power source and check the ultraviolet (UV) light for sterilisation.
   c. Make sure the high-efficiency particulate absorbing (HEPA) filter is intact and perform a smoke test to verify airflow.

Testing the visual and audible alarms to see if they are functioning correctly, is necessary.

2. **Organising work within the cabinet**
   a. Place all necessary materials in the middle of the cabinet, away from air vents.
   b. Keep your workspace clean by often sterilising surfaces and planning your workflow to minimise movement.

Carefully planning workflow is essential for minimising movement in and out of the hood. This includes setting up the work area so that samples move from the clean side to the dirty side, with materials placed at least 12 inches apart from each other. This ensures that contaminated items do not pass over the clean items, preventing the spread of contamination.

3. **Maintaining a clean work surface**
   a. Choose specific areas for different tasks to avoid cross-contamination.
   b. Clean and disinfect surfaces before and after use, and regularly check BSC performance indicators like airflow, speed, and filter conditions.

**Did you know?**

Adhering strictly to workplace sterilisation processes helps you to avoid introducing contaminants into the BSC.

In addition to the UV light mentioned, other methods can be used for sterilising surfaces, including:

i. Chemical disinfectants: appropriate disinfectants, such as bleach solutions or alcohol-based cleaners, can be used to wipe down surfaces and effectively kill microorganisms.

ii. Autoclaving: items that can withstand high heat and pressure, like glassware and tools, can be sterilised using an autoclave, which uses steam under pressure.

iii. Ethylene oxide gas: for sensitive equipment or materials that cannot be autoclaved, ethylene oxide gas can be used as a sterilising agent.

iv. Hydrogen peroxide vapour: some BSCs are equipped with hydrogen peroxide vapour generators that can decontaminate the interior surfaces.

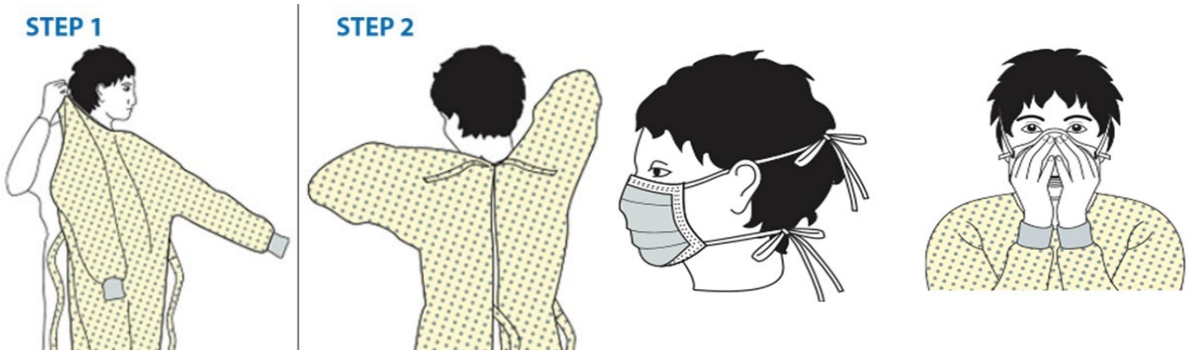
The specific sterilisation methods used will depend on the laboratory protocols, the types of materials and equipment present, and the biological agents being handled within the BSC.

# THE SEQUENCE AND TECHNIQUE FOR PROPER DONNING AND USING PERSONAL PROTECTIVE EQUIPMENT (PPE)

Wearing and removing PPE correctly is essential for safety, especially when handling biohazardous materials. Here is how to properly put on (don) PPE (**see Figure 2.6** for 2-6):

## Steps for Donning PPE

1. **Wash your hands:** Start with thorough handwashing (**see Figure 2.8**) or sanitising with 70% alcohol.
2. **Wear a gown:** Insert your arms into the sleeves and tie securely at the neck and waist. Ensure it covers your body adequately.
3. **Put on a mask:** Choose a mask that fits tightly over your nose and mouth.
4. **Wear goggles or a face shield:** Adjust it to fit snugly over your eyes.
5. **Tie back hair:** Use a hairnet to keep your hair from interfering with your work.
6. **Put on gloves last:** Gloves are the last thing worn to avoid contaminating them during the process of donning. Make sure they fit well and extend beyond the gown cuffs.
7. **Adjust for comfort:** All PPE should be properly adjusted for comfort and adequate coverage without disrupting safety

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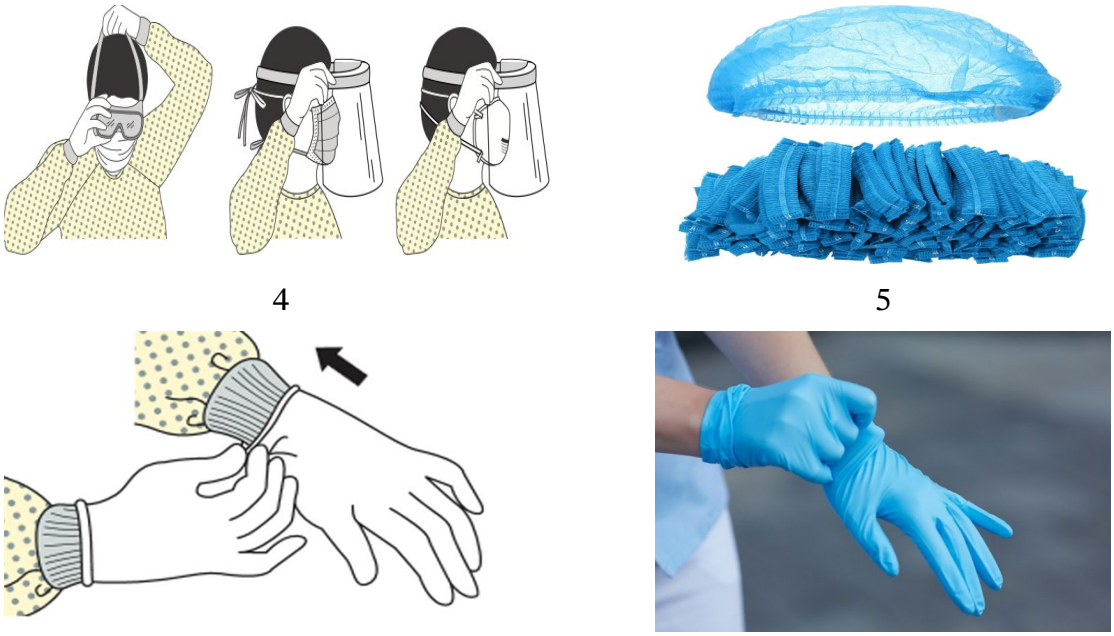

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6

**Figure 2.6:** Donning of personal protective equipment (2-6).

# SAFE REMOVAL OF PPE TO MINIMISE CONTAMINATION RISK

Did you know that removing PPE correctly is just as important as putting it on? Proper removal (doffing) of PPE is essential since it can either spread or prevent contamination. Correct removal procedures reduce the chance of self-contamination and guarantee that used PPE is disposed of or cleaned correctly. Each step is carefully carried out to protect both the wearer and others from potential exposure to infectious agents and biohazardous materials. Check below, to find out how to do it safely:

## Steps for Doffing PPE

1. **Carefully remove gloves:** Grasp the outer surface near your wrist and peel them off, turning them inside out. Hold the gloves in the other gloved hand. See **Figure 2.7**

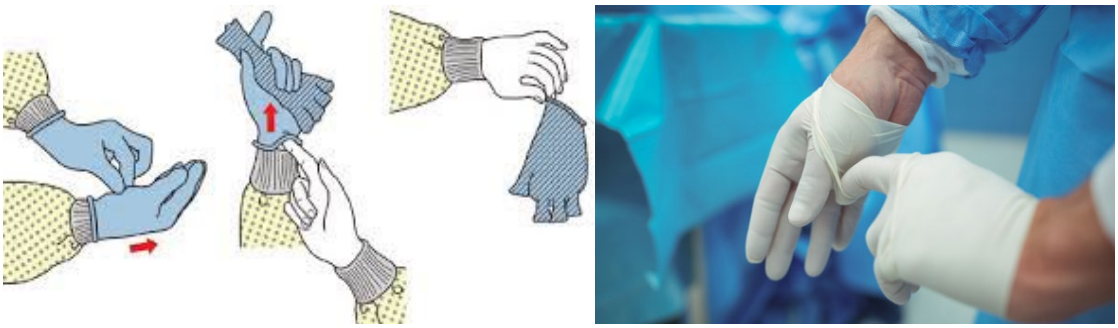


**Figure 2.7:** Removal of disposable gloves

2. **Wash your hands:** Immediately wash your hands with soap and water after removing gloves. Sanitise hands with 70% alcohol if water is unavailable. See **Figure 2.8**


**Figure 2.8:** Washing of hands

3. **Take off goggles:** Use the headband or earpiece to carefully remove them without touching the front. See **Figure 2.9**

**Figure 2.9:** Removal of goggles

4. **Remove the gown:** Untie the ties and peel it off, rolling it inside out. See **Figure 2.10**

**Figure 2.10:** Removal of gown

5. **Remove the mask:** Take off the mask by the straps, avoiding the front surface. See **Figure 2.11**

**Figure 2.11:** Removal of nose mask

6. **Final hand hygiene:** Wash or sanitise your hands again to ensure they are clean from all potential contaminants. See **Figure 2.8**

## Proper Disposal of Used PPE

Disposing of PPE correctly is crucial for safety as it reduces contamination risks, especially in healthcare and in a biohazardous environment. Biohazard containers in the laboratory are set aside for disposal of biohazardous waste and one-time use of PPE like gloves and nose masks. See **Figure 2.12** for the various kinds of biohazard containers.

Here are the protocols to follow:

1. **Separate used PPE:** Keep used PPE away from regular waste to avoid cross-contamination.
2. **Seal containers:** Ensure that biohazard containers are tightly closed.
3. **Clean reusable PPE:** Place reusable items in designated containers for proper cleaning.
4. **Train Staff:** Ensure everyone knows how to dispose of PPE correctly.
5. **Follow local guidelines:** Dispose of PPE according to local environmental regulations.

By following these guidelines, you can ensure safety for yourself and others while working in a laboratory environment.


**Figure 2.12:** Biohazard containers

Fantastic! All too soon section 2 has ended. Are you ready to embark on a journey to explore further with some activities while having fun? Let us get started!

## Activity 2.8 PPE Donning and Doffing Training

1. Search online engines like YouTube to watch a video on proper donning and doffing PPE. (Click here to watch a video on proper PPE donning and click here for PPE donning and doffing training.
2. Write down the PPE you observed. Demonstrate this to a friend or family member

## Activity 2.9 PPE Fashion Show - Donning and Doffing

**Materials needed:** Lab coat, gloves, face mask, goggles, or face shield.

**Steps:**

1. Donning:
   a. Wash hands or use sanitiser.
   b. Put on the lab coat.
   c. Wear the face mask, ensuring a snug fit.
   d. Put on goggles or face shields.
   e. Finally, put on gloves, extending them over the coat cuffs.

2. Doffing:
    a. Remove gloves first, turning them inside out.
    b. Wash hands or sanitise.
    c. Remove goggles/face shields without touching the front.
    d. Take off the lab coat by rolling it inside out.
    e. Remove the mask without touching the front, and wash hands again.
3. Fashion show: Model in your PPE while explaining the importance of each piece to a friend or family member. Add funny poses or a runway walk! Do a video of yourself.

## Activity 2.10 Matching Speed Challenge

**Materials required:** A list of BSCs and their descriptions, a stopwatch or timer, a piece of paper and a pen or pencil.

How to go about this game

1. On one paper, write down the names of the biosafety cabinets in one column:

| Biosafety Cabinet | Description |
|---|---|
| Class I BSC | |
| Class II BSC | |
| Class III BSC | |

2. Write down the descriptions of the BSC below on separate papers and cut them out:
    a. Fully enclosed and ventilated, known as glove boxes,
    b. Protects personnel but not samples, and
    c. Protects both personnel and samples.
3. Set your timer for 1 minute. Shuffle the cutouts and pick one.
4. Flip and write down your match against the cabinet on the first sheet of paper.
5. After the timer goes off, compare your matches with the correct answers in the notes. Educate someone on the various classes of BSCs!

## Activity 2.11 Lab Hazard Detective Challenge

**What you will do:**

1. Grab a clipboard and a checklist of hazards: Pathogens (germs), Spills (liquids), Toxins (chemicals), Sharp objects (needles, glass)

2. Take a tour of the lab or community (in person or watch a video).
3. Check off any hazards you find!
4. Be a Detective: For each hazard, think about what could go wrong if it is not handled properly.
5. Draft a brief report (1-2 paragraphs) describing the potential negative outcomes of each hazard.
6. Gather with your friends or family members and share what you found and how to stay safe.

## Activity 2.12 Safety Solutions Brainstorm

**Materials required:** Whiteboard or large paper for mind mapping, markers, or pens.

**Steps:**

1. Write down the common risk of hazards related to BSCs (e.g., improper disposal, improper labelling, putting all waste into the same container, and facility design that supports moving contaminated and uncontaminated materials through the same space).
2. Create a mind map with potential solutions for each hazard.
3. Share your ideas with friends or family and educate them on the best practices.

## Activity 2.12 PPE Challenge with Glo Germ

**Materials needed:**

- Glo Germ or a similar product (dyes)
- PPE such as gloves, lab coats, and masks.
- A UV light (black light) to check for Glo Germ contamination.

**Steps:**

1. Put on your PPE (lab coat, gloves, mask) and apply Glo Germ to your hands and arms.
2. Carefully remove the PPE following proper procedures to minimise contamination.
3. Use the UV light to check for any remaining Glo Germ on your skin after doffing.
4. Reflect and share with a family member or friend, the importance of proper PPE use and removal to prevent contamination.

## Self-reflection

1. Were you able to show proper procedures for removing PPE so that there was no cross-contamination? If not, feel free to review the procedures.
2. Write down one new thing you learned about each type of activity.
3. How will your understanding of donning and doffing of PPE help save others from infections?

# EXTENDED READING

- To explore further on biosafety cabinets and classes, click https://me-qr.com/W6hodxWO here
- Click here or https://me-qr.com/Z18cpK5O for preparing and cleaning Biosafety cabinets.

# REVIEW QUESTIONS 2.1

## Multiple choice questions

**1.** What do the letters BSL stand for?

A. Bacterial Sanitising Light
B. Bench Sanitising Lotion
C. Bio Safety Lab
D. Bio Safety Level

**2.** What information does the following symbol indicate

A. Biohazard
B. Chemicals
C. Radioactivity
D. Yellow safety zone

**3.** How many different Biosafety levels are there?

A. 2
B. 3
C. 4
D. 6

**4.** What would you use a pipette for?

A. Drawing up liquids
B. Filling up liquids
C. Mixing up chemicals
D. Sterilising substances

**5.** What do the words donning and doffing mean?

A. closing and opening
B. heating up and down
C. pulling on and off
D. putting in and out

**6.** Which of the following are NOT categorised as a 'sharp'?

A. Gloves
B. Needles
C. Scalpels
D. Scissors

7. Short-answer questions

   a. What term is used to describe organisms which cause disease? _____

   b. What do the letters PPE stand for? _____

   c. What kind of organism is *Escherichia coli?* _____

## Essay type questions

1. Name one example of a pathogen classified as BSL-1.
2. How should a laboratory worker handle a spill of a BSL-2 pathogen?
3. What steps should be taken to ensure proper waste disposal in a BSL-2 lab?
4. Evaluate the impact of not following biosafety protocols in a BSL-3 lab. What could be the consequences?
5. Discuss how training on biosafety levels can improve laboratory safety.
6. Analyse a scenario where a laboratory technician ignored personal PPE guidelines. What steps should be taken to address this violation?

### 7. Case Study 1: Handling Pathogens at a Ghanaian Research Lab

Scenario: Dr. Patel is a microbiologist at the Noguchi Memorial Institute for Medical Research in Accra, Ghana. One day, she discovers that a batch of samples holding *Staphylococcus aureus* has been mislabelled. She must quickly assess the biosafety level needed for handling this pathogen to prevent any potential exposure.

**Questions**

a. What biosafety level is *Staphylococcus aureus* classified under, and what precautions should Dr. Patel take while handling it in the lab?

b. How should Dr. Patel manage the mislabelled samples to ensure safety for herself and her colleagues in the Ghanaian lab environment?

c. What steps can she implement to prevent similar labelling errors in the future, considering the local context?

### 8. Case Study 2: Managing Biological Waste in a Ghanaian Hospital

Scenario: At a regional hospital in Kumasi, a nurse discovers that biohazardous waste, including used PPE and contaminated materials, has not been disposed of according to biosafety guidelines. The waste is accumulating in a corner of the lab.

**Questions**

a. What immediate actions should the nurse take to address the biohazardous waste situation?

b. What long-term strategies can the hospital implement to improve biohazard waste management?

c. How can the hospital raise awareness among staff about the importance of biosafety and waste management?

## 9. Case Study 3: Responding to a Laboratory Spill in a Ghanaian University

**Scenario:** A student at the University of Ghana accidentally spills a culture of *Escherichia coli* in a laboratory during an experiment. The culture is classified as BSL-1, but the student is unsure of the correct cleanup procedure.

**Questions**

a. What immediate steps should the student take to contain the spill?

b. What is the recommended procedure for cleaning up a BSL-1 spill?

c. What can the university do to prevent future spills and improve lab safety?

## 10. Case Study: Laboratory Incident at a University

At a prominent university in Ghana, a biology lab was using a Class II BSC to conduct experiments with pathogenic microorganisms. During a routine session, a student accidentally spilled a biological sample inside the cabinet. The student quickly responded by using disinfectant, but there was a delay in reporting the incident to the lab supervisor.

**Questions**

a. What type of BSC was used in the university lab?

b. What action did the student take immediately after the spill occurred?

c. What might be the consequence of not reporting the incident promptly?

## 11. Case Study 2: Contamination at a Research Facility

At a research facility in Accra, a team was working with a Class III BSC to safely handle highly infectious agents. One of the researchers neglected to wear the required PPE while working. During the process, a small breach occurred in the cabinet, leading to potential exposure. The incident was documented, and a safety review was conducted afterward.

**Questions**

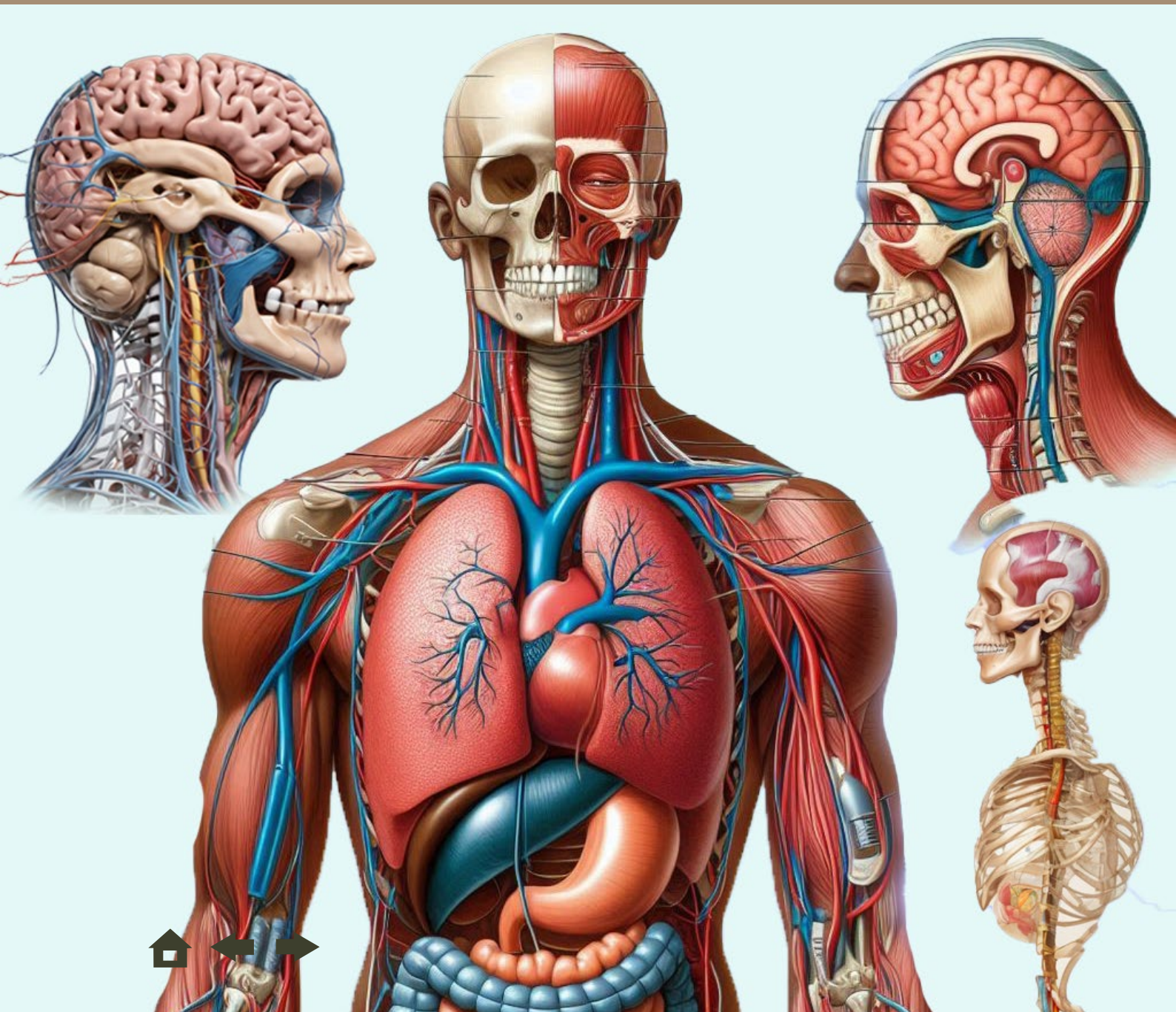
a. What type of BSC was used at the research facility?

b. What safety measure did the researcher neglect?

c. What action was taken after the incident was documented?

SECTION 3

# ANATOMY AND PHYSIOLOGY- COMMUNICATION SYSTEMS



# HUMAN BODY SYSTEMS

## Anatomy And Physiology

## INTRODUCTION

Welcome, young explorer! In this section, you will dive into the incredible world of the human brain—the command centre of your body. You will discover how the brain's distinct regions regulate or control cognition (thinking), emotions, sensory processing (how you sense the world), and movement. Imagine each region or area as a specialised team, working together to keep everything running smoothly.

You will also explore brain mapping; a fascinating process that reveals how various parts of the brain communicate with one another and with other body systems. This communication is essential for everything we do, from reacting to the world around us, like laughing at a friend's joke, to moving our bodies like dodging a ball!

Furthermore, you will examine the role of technological tools in biomedical science that help measure communication within the body. These tools provide essential data that can enhance our understanding of health and disease, making them crucial for advancing medical science.

**Key Ideas**

- Brain mapping is a crucial process that helps scientists understand how various parts of the brain communicate with each other and with other bodily systems.
- Effective communication within the brain and between body systems is essential for all human activities, from basic reactions to complex thoughts.
- Technological tools in biomedical sciences play a vital role in measuring communication parameters in the human body, enhancing our understanding of health and disease.
- The human brain is organised into distinct regions that regulate cognition, emotions, sensory processing, and motor functions, working together like a coordinated team.

## THE ROLE OF THE BRAIN AS THE CENTRAL PROCESSING UNIT OF THE COMMUNICATION SYSTEM

How does the brain turn thoughts into actions and sensations into emotions? Brain mapping holds the answers, giving us insight into how information is processed and communicated throughout the human body. The brain and brain mapping are fundamental to understanding how information is processed and transmitted throughout the human body. By mapping the brain's networks, we can discover how

different regions communicate, helping us understand the complex ways our bodies function and respond to the world around us. Let us dive deeper!

Before we dive into the fascinating world of the brain, let us take a moment to explore an overview of the nervous system! The nervous system is a system in your body that controls and coordinates (manages) all activities. It helps you with cognition, sensing your environment, feeling emotions and performing motor functions.

## Brain Anatomy and its Different Components

There are specialised nerve cells in the nervous system that transmit information through electrical and chemical signals, working as the basic building blocks of the brain and nervous system! They are known as neurons (see **Figure 3.1**). These neurons consist of the cell body, the axon (the long, thin part that carries signals), and the dendrites (the branch-like part that receives signals). The main role of neurons is to receive signals from your senses or other nerve cells, relay those signals to other neurons, and then send a message to your body to trigger a response.

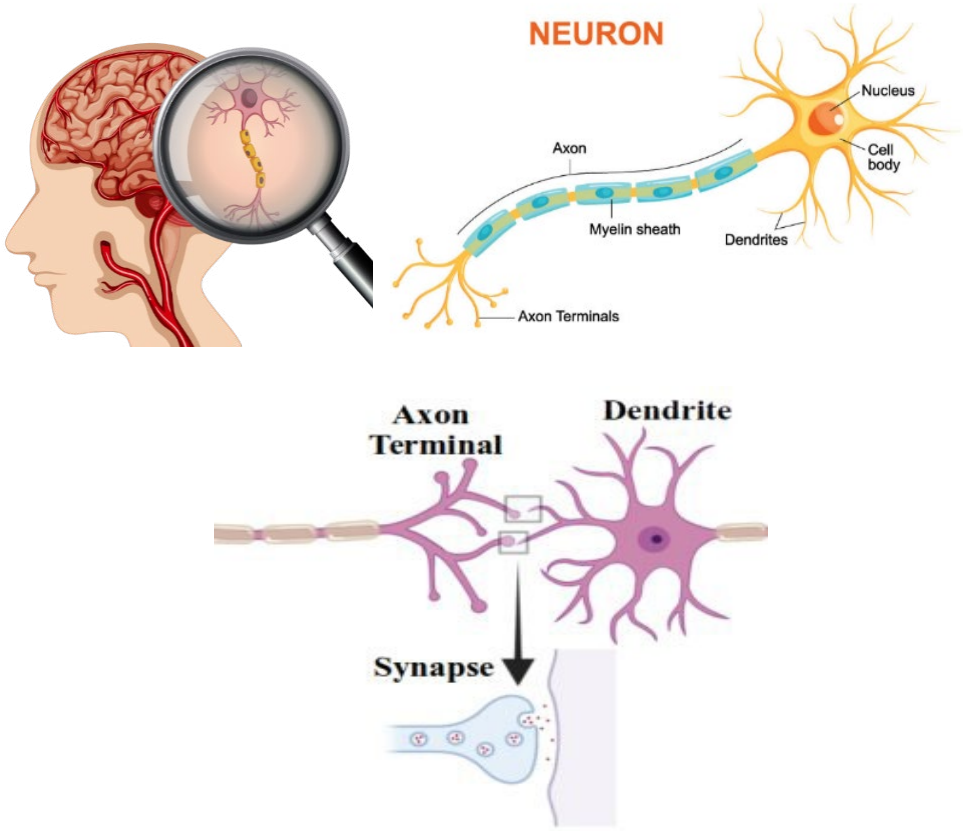



**Figure 3.1:** Neurons and synapse

**Neurons** and **synapses**: The axon terminals (the ends of the long part) of one neuron release chemicals into the synapse (the small gap between two neurons), which are then picked up by the dendrites of the next neuron. This process allows signals to pass from one neuron to another, helping messages move through the brain and body.

The nervous system has two main parts:

1. Central Nervous System (CNS): made up of the brain and spinal cord. It processes information and sends signals throughout the body.
2. Peripheral Nervous System (PNS): Includes all the nerves outside the CNS that connect the brain and spinal cord to the rest of the body, helping to relay or send messages and control movements. Example include sensory and motor nerves, which often work in together.

- Sensory nerves detect a stimulus (trigger, e.g., stepping on a sharp object) and send the signal to the CNS.
- The CNS processes the information and sends commands through motor nerves to respond (react) (e.g., lifting your foot).

This interaction forms the basis (foundation) of reflexes (automatic responses) and coordinated actions (like teamwork) in the body. — See **Figure 3.2**

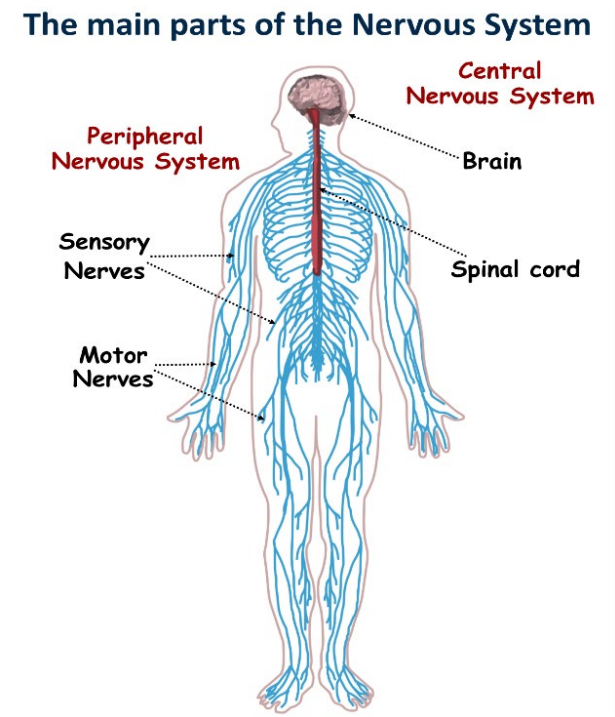



**Figure 3.2:** The main parts of the nervous system

Think of your body as a huge communication network. Your eyes send messages about what you see, your ears pick up sounds, and your skin feels different textures. But where does all this information go? That is where your brain comes in!

Are you ready to explore the amazing anatomy of the brain and see how each part works together to shape who we are? Let us get started!

## Anatomy of the Brain

It acts like the central processing unit (CPU) of your body's communication system. The brain has three main parts (see **Figure 3.3 a**) namely:

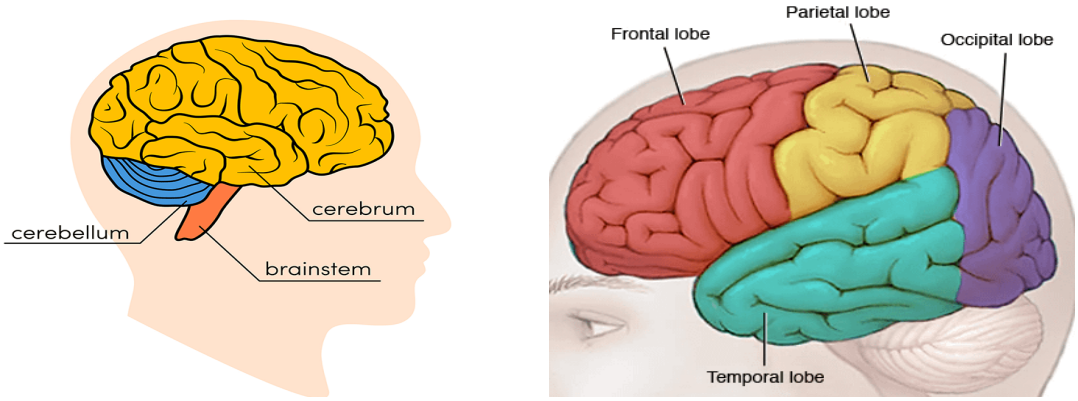
1. cerebrum
2. cerebellum
3. brainstem

Now, let us examine these major parts of the brain in detail and their general functions or roles in relation to communication!

## Structure of the Cerebrum

The cerebrum, also known as the cerebral cortex, is the largest and outermost part of the brain. It has a wrinkly appearance. The cerebrum is divided into two symmetrical halves—the left and right hemispheres—by a deep groove known as the longitudinal fissure. The hemispheres are connected by a thick band of nerve fibres called the corpus callosum (see **Figure 3.4**). This connection allows communication between the two sides. Each hemisphere is further divided into four regions or lobes (see **Figure 3.3 b**):

1. frontal lobe
2. parietal lobe
3. occipital lobe
4. temporal lobe

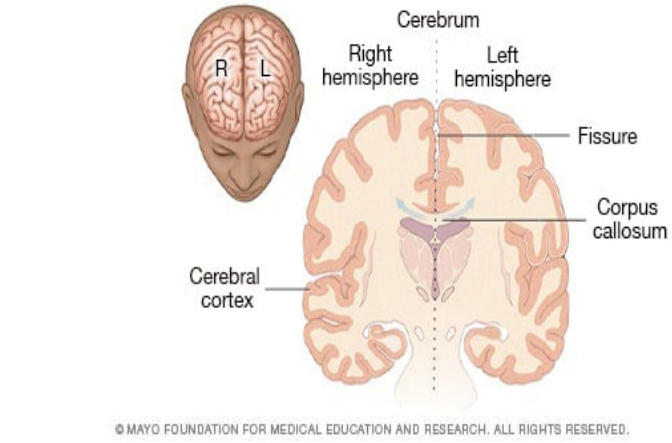



**A** **B**

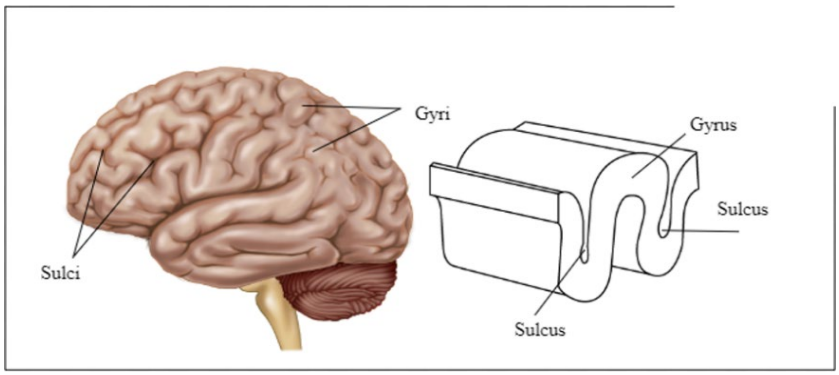
**Figure 3.3:** The three major parts of the brain (A) and the four cerebral lobes (B)

**Did you know?**

- *Each lobe is named after the skull bones that cover them!*
- *The lobes are divided by raised regions called gyri (singular: gyrus) and shallow grooves known as sulci (singular: sulcus). — See* ***Figure 3.4***
- *The combination of gyri and sulci gives the brain its folded appearance, helping it fit inside the skull. These folds increase the brain's surface area, helping it process more information and boost its thinking abilities. Interesting right?*






**Right and left cerebral hemispheres** **Folds of cerebrum**

**Figure 3.4:** Parts of the cerebrum showing hemisphere, corpus callosum, fissure, gyri and sulci.

Let us investigate how each lobe plays a unique role in how we think, feel, and interact with the world around us!

## Frontal Lobe

The frontal lobe is the largest part of the cerebral cortex. It is located at the front of the brain, positioned above the eyes and behind the forehead. The frontal lobe is crucial for many higher-level functions, including cognitive skills, emotional regulation, motor control and speech production.

**Roles**

a. Cognitive functions: involved in planning, reasoning, and problem-solving.
b. Emotional regulation: manages emotions and social interactions.
c. Motor control: contains the primary motor cortex for voluntary movements.
d. Speech production: houses Broca's area, essential for producing speech, forming sentences and understanding grammar
e. Decision making: plays a role in impulse control and decision-making processes

## Parietal Lobe

It is found behind the frontal lobe and separated by the central sulcus. The central sulcus is a deep groove in the brain that separates the frontal lobe from the parietal lobe and helps differentiate areas for movement and sensation. The parietal lobe integrates sensory information.

**Roles**

a. Sensory integration: handles feelings like touch, heat, pressure, and pain.
b. Spatial awareness: helps you know where your body is in space.
c. Object recognition: assists in noticing objects by feeling them.
d. Mathematical reasoning: aids in solving math problems and understanding numbers.
e. Coordination of movement: processes sensory information to control actions.
f. Attention and focus: helps to maintain attention and focus on tasks or objects.

## Temporal Lobe

Found around the temple and ear areas, in front of the occipital lobe. This lobe houses important structures like the primary auditory cortex, Wernicke's area, hippocampus and amygdala.

**Roles**

a. Auditory processing: the auditory cortex processes sound and is vital for hearing.
b. Memory formation: the hippocampus is responsible for organising and storing memories.
c. Emotional responses: the amygdala processes emotions such as fear, anger, and pleasure.
d. Language comprehension: involved in understanding spoken language (Wernicke's area).
e. The **temporal lobe** plays a key role in recognising faces and interpreting visual information.

## Occipital Lobe

The occipital lobe is situated at the back of the head and is the smallest of the four lobes. It handles processing and interpreting visual information from the eyes, allowing us to see and understand what we see.

**Roles**

a. Visual processing: the primary visual cortex helps to understand what you see.
b. Colour recognition: interprets colours and brightness.
c. Movement detection: spots motion and where objects are in space

## Structure of Cerebellum

Often called the "little brain," the cerebellum is found at the back of the brain, below the occipital and temporal lobes.

a. Although it makes up about 10% of the brain's volume, it holds over 50% of its neurons.
b. The cerebellum is a key part of the hindbrain that is essential for motor control and coordination.
c. It helps maintain balance and posture, coordinates voluntary movements, and allows for the learning and refinement of motor skills through practice. The cerebellum also enables precise control of fine movements, such as writing or playing a musical instrument.

d. While it is mainly associated with motor functions, the cerebellum also plays a role in certain cognitive processes, including attention, language, and decision-making.

## Structure of the Brainstem

The brainstem is found at the base of the brain. It connects the brain to the spinal cord, serving as a vital pathway for communication between the brain and the rest of the body. It regulates vital functions such as balance, breathing, heart rate, blood pressure, and many involuntary (reflex, automatic) actions like eye movements, sneezing and sleep.

The brainstem has three main parts: the midbrain, pons, and medulla oblongata.

a. **Midbrain:** controls eye movement and processes sound and sights. It helps us react to sounds and stay alert.
b. **Pons:** coordinates signals between the left and right sides of the brain and the spinal cord. It also helps regulate breathing and controls facial movements and sensations.
c. **Medulla oblongata:** this is the lower part of the brain stem that connects the brain to the spinal cord. It regulates vital functions like heart rate, blood pressure, and breathing. It also controls reflexes like coughing, sneezing, and swallowing, and helps in making sounds for speech. — See **Figure 3.5**

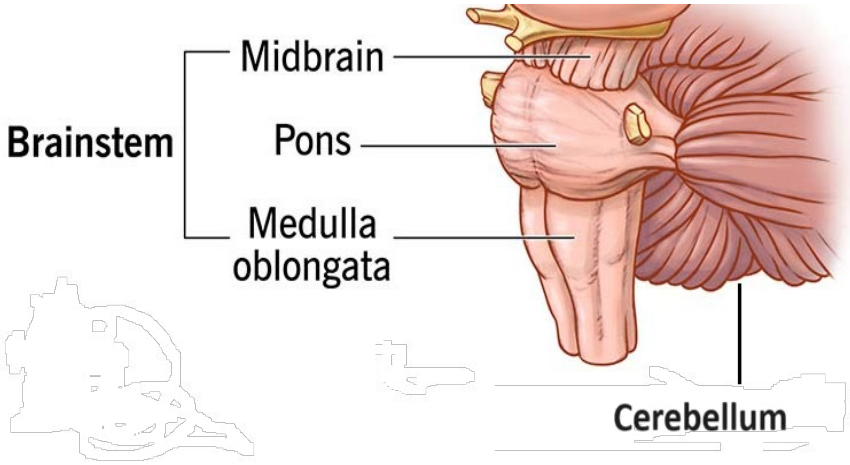



**Figure 3.5:** Parts of Brainstem with cerebellum

In relation to communication, the brain is involved in sensory processing, motor control, and decision-making. It receives information from all the senses, processes that information, and then sends instructions back to the body through the cranial nerves and spinal cord, as well as other neural pathways. It works like a supercomputer that controls everything you do, from simple reflexes to complex thoughts and feelings. Various parts of the brain, such as the four lobes, cerebellum, brainstem, and spinal cord, play crucial roles in how you engage with the world around you. They make survival and daily activities possible.

# THE CONCEPT OF BRAIN MAPPING AND ITS ROLE IN UNDERSTANDING COMMUNICATION PATHWAYS

Brain mapping is a powerful technique that helps scientists and doctors understand how various parts of the brain function and communicate with each other. Brain mapping creates a detailed or clear picture (representation) of how the brain is built and how it works. It aims to find areas linked (connected) to specific tasks (functions), actions (behaviours), and activities. By understanding the differences between brain regions, we can improve (enhance) and refine (optimise) how the brain works. It helps us learn about the brain's complex structure and how it works. Brain mapping also shows communication pathways, which are crucial for cognition and motor function.

Brain mapping uses different technologies to visualise and describe how the brain is organised. This process includes finding diverse types of neurons (see **Figure 3.1**), studying the brain's electrical activity, and finding how various parts of the brain communicate with each other.

## Exploring the Different Brain Mapping Imaging Techniques

Brain mapping employs a range of imaging techniques, each offering unique insights into the brain's structure and function. Each technique comes with its strengths and limitations. Below are some examples of brain-mapping imaging techniques:

a. **Magnetic Resonance Imaging (MRI):** is a medical imaging technique that uses powerful magnets and radio waves to create detailed images of the brain's structures. Magnetic fields and computer-generated radio waves are used to create detailed images of the organs and tissues in your body. (Mayo Clinic, 2023). MRI provides high-resolution images of brain anatomy (see **Figure 3.6**).

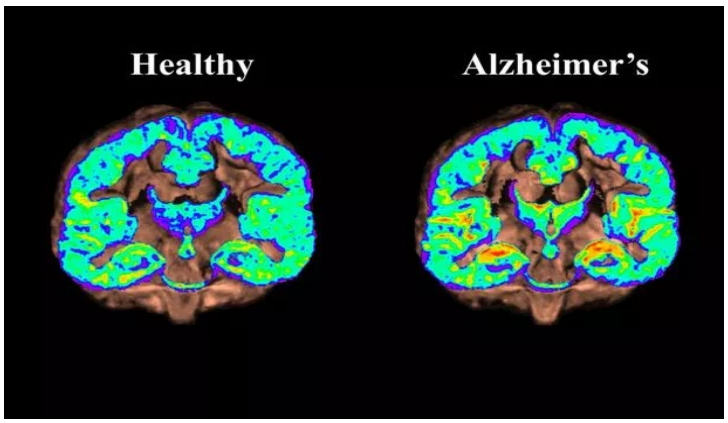



**Figure 3.6:** Image of brain mapped using MRI. Left (Healthy)

The brain is working normally, with even colours of blue and green showing good activity. Right (Alzheimer's): The brain shows less activity in some areas, with more dark and red spots. This can cause memory problems and make it harder to think clearly.

b. **Electroencephalogram (EEG):** small sensors (electrodes) are placed on the head (scalp) to monitor brain activity. These sensors detect brain waves, which are electrical signals produced by neurons (nerve cells) in the cerebral cortex. The brain waves are then analysed to help doctors understand how the brain is functioning (see **Figure 3.7** and **Figure 3.8**).

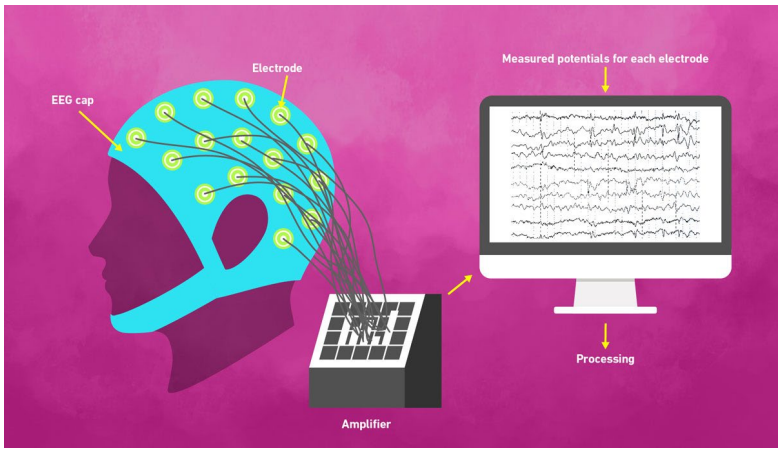



**Figure 3.7:** Electroencephalogram (EEG) cap on a patient

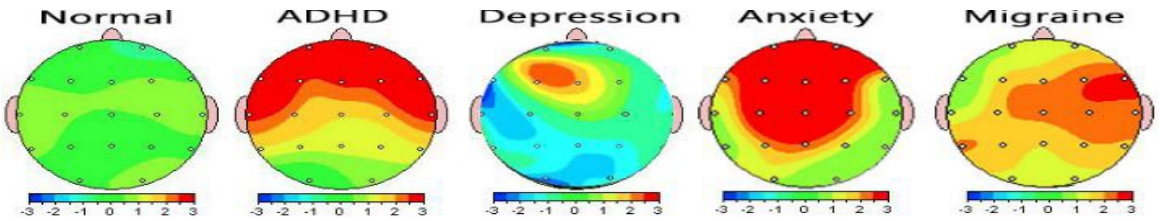



**Figure 3.8:** EEG of a healthy human brain compared to common diagnoses (Behavioural Associates, 2018).

This image shows brain activity patterns for different conditions using colour maps: Normal: mostly green, showing typical brain activity. ADHD: more red areas, indicating higher brain activity in certain regions. Depression: cooler colours (blue) in some areas, showing reduced brain activity. Anxiety: red areas, indicating more activity in specific regions. Migraine: mixed colours (yellow and orange), representing changes in brain activity related to migraines.

Well done for completing this session! Always remember that each brain map helps doctors understand how the brain works differently in every condition. Proceed to explore the activities while having fun.

## Activity 3.1 Brain Region Art Project

**Materials needed:** Coloured pencils, markers, large paper.

**Steps:**

1. Start by researching each brain region online or in textbooks. Learn about its functions and interesting facts. (After your search, you can click here to watch another video)
2. Sketch a rough layout of your brain diagram, deciding where each region will go.
3. Use different colours for each region, making it vibrant and eye-catching!
4. Write fun facts about each region on the back of your diagram.
5. Present your artwork to a friend or family member, using your new knowledge to explain the brain's functions.

## Activity 3.2 Communication Pathway Model

**Materials needed:** Clay, straws, pipe cleaners, scissors, and labels.

**Steps:**

1. Sketch a simple version of the brain (e.g., like this or search for one) on paper to guide your model.
2. Use clay to shape the major brain regions and straws or pipe cleaners to connect them, standing for communication pathways.
3. Create labels for each region and attach them to your model.
4. Explain to someone how information flows through your model, showing how different regions communicate.
5. Put your model on display and invite others to ask questions about it!

## Activity 3.3 Sensory Processing Role-Play

**Materials needed:** Props related to the senses (e.g., food items, musical instruments, scented items).

How to go about this roleplay:

1. Pick a sensory experience to act out, like eating your favourite meal or listening to music.
2. Collect items that stand for each sense of your scenario.
3. Present your scenario with enthusiasm:

a. Start by greeting your audience and explaining the sensory experience you will act out (e.g., "Today, I am going to show you what it's like to eat my favourite meal.")

b. Use props to describe each sense involved: taste (this food tastes good), sight (look at how bright and colourful this food is), sound (noises), smell (aromas), and touch (textures).

c. As you present, mention which brain regions are activated. For example, "When I taste this mango, my brain's taste centre lights up, helping me enjoy the flavour." Etc.

4. Wrap up by summarising how all the senses work together in the experience. "All these senses combine to make eating this meal so enjoyable!"
5. Ask a friend or family member to watch your presentation and give you feedback. This will help you understand sensory processing better!

## Activity 3.4 Brain Mapping Exploration

**Materials needed:** Access to the internet, poster board, markers.

**Steps:**

1. Research: Investigate different brain mapping techniques. Look for videos or articles that show how they work.
2. Create visuals: Use screenshots or drawings to illustrate each technique.
3. Organise your findings into a colourful infographic that highlights each method's purpose and benefits.
4. Share your infographic with classmates or family, explaining how these techniques help scientists understand brain function.
5. Encourage questions and discussions to deepen your understanding of brain mapping!

## Activity 3.5 Personal Brain Journal

**Materials needed**: A journal or notebook, pens.

**Steps:**

1. Daily Entries: For one week, write daily entries about activities you do, focusing on how you think your brain is involved.
2. Note your feelings during different activities and which brain regions might handle them.
3. After a week, look for patterns in your activities and reflections, noting how various brain regions contribute to your experiences.

4. Write a summary of your findings, connecting personal insights with what you have learned about brain functions.
5. Present your journal to a friend or family member, discussing how your brain affects your daily life!

## Activity 3.6 Brain Function Skit

**Materials needed:** Simple costumes or props (e.g., hats, scarves), paper for scripts.

**Steps:**

1. Ask peers or family members to join you for this skit
2. Choose functions: Select specific brain functions to portray, such as memory, movement, or sensory processing.
3. Write a Script: write a short skit that illustrates how different brain regions work together for a particular function.
4. Assign roles: Assign roles to each member, standing for different brain regions or sensory inputs (e.g., eyes, ears).
5. Practice your skit, adding fun elements and creativity to make it engaging.
6. Record and share (or present) your skit to people and ask for feedback on how well you conveyed the brain's functions!

## Activity 3.7 Brain Communication Relay Race

**Materials needed*:*** Small objects (e.g., balls, books), cones or markers for a relay course.

**Steps:**

1. Grab a peer or family member for this activity
2. Set up a course: Create a relay racecourse with markers to stand for different brain regions (e.g., cones for lobes).
3. Explain Roles: Each participant stands for a brain region responsible for a specific function (e.g., sensory input, motor output).
4. Relay Race: The first player must pick up an object (standing for sensory information) and run to the next marker (brain region), where they "process" the information before passing it to the next player.
5. After the race, gather to discuss how each brain region contributed to the overall process of communication and movement in the body.

## Activity 3.8 Brain Diagram Picture Puzzle

**Materials needed:** Printed brain diagram template (with major parts outlined but unlabelled), scissors, timer.

**Steps:**

1. Search and print out the brain diagram template. Cut the diagram into six puzzle pieces along the patterned lines. (Check here and search online for a sample template).
2. Challenge yourself to reassemble the brain diagram within a set time limit (e.g., 5 minutes).
3. Mix up the pieces and try to put them back together as quickly as possible.
4. Once completed, label the major parts of the brain: frontal lobe, parietal lobe, occipital lobe, temporal lobe, cerebellum, and brainstem.
5. Write down the functions of each part based on your research or notes. For example, the frontal lobe is involved in decision-making and problem-solving.
6. After completing the puzzle, reflect on how the shape and structure of the brain relate to its functions.

## Self-reflection

1. What new insights did I gain about the brain's functions and its role in communication after completing these activities?
2. In what ways can I apply what I learned about the brain and communication pathways to my daily life or future studies?

# UNDERSTANDING HOW COMMUNICATION WORKS AND ITS EFFECTS ON THE HUMAN BODY

As a biomedical scientist, by understanding how the human body systems communicate and the effects of disruptions or disturbances, you can enhance your ability to investigate and contribute to the diagnosis and treatment of various health conditions.

## The Basic Flow of Communication in the Body

The human body relies on a complex network of systems that work together to communicate and maintain homeostasis. This communication involves sensory input, processing by the central nervous system (CNS), and motor output or hormone release to produce a response. The two primary systems involved in this communication are the nervous system and the endocrine system. Together, they ensure the body can effectively respond to internal and external changes.

Let us explore the contributions of the two primary systems involved in communication:

## Nervous System Communication

1. The nervous system is essential for rapid communication using electrical and chemical signals. It consists of two main parts: the central nervous system (CNS), which includes the brain and spinal cord, and the peripheral nervous system (PNS), which connects the CNS to the rest of the body (see **Figure 3.2**).
2. This system functions as the central command centre, transmitting messages via nerve impulses (electrical signals) throughout the body.
3. These signals can convey various information, such as pain sensation or movement initiation.
4. About communication in the body, the nervous system is further divided into sensory input, processing and integration and motor output (See **Figure 3.9**). Let us examine them!

   a. **Sensory Input**

      i. *Stimulus detection*: sensory receptors detect stimuli (changes) such as touch, light, sound, and temperature (e.g., in the skin, eyes, and ears).

      ii. *Signal transmission*: sensory neurons carry information from these receptors to the CNS.

   b. **Processing and Integration**

      Central nervous system: The brain and spinal cord process and interpret sensory information, integrating signals and generating responses. The brainstem regulates vital functions like heart rate and consciousness.

   c. **Motor Output**

      i. *Signal transmission:* motor neurons carry signals from the CNS to muscles and glands (effector organs).

      ii. *Response execution:* effector muscles respond with actions such as contraction, enabling movements or reflexes, while glands may secrete hormones for adjustments.

In a reflex (automatic, involuntary) response, the stimulus is detected by sensory receptors, triggering an impulse that travels through sensory neurons to the spinal cord. The spinal cord processes the signal and sends a response via motor neurons to the effector (a muscle), resulting in a quick, involuntary action. This bypasses the brain for an immediate reaction, though the brain processes it later for awareness. It helps protect the body. This is possible because of reflex neurons a part of the spinal reflex arc! Interesting right? —See the pink arrow in **Figure 3.9**, this is a reflex neuron connecting sensory neuron to motor neuron.

**Reflex neuron**: a nerve cell that is part of a reflex arc, enabling quick, automatic responses to stimuli by connecting sensory neurons to motor neurons without involving the brain.

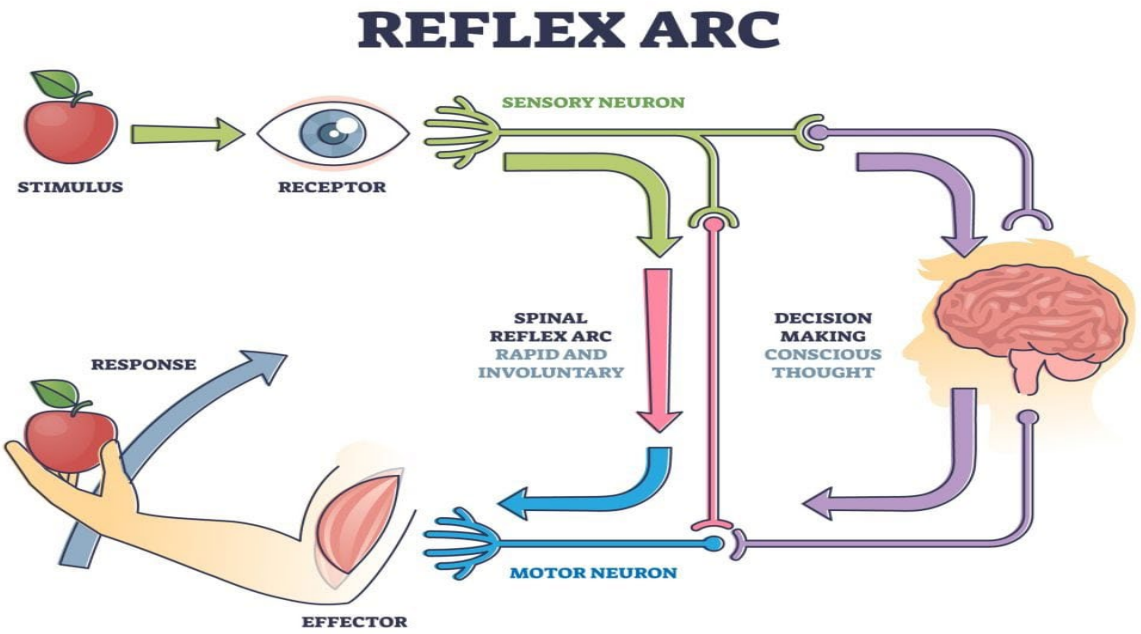



**Figure 3.9:** The Pathway of Reflex Responses

## Endocrine System Communication

1. The endocrine system uses hormones (chemical messengers) to regulate physiological processes over longer periods.
2. Unlike the nervous system, which uses electrical impulses for rapid and precise signalling, the endocrine system relies on chemical messengers (hormones) that travel through the bloodstream to reach their target cells and organs.
3. A hormone is a chemical substance produced by glands that regulate various functions in the body, such as growth, metabolism (energy processes), and mood, by travelling through the bloodstream to target organs or cells.

With respect to communication, the endocrine system is divided into hormone production and signal reception:

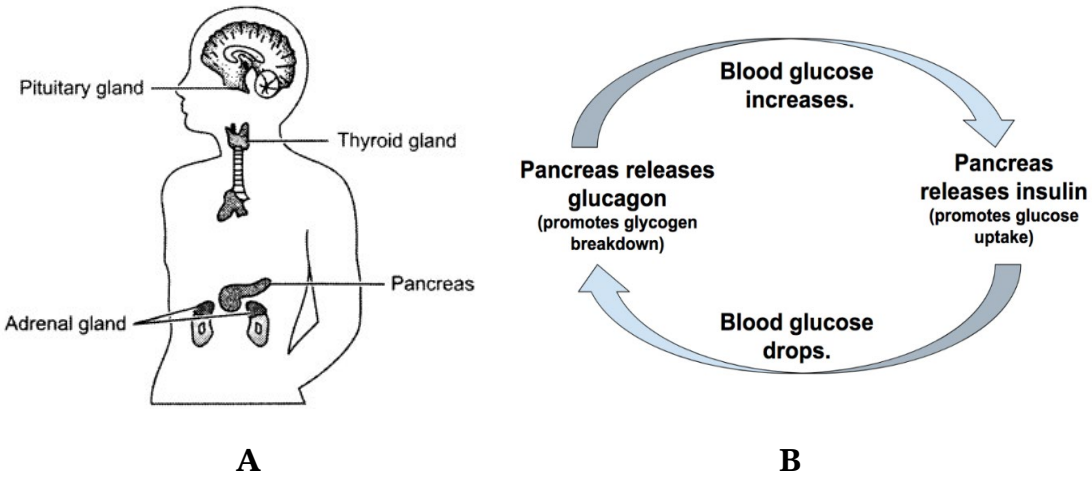
a. **Hormone production:** The endocrine system handles the production and regulation of hormones, which are chemical messengers that travel through the bloodstream to target organs and tissues. Hormones regulate a variety of physiological processes, including growth, metabolism, reproduction, and homeostasis.

Below is how the endocrine system works for communication:

i. **Glandular secretion:** Endocrine glands (like the pituitary and thyroid) produce hormones in response to specific stimuli, releasing them into the bloodstream. See **Figure 3.10a**

ii. **Bloodstream transport:** Hormones travel through the bloodstream to target cells, bringing about responses. For example, insulin is released by the pancreas in response to high blood glucose. It binds to cell surface receptors on liver, muscle, and fat cells, promoting glucose uptake and storage (see **Figure 3.10b**).

Insulin lowers blood sugar by helping cells absorb glucose, while glucagon raises blood sugar by signalling the liver to release stored glucose.




**A** **B**

**Figure 3.10:** Glands of Endocrine System (A) **and Insulin vs Glucagon (B)**

**Table 3.1**: Glands, hormones they produce, and their functions

| Gland | Hormones | Functions |
|---|---|---|
| ***Pituitary gland*** | Growth Hormone (GH) | Stimulates growth and tissue repair. |
| | Thyroid-stimulating hormone (TSH) | Stimulates the thyroid to produce thyroid hormones. |
| | Antidiuretic Hormone (ADH) | Regulates water balance in the kidneys. |
| | Oxytocin | Triggers labour contractions and milk ejection |
| ***Thyroid gland*** | Thyroxine (T4) | Controls metabolism and energy production. |
| | Calcitonin | Lowers blood calcium levels. |
| ***Adrenal glands*** | Cortisol | Manages stress and regulates metabolism |
| | Adrenaline (Epinephrine) | Prepares the body for fight-or-flight responses |
| ***Pancreas*** | Insulin | Lowers blood sugar levels. |
| | Glucagon | Raise blood sugar levels. |

b. **Signal reception:** Signal reception in the endocrine system involves the detection and response to hormones by target cells. This process is crucial for effective communication and regulation of various physiological processes within the body.

   i. *Target cells:* these are cells that have specific receptors for hormones, allowing them to bind and initiate cellular responses.
   ii. *Cellular response:* when a hormone binds to its receptor on a target cell, it triggers changes within the cell that can affect gene expression

**Did you know?**

*Gene expression is the process by which information from a gene is used to produce proteins, while metabolism is the chemical processes that convert food into energy and support cellular functions!*

# DISRUPTIONS IN COMMUNICATION AND HEALTH ISSUES

Problems in the body's communication systems can cause many health issues. These systems are important for keeping the body stable and maintaining homeostasis, as well as organising how it works. Issues can come from problems with hormone levels, brain chemicals that send signals when receptors do not respond properly, damage to nerve cells, and failures in processes that help the body adjust. Understanding these processes is important for contributing to diagnosing and treating hormone-related and nervous system disorders. Below is an overview of how these problems can lead to health issues:

## Metabolic Disorders

1. ***Diabetes mellitus:*** Type 1 diabetes occurs when the immune system mistakenly attacks insulin-producing cells in the pancreas. Type 2 diabetes is characterised by insulin resistance. Both types lead to high blood sugar levels known as hyperglycaemia. This condition can cause complications such as neuropathy (nerve damage) and cardiovascular disease.
2. ***Obesity:*** hormonal imbalances involving leptin and insulin can contribute to excessive fat accumulation. Leptin is a key hormone in regulating hunger, energy balance, and fat storage. Leptin resistance reduces the hormone's ability to signal satiety (fullness or satisfaction), leading to overeating, while insulin resistance results in increased fat storage and reduced fat breakdown, both of which promote weight gain and obesity.
3. ***Muscle damage:*** Muscle damage can result from direct injury, metabolic disorders, or neurological conditions that affect muscle function. Genetic mutations may also lead to the production of abnormal proteins that impair muscle function and repair. This disrupts communication between nerves and muscles causing muscular dystrophy.

## Neurotransmitter Imbalances

Neurotransmitters are chemical messengers in the brain that transmit signals between nerve cells, playing a key role in regulating mood, emotions, and various bodily functions. When the levels of neurotransmitters are too high or too low, it affects overall brain function. The health issues arising include:

1. ***Depression*:** imbalances in neurotransmitters such as serotonin and dopamine can cause mood disorders.
2. ***Migraines:*** disruptions in neurotransmitter balance can lead to severe headaches typically on one side of the head, triggered by abnormal brain activity.
3. ***Tension headaches:*** stress and altered pain processing pathways can contribute to dull aches and tightness in the head.

## Growth and Developmental Disorders

1. ***Dwarfism:*** a deficiency in growth hormone leads to short height in children.
2. ***Gigantism:*** excessive growth hormone production causes abnormal growth.

## Neural Communication Disruptions

1. ***Multiple sclerosis:*** occurs when the immune system mistakenly attacks the protective covering of nerves in the brain and spinal cord.
2. ***Epilepsy:*** occurs due to abnormal electrical activity in the brain, leading to repeated seizures

Well done! Ready for some challenging activities? Go ahead and explore further!

### Activity 3.10 Human Body Communication Video Exploration

**Materials needed:** Access to a short educational video on human body communication systems.

**Steps:**

1. Search online to watch a video on human body communication and focus on finding the key systems involved in communication (nervous and endocrine systems).
2. As you watch, take notes on the main points, especially the roles of the nervous and endocrine systems.
3. After the video, write a summary of what you learned and be prepared to share it with a peer or family member.
4. Search for another video to watch a short educational video on human body communication systems.

## Activity 3.11 Neurons in Action: Model Creation

**Materials needed:** Craft supplies (clay, straws, pipe cleaners, markers).

**Steps:**

1. Begin by researching the structure and function of neurons.
2. Create a 3D model of a neuron using craft supplies, highlighting key parts (dendrites, axons, synapses).
3. Use coloured markers to show how electrical impulses travel along the axon and how chemical signals are transmitted across synapses.
4. Explain your model to a friend or family member, describing how neurons communicate.

## Activity 3.12 Impulse Transmission Brainstorming Session

**Materials needed**: Whiteboard or flip chart paper, markers.

**Steps:**

1. Brainstorm Impulses: Think about diverse types of impulses (e.g., reflex actions, sensory input) and write them down.
2. Group Discussion: Form a small group or meet with a classmate to discuss how these impulses are transmitted throughout the body.
3. Create a Presentation: Compile your findings into a brief presentation to share with the class or in front of a group, explaining the process of impulse transmission.
4. Feedback Session: After presenting, invite feedback from your audience to enhance your understanding.

## Activity 3.13 Endocrine System Hormone Tracker

**Materials needed*:*** Access to the internet for research, notebook.

**Steps:**

1. Research Hormones: Select 3-5 hormones produced by different endocrine glands.
2. Create a Tracker: Make a table in your notebook that includes the hormone name, the gland that produces it, its function, and its effects on the body.
3. Visual Representation: Draw a diagram showing where these hormones are produced in the body and how they travel to their target organs.
4. Reflection: Write a short reflection on how the endocrine system communicates differently from the nervous system.

## Activity 3.14 Disruption in Communication Case Study Analysis

Search for a couple of case studies that describe health issues related to communication disruptions in the nervous or endocrine systems. Start with these two scenarios:

**Scenario 1**

Meet Ama, a 45-year-old woman living in Accra. Ama has been experiencing increased thirst and frequent urination. After visiting her doctor, she learns that she has Type 2 diabetes.

**Scenario 2**

Kwame, a 12-year-old boy from Kumasi, experiences his first seizure while playing football with friends. After being taken to the hospital, he is diagnosed with epilepsy.

**Steps:**

1. Highlight the main disruptions and their effects on the body.
2. Share your findings with a classmate or family member, focusing on how these disruptions affect overall health.
3. Create a brief report or presentation summarising your findings and suggesting treatments or interventions for the health issues.

## Activity 3.15 Nervous System Communication Race

**Materials needed:** Small stones or empty plastic bottles (to stand for signals), sticks or chalk to mark out a relay course

**Instructions:**

1. Find an open space, like a schoolyard or community area. Use sticks or chalk to create a simple relay course with a start and endpoint.
2. Label your stations: At the start, label it "Sensory Input," in the middle "Processing," and at the end "Motor Output." You can use stones to mark these stations.
3. Get ready: You will be the signal! Start at the "Sensory Input" station.
4. Relay the signal: When you say "Go," pick up a stone (signal) and run to the "Processing" station, where you will pause for a moment to think. Then, run to the "Motor Output" station and drop the stone to stand for a response (like a muscle contraction).
5. Repeat and Challenge: Time yourself and see how quickly you can complete the relay. Challenge yourself to improve your time with each round. You can also invite friends to join.

## Activity 3.16 Endocrine System Hormone Storytelling Game

**Materials needed:** A large piece of paper or cardboard (or use the back of an old school exercise book), pens or pencils, local stories or experiences related to health

**Instructions:**

1. Create your storyboard: Draw a winding path on your paper, with spaces marked for different hormones like insulin, adrenaline, and thyroid hormones.
2. Add local context: Next to each hormone space, write down a local story or health experience that relates to what that hormone does. For example, you might write about how adrenaline is released when someone is excited or scared, such as during a local festival.
3. Play the game: Roll a small ball (or use a coin) to move along the path. When you land on a hormone space, read what you wrote aloud and share the local story related to that hormone.
4. Create scenarios: If you land on a hormone space, think of a scenario where that hormone would be important. For example, "What happens when someone runs away from a goat chasing them?" Discuss how adrenaline helps in that situation.
5. Invite friends: If possible, invite friends to join your storytelling game, taking turns sharing stories and scenarios. This will make it more fun and interactive!

## Self-reflection

1. What new knowledge did I gain about communication in the human body, particularly in the nervous and endocrine systems?
2. In what ways can I connect what I learned to my daily life, and how can I share this knowledge with my classmates or community?

# TECHNOLOGICAL TOOLS USED IN BIOMEDICAL SCIENCES TO ASSESS COMMUNICATION WITHIN THE HUMAN BODY

In biomedical science, technology plays a crucial role in understanding how different systems in the human body communicate. By using advanced tools, healthcare professionals can visualise and measure the electrical and chemical signals that help interactions between organs and tissues. This understanding helps in diagnosing health issues, monitoring treatments, and improving overall patient care.

# Technological Tools Used In Assessing Communication In The Human Body

Technological tools used to assess communication within the human body help us see, measure, and analyse the signals and processes that allow various parts of the body to work together.

Let us explore key technological tools that assess communication within the human body.

1. **Electrocardiograms (ECGs)**
   ECGs measure the electrical activity of the heart. This imaging tool checks your heartbeat and records the electrical signals of the heart. There are several types of ECGs, including:
   a. Resting ECG: Taken while you are at rest.
   b. Ambulatory ECG: Watched over 24 hours while you go about your daily activities.

**Did you know?**

*Ambulatory means walking or moving around!*

   c. Cardiac stress test: Done while you exercise to see how your heart performs under stress.

**Uses of ECGs:**

   a. Diagnosing heart conditions: helps find problems with heart size, position, and rhythm.
   b. Detecting blocked arteries: shows narrowed arteries that can cause chest pain or heart attacks.
   c. Evaluating symptoms: looks for reasons behind tiredness, shortness of breath, dizziness, or fainting.
   d. Monitoring treatments: checks how well drugs or devices are working to control heart issues.

2. **Electroencephalograms (EEGs)**

   EEGs are used to monitor electrical activity in the brain and can help diagnose conditions like seizures, sleep disorders, and neurological diseases. There are different types of EEGs, such as routine EEG, ambulatory EEG, sleep EEG, and video EEG, each serving specific diagnostic purposes depending on the condition being evaluated. The electrodes (sensors) measure signals from the brain's neurons, using a standard layout called the 10-20 system.

   Brain waves, as recorded by an EEG, are electrical patterns in the brain that reflect different mental states and activities. The brainwaves measured include:

   a. ***gamma waves*** (30–100 Hz), the fastest, are associated with problem-solving and high-level thinking.

b. ***beta waves*** (12–30 Hz) occur during active thinking and alertness.

c. **alpha waves** (8–12 Hz) are linked to relaxation, creativity, and meditation.

d. ***theta waves*** (4–8 Hz) are observed during light sleep, daydreaming, or deep focus.

e. ***delta waves*** (0.5–4 Hz), the slowest, are present in deep sleep and support healing.

**Did you know?**

*The name "10-20 system" refers to the distances between electrodes, which are either **10% or 20%** of the total length of the head! See **Figure 3.11***

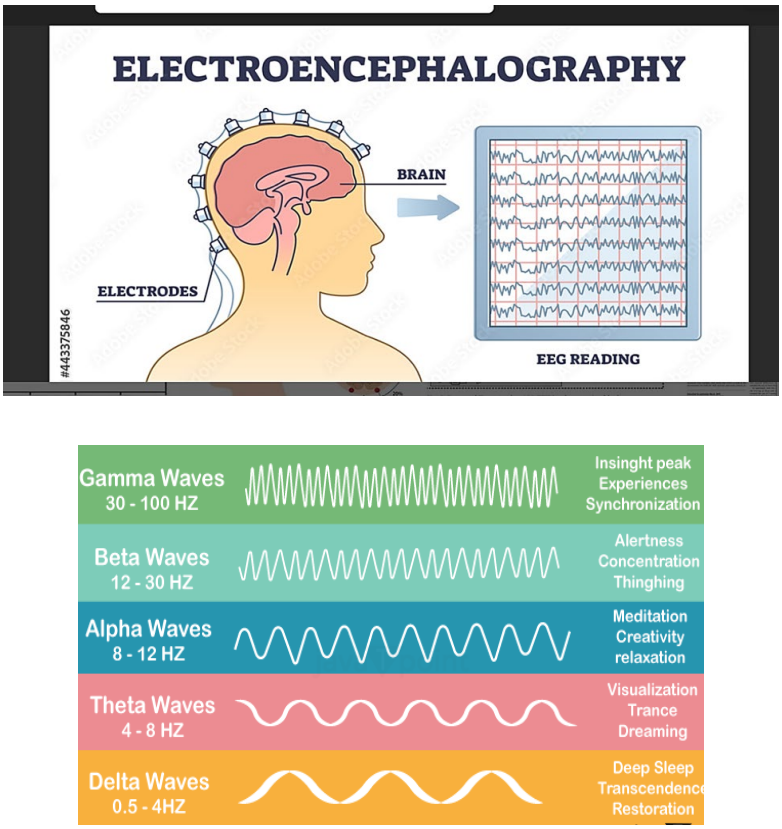



**Figure 3.11** EEG with brainwaves: The numbers in brackets (Hz) show the frequency of the brain waves, measured in hertz (Hz) which indicates the number of cycles per second.

### 3. Electromyography (EMGs)

EMGs measure the electrical activity of muscles. This tool records how muscles respond to nerve signals. Electrodes are placed through the skin into a muscle, or sometimes on the skin's surface. The electrodes in the muscle or on the skin pick up electrical activity and display it on a monitor in the form of waves which can be heard when an audio-amplifier is used.

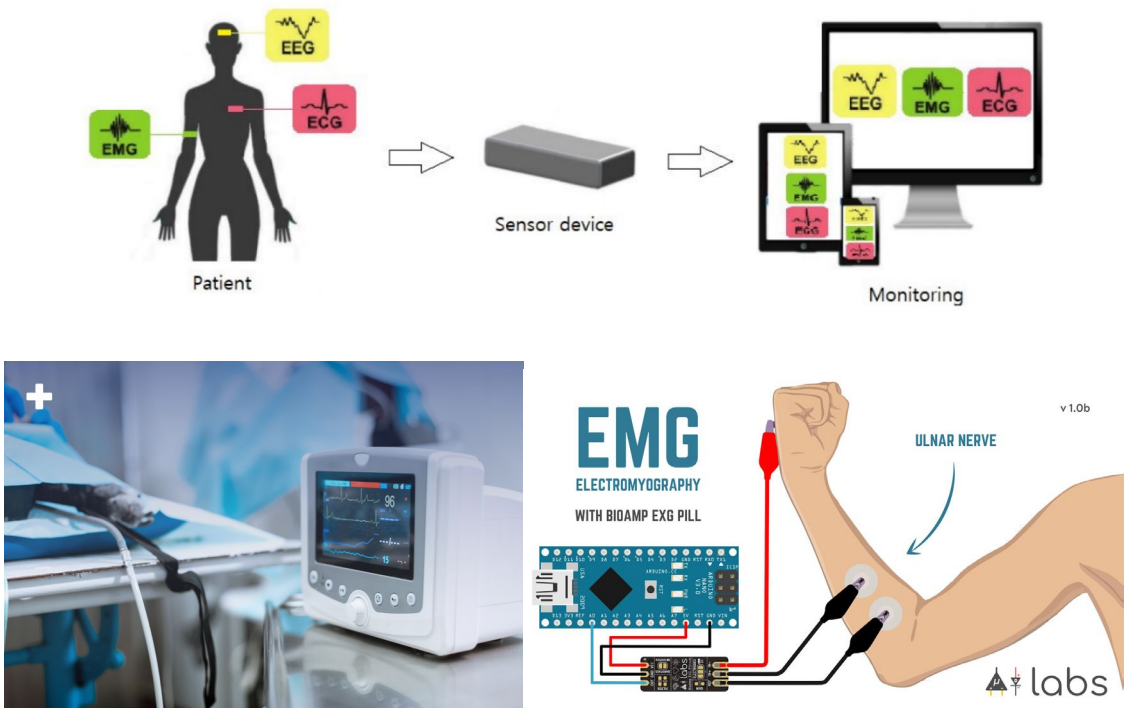



**Figure 3.12:** General setup of a bio-signal monitoring system for EEG, ECG and EMG.

Splendid work done! By understanding these technological tools, you can better assess how communication works in the human body and help diagnose various health conditions.

Now, go ahead and explore the activities below for more understanding while having fun! Remember to try your hands on the review questions.

## Activity 3.17 Virtual Hospital Tour

**Materials needed:** Access to a video or virtual tour of a hospital's cardiology and neurology departments.

**Steps:**

1. Find a video that explains how ECGs and EEGs are used in hospitals, focusing on the use of external electrodes. Click here and here to watch videos on EEG and ECG, respectively.
2. As you watch, note the differences in frequency and amplitude of the electrical patterns (waves) for both ECG and EEG.
3. After watching, write a short paragraph summarising what you learned about how these tools check electrical activity.

## Activity 3.18 Brain Wave Classification

**Materials needed:** Chart of brain waves (alpha, beta, theta, delta), markers or sticky notes

**Instructions:** Use this video as a guide! Glance through these slides

1. Use online resources or textbooks to research the characteristics of different brain waves and their associated states of consciousness.
2. Create a personal chart that summarises each type of brain wave, including its frequency range and the state of consciousness it stands for.
3. Write a few sentences about how this knowledge might help you understand brain function better.

## Activity 3.19 EEG Sample Analysis

**Materials needed:** Samples of EEG readings (can be printed or displayed on a screen). Reference guide on brain wave patterns. Click here for sample!

**Steps:**

1. Review provided EEG samples on your own.
2. Use your reference guide to find different brain wave patterns (alpha, beta, theta, delta) in the samples.
3. Write a short reflection on the clinical significance of any unusual patterns you see, particularly those related to seizures. Feel free to refer to this video!

## Activity 3.20 Hands-On ECG Simulation

**Materials Needed**: Cardboard or paper for creating a simple ECG model, markers for drawing ECG patterns

**Steps:**

1. Use cardboard or paper to create a simple model of an ECG machine.
2. Based on what you learned, draw different ECG patterns on your model standing for various brainwaves.
3. Write a brief explanation for each pattern you created, discussing its significance.

## Activity 3.21 Research on Clinical Conditions

**Materials needed:** Research materials on clinical conditions affecting brain waves (e.g., seizures, sleep disorders)

**Steps:**

1. Choose a clinical condition that affects brain waves.
2. Research how this condition alters EEG patterns and affects brain function.
3. Prepare a short report on your findings, including how the condition impacts brain activity and the significance of the observed brain wave patterns.

## Activity 3.22 Interactive Quiz Challenge

**Materials needed:** Access to a quiz platform (like Kahoot, Quizizz, or a printed quiz sheet), notebook for notes

**Steps**:

1. Create or find a quiz that focuses on technological tools such as ECGs, EEGs, and EMGs. Include questions about their functions, how they work, and their importance in measuring communication in the body.
2. Complete the quiz on your own, aiming to answer as many questions correctly as possible.
3. After finishing, review the answers and reflect on any questions you got wrong. Make notes on the correct information to deepen your understanding.
4. Write a short paragraph discussing what you learned from the quiz and how these tools contribute to healthcare.

## Activity 3.23 Create Your Own Quiz

**Materials needed:** Paper or digital document for creating the quiz, research materials (textbooks, online resources)

**Steps:**

1. Choose three technological tools (like ECGs, EEGs, and EMGs) and gather information about each one. Focus on their functions, how they are used, and their significance in measuring communication in the human body.
2. Create a quiz with at least 10 questions based on your research. Include multiple-choice, true/false, and short answer questions to test your knowledge.
3. Once your quiz is ready, take it yourself, answering each question without looking at your notes first.
4. After completing the quiz, review your answers and reflect on what you learned. Write down any new insights or questions you still have about the tools.

## Self-reflection

1. What did I learn about the technological tools used to measure communication in the human body, and how did this knowledge change my understanding of their importance?
2. How did taking part in the interactive quiz help reinforce my knowledge of ECGs, EEGs, and EMGs? Were there any questions that challenged me or surprised me?
3. In what ways can I apply what I learned from these activities to my studies or future interests in biomedical sciences or healthcare?

# EXTENDED READING

- Click here to watch a video on the four lobes of the brain
- What are the various parts of the brain and what do they do? Click here
- To learn more about neurons, click here.
- Click here to explore how brain mapping helps mental health

# REVIEW QUESTIONS 3.1

## Carefully read each case scenario, and answer the questions that follow:

### Case scenario 1: The Athlete's Brain

Kwame is a talented footballer in a senior high school in Ghana. During a match, he relies on quick decision-making, coordination, and sensory input to navigate the field. His frontal lobe helps him plan his moves, while his cerebellum coordinates his balance and motor skills. After the game, Kwame reflects on how his brain processes information from his eyes and ears to react to the game.

**Questions**

a. What part of Kwame's brain helps him plan his moves during the game?

b. How does the cerebellum contribute to Kwame's performance on the field?

c. Explain how sensory input from his eyes and ears affects Kwame's decision-making during a match.

d. Analyse how the interaction between the frontal lobe and cerebellum enhances Kwame's overall performance in football.

### Case scenario 2: The Artist's Inspiration

Ama is an aspiring artist who often finds herself lost in creativity. When she paints, her occipital lobe processes visual information, allowing her to see colours and shapes. Meanwhile, the temporal lobe helps her recall memories of past artwork and emotional experiences that inspire her current piece. Ama's ability to express herself through art is a result of the complex interactions in her brain.

**Questions**

a. Which lobe of Ama's brain processes visual information?

b. How does the temporal lobe help Ama in her artistic expression?

c. Discuss how the occipital and temporal lobes work together during Ama's creative process.

d. Evaluate the importance of emotional memory in Ama's artwork and how it influences her creative decisions.

### Case scenario 3: The Student's Challenge

Kofi is a high school student who struggles with maths. He often feels frustrated because he has difficulty integrating sensory information. His parietal lobe plays a crucial role in processing touch and spatial awareness, which are essential for

understanding mathematical concepts. With help from a teacher, Kofi learns strategies to engage his brain's resources effectively.

**Questions**

a. What does the parietal lobe help Kofi process?

b. How can Kofi's difficulty in integrating sensory information affect his learning in maths?

c. Explain how Kofi can use strategies to enhance his understanding of mathematical concepts by engaging his parietal lobe.

d. Propose a tailored learning plan for Kofi that incorporates activities to strengthen the functions of his parietal lobe.

## Case scenario 4: The Elderly Woman's Memory

Mama Adwoa, an elderly woman, often forgets recent events and struggles with her memory. Doctors explain that the hippocampus, found in the temporal lobe, is essential for forming and retrieving memories. They recommend cognitive exercises to stimulate her brain and improve her memory retention. Mama Adwoa's family supports her by engaging in memory games and storytelling.

**Questions**

a. What part of Mama Adwoa's brain is associated with memory formation and retrieval?

b. How can cognitive exercises help improve Mama Adwoa's memory?

c. Discuss the role of her family in supporting Mama Adwoa's cognitive health through memory games.

d. Assess the overall impact of engaging in memory exercises on Mama Adwoa's quality of life and brain function.

## Case scenario 5: The Reflex Action

During a science class, a student accidentally touches a hot surface. Instinctively, they pull their hand away before feeling any pain. This quick response is a classic example of a reflex action, which involves sensory input, processing by the spinal cord, and motor output.

**Questions**

a. What immediate action did the student take upon touching the hot surface?

b. Describe how the sensory input and motor output are involved in this reflex action.

c. Explain the role of the spinal cord in processing the reflex action and why it allows for a quicker response than if the brain were involved.

## Case scenario 6: Hormonal Regulation of Blood Sugar

A teenager eats a large meal high in carbohydrates. In response, the pancreas releases insulin, a hormone that helps regulate blood sugar levels. This process ensures that glucose is absorbed by cells for energy, preventing hyperglycaemia.

**Questions**

a. What hormone is released by the pancreas after consuming a high-carbohydrate meal?

b. Explain the role of insulin in regulating blood sugar levels after a meal.

c. Evaluate the importance of keeping balanced blood sugar levels for overall health and discuss potential health issues that can arise from imbalances.

SECTION

4

# DISEASES AND DISORDERS

# HUMAN BODY SYSTEMS

## Diseases and Disorders

## INTRODUCTION

Welcome to another exploration of diseases and disorders! In this journey, you will dive into how major nervous system disorders affect quality of life, explaining how these disorders impact daily living. Consider the daily challenges individuals face when living with these disorders and the broader effect on their routines and mental well-being.

As you progress, you will take on the role of a biomedical scientist, interpreting the symptoms and physical characteristics of a given patient to determine an endocrine system malfunction, such as hyperthyroidism. Think critically about the signs you will observe and how they relate to overall health. You will also tackle diabetes by identifying and discussing its causes, symptoms, treatments, effects, and impact on the human body and lifestyle.

You will investigate the structural differences between bacteria and viruses. You will then explore the systems, prevalence, and treatment of bacterial and viral infections, considering infections of the reproductive system. You will also explore the immune response in relation to the introduction of antigens. Consider antibiotics—they are powerful tools against bacteria, but remember, they do not work on viruses. Analyse how antibiotics are used to treat infections and explain how their effectiveness depends on the causative bacterium. Throughout this journey, you will gain valuable insights into the prevalence of infections. Lastly, discuss the global and social impact of some infectious diseases caused by bacteria and viruses and think about how they influence your life.

### Key Ideas

- Antibiotics work against bacteria but not viruses; their effectiveness depends on the bacterial type. Infectious diseases have significant global and social effects.
- Bacteria and viruses have distinct structural differences that influence how they affect us.
- Bacterial and viral infections, especially in the reproductive system, require specific treatments and they also trigger immune responses.
- By studying symptoms, we can find problems in the endocrine system, like hyperthyroidism.
- Diabetes affects health and lifestyle through its causes, symptoms, and treatment options.
- Nervous system disorders can affect a person's daily life and overall well-being.

# EXPLORING HOW VARIOUS NERVOUS SYSTEM DISORDERS CAN IMPACT A PERSON'S QUALITY OF LIFE

Nervous system disorders can really change how you feel and how you live each day. Let us look at several types of these disorders and see how they can affect your daily activities and the way you connect with others!

Nervous system disorders can be sorted into separate groups depending on what they are like and what causes them. Let us take a closer look at these distinct types and see how we can classify them!

## Types of Nervous System Disorders

1. **Structural Disorders:** happens when there is damage or injury to the nervous system. This can include traumatic brain injuries, spinal cord injuries, or even tumours. A tumour is a lump or growth of abnormal cells in the brain or spinal cord that can affect how a person moves, thinks, or feels. These disorders can cause chronic pain, trouble with coordination, or difficulties with memory and concentration. Have you ever wondered how an injury to the brain or spine might change the way a person walks, talks, or even remembers things?

2. **Neurodevelopmental Disorders:** are conditions that happen as the brain and nervous system are developing, often before birth, and they can lead to different challenges in daily life. Let's look at a couple of the most common ones:

    a. Autism Spectrum Disorder (ASD): affects how someone communicates, behaves, and interacts with others. People with ASD may find social situations challenging and might have unique ways of expressing themselves.

    Have you ever met someone with ASD or heard about it? What was that experience like?

    b. Attention-Deficit/Hyperactivity Disorder (ADHD): involves issues with focus, being highly active, and sometimes acting without thinking. It usually shows up in childhood but can last into adulthood.

    Do you ever have times when focusing is tough or find yourself super energetic? How might that feel for someone with ADHD?

3. **Learning Disorders:** These can make certain areas of learning more challenging, such as reading, writing, or mathematics. For example, dyslexia makes reading difficult, as letters and words may appear jumbled or hard to recognise.

    Have you ever had trouble understanding a word right away? Imagine if that happened often—how would it make learning feel?

4. **Communication Disorders:** These involve difficulties with speech and language. For instance, some people may struggle with pronouncing certain sounds or letters. They might say "wabbit" instead of "rabbit" or mix up sounds like "s" and "sh."

Do you know anyone who has a unique way of speaking or says some words differently? How do they make themselves understood?

3. **Infections:** Some disorders are caused by infections that affect the nervous system, such as meningitis or poliomyelitis. These can have long-term effects, making it difficult for people to think or move as they did before.

4. **Functional Disorders:** affect how the nervous system works without causing any physical damage. For example, people with epilepsy or migraines can have sudden, unpredictable symptoms that can really disrupt their day-to-day activities.

   How would you feel if you had to deal with that?

5. **Degenerative Disorders:** happen when nerve cells in the brain slowly stop working as the years go by. This can make it harder for a person to remember things, move properly, or do everyday activities. For example, Alzheimer's disease can cause serious memory loss, making it difficult for someone to recognise their own family. Parkinson's disease affects movement, so a person may shake, move slowly, or have trouble walking. It can be really tough to see how these conditions change a person's life, do you agree?

6. **Vascular Disorders:** affect blood flow in the body, especially to the brain. A major example is a stroke, which happens when blood flow to the brain is blocked or reduced, causing brain cells to die. This can have a big impact on a person's life, sometimes leading to difficulty moving, speaking, or thinking clearly. Recovering from a stroke can take a long time, and some people may never fully regain their abilities. Have you ever met someone who had a stroke?

7. **Autoimmune Disorders:** happens when the body's defence system, which is supposed to fight off germs, attacks the body by mistake. One example is Multiple Sclerosis, where the body attacks the nerves. This can make a person feel very tired, have trouble walking, or find it hard to think clearly. Imagine trying to walk, but your legs feel too heavy, or trying to remember something, but your mind feels cloudy. That is what someone with Multiple Sclerosis might go through!

## Impact on Quality of Life

Now, explore how these disorders can change everyday life.

1. **Physical Limitations:** Many people with nervous system disorders face challenges with movement. For instance, someone with Parkinson's disease may have tremors that make even simple tasks like holding a cup difficult. How would you adapt to that situation?

2. **Communication Difficulties:** If someone has damage to the parts of their brain responsible for speech, they might struggle to express themselves or understand others. Imagine recovering from a stroke and trying to communicate your needs—frustrating, isn't it?

3. **Sensory Impairments:** Some disorders can lead to loss of senses, such as sight or feeling. This can make interacting with the world challenging. Have you ever thought about how much you rely on your senses every day?
4. **Cognitive Challenges:** Conditions affecting memory and problem-solving can be tough. For example, someone with Alzheimer's disease might forget their daily routine or struggle to recognise family members. How do you think this affects their relationships?

## REAL-LIFE EXAMPLES OF PEOPLE LIVING WITH NERVOUS SYSTEM DISORDERS

Some health conditions can really change how people live. Nervous system disorders are especially important to understand because they affect the brain, spinal cord, and nerves all over the body. These disorders can cause serious symptoms that might make daily activities difficult, and sometimes there is no cure. Learning about them helps us see how they impact not just the person who has them, but also their families. Let us examine some real-life stories of people living with nervous system disorders.

1. **Dementia:** People with Alzheimer's disease experience dementia, which gets worse over time. Dementia is not just about memory loss—it also affects how a person speaks and interacts with others. As it progresses from mild to severe, it can make communication difficult and impact relationships. In the later stages, some people with dementia may struggle to recognise their own family or even themselves. If you want to learn more, click here to watch videos of people living with Alzheimer's disease and hear their stories!
2. **Aphasia:** Aphasia is a language disorder that affects how someone communicates. It can happen suddenly, often after a stroke or brain injury, or it can develop slowly due to things like brain tumours or other diseases. People with aphasia might find it hard to put together clear sentences. For example, instead of saying, 'Mum will drive to the market today,' they might say, 'Drive, mum, market.' In more serious cases, they may even have trouble understanding spoken language, which makes it hard to communicate. If you want to learn more, check out this link to watch a video about a teenager who experienced aphasia after a stroke. His story is quite inspiring!
3. **Autism:** Autism is a neurodevelopmental disorder that changes how people see the world and interact with others. For individuals with autism, communication and making friends can sometimes be challenging, which can make daily life a bit tougher. It is important for all of us to understand and support those with autism so we can create a welcoming environment for everyone. If you want to learn more about this, check out this link.
4. **Parkinson's Disease:** If you want to understand more about living with Parkinson's disease, check out this video! It shares the story of a patient with Parkinson's and shows how symptoms like shaking (tremors), stiff muscles, and balance problems can make daily tasks more challenging. Watching this will give you valuable insights into how the condition affects people and how they manage it. Don't miss it!

5. **Chronic Pain:** Chronic pain is another big issue that can come from different nervous system disorders. Unlike acute pain, which is our body's way of saying something is wrong after an injury, chronic pain sticks around for months or even years. It can really take a toll on someone's physical and mental health. Chronic pain might be caused by things like nerve damage, spinal cord injuries, or other health problems. It is important for us to understand what people living with chronic pain go through so we can offer them better support and create more inclusive environments. If you want to learn more about this, check out this link! You can watch a video featuring a patient who shares their experiences with chronic pain, and their story is sure to be eye-opening!

Imagine someone with a nervous system disorder who finds it hard to join social activities and has expensive treatments. How do you think these challenges—feeling isolated and managing excessive costs—could affect their daily life and relationships?

Get ready for some intriguing activities!

## Activity 4.1 Understanding Nervous System Disorders

**Materials needed:** Paper, markers or coloured pencils, cardboard, or poster board (optional), computer (optional).

**Steps:**

Choose a nervous system disorder from Alzheimer's disease, Aphasia, Autism, Parkinson's disease, or Chronic pain, and think about how it affects daily life. Refer to the Glossary for definitions and key information about these disorders.

1. Create a drawing using paper, markers, or a computer, highlighting the symptoms, causes, and impact of the disorder.
2. Imagine explaining your drawing to someone else and think about what you would say.
3. Write a few sentences about how the disorder affects people and their families, and what might help them.
4. Reflect on what you learned and how it can help you understand and support those affected in your community.

## Self-reflection

1. How can I apply what I have learned about nervous system disorders to better support individuals and families affected by this disorder in my community?
2. What additional resources or support systems can be developed to enhance the quality of life for those living with nervous system disorders?

# THE ROLE OF THE ENDOCRINE SYSTEM IN REGULATING VARIOUS BODILY FUNCTIONS

Imagine feeling anxious all the time, losing weight without trying, and having a heart that beats really fast. What do you think could be causing this? It might be a condition called hyperthyroidism, where the thyroid gland makes too many hormones. Scientists study this by testing blood samples to check hormone levels and finding out what causes the thyroid to become overactive. By learning how the thyroid works, they help doctors find better ways to diagnose and treat the condition. What other body processes do you think the thyroid might control?

Let us explore the endocrine system together! Think of the endocrine system as a messaging network in your body. It consists of glands and organs that produce and release special chemical messengers known as hormones. These hormones are particularly important because they help control how your body grows, how it uses energy (metabolism), how you feel (mood), and even how you go through puberty.

Some key parts of the endocrine system include glands such as the hypothalamus, pancreas, pituitary, adrenal, and thyroid. Other organs, such as your kidneys, testes (in boys), and ovaries (in girls), also produce hormones. For instance, hormones from the testes and ovaries play a crucial role in the changes that occur during puberty and in the ability to have children later.

## Major Glands, the Hormones They Secrete and Their Functions

Go ahead and explore more about each of these glands, the types of hormones they release, and how these hormones help your body function. Let us get started!

1. ***Pituitary Gland:*** This is a small gland at the base of the brain. It controls other endocrine glands and produces important hormones. Growth Hormone helps bones and muscles grow. Prolactin supports milk production. Adrenocorticotropic Hormone helps the body respond to stress. Thyroid-stimulating hormone (**TSH**) controls metabolism. Luteinising Hormone helps with ovulation and testosterone production. Follicle-stimulating Hormone (**FSH**) supports egg and sperm development.
2. ***Adrenal Glands:*** The adrenal glands are two small glands located on top of each kidney. They produce important hormones that help regulate various body functions. Cortisol helps manage stress and control inflammation. Adrenaline prepares the body for emergency responses by increasing heart rate and energy levels. Aldosterone helps maintain blood pressure and balance salt and water in the body.
3. ***Thyroid Gland:*** This is a small, butterfly-shaped gland in the front of the neck, just below the voice box. It makes hormones that help control how the body uses energy. Thyroxine (T4) and Triiodothyronine (T3) help with growth, energy, and metabolism. Calcitonin helps control calcium levels in the blood.

4. ***Pancreas:*** This gland is located behind the stomach. It produces hormones that help control blood sugar levels. Insulin lowers blood sugar by helping cells take in glucose, while glucagon raises blood sugar by releasing stored glucose from the liver.
5. ***Ovaries:*** The ovaries are two small organs located on either side of the lower abdomen in females. They produce eggs and release hormones that control the menstrual cycle and reproduction. The main hormones made by the ovaries are oestrogen, which helps develop female characteristics and regulates the menstrual cycle, and progesterone, which prepares the body for pregnancy. The menstrual cycle is the monthly process in which the body prepares for pregnancy by releasing an egg and thickening the uterus lining. If pregnancy does not occur, the lining is shed as menstrual bleeding.
6. ***Testes:*** The **testes** are two small organs located in the scrotum, below the penis. They produce **sperm** for reproduction and release **hormones** that control male development. The main hormone made by the testes is **testosterone**, which is responsible for male characteristics such as a deeper voice, muscle growth, and facial hair. Testosterone also helps in sperm production and plays a role in maintaining overall male health.
7. ***Hypothalamus:*** The **hypothalamus** is a small part of the brain that helps control important body functions. It sends signals to the **pituitary gland** to release hormones. These hormones help control growth, stress, body temperature, hunger, thirst, sleep, and the release of other hormones from different glands. The hypothalamus makes **growth hormone-releasing hormone (GHRH)** to help with growth, **thyrotropin-releasing hormone (TRH)** to control energy use, and **gonadotropin-releasing hormone (GnRH)** to manage reproductive functions. Look at **Figure 4.1**. It shows the major glands in our body.

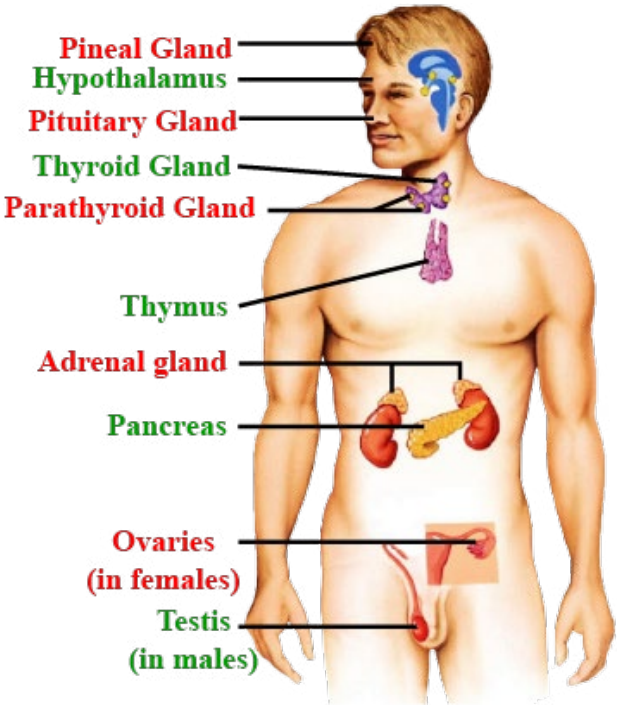



**Figure 4.1:** Major Glands of the Human Body

# SYMPTOMS AND PHYSICAL CHARACTERISTICS OF ENDOCRINE SYSTEM MALFUNCTION

Have you ever felt extremely tired, noticed sudden weight changes, or seen someone with unusual growth patterns? These could be linked to the endocrine system, which controls hormones in the body.

Imagine someone's thyroid is working too fast—this is called hyperthyroidism. They might lose weight quickly and have a rapid heartbeat. But if the thyroid is too slow, a condition called hypothyroidism, they could feel tired all the time and gain weight.

Growth and appearance are also affected by the endocrine system. Gigantism and dwarfism influence height, while Cushing's syndrome can cause weight gain and a round face. Addison's disease may lead to constant fatigue and darker skin patches. These conditions are examples of syndromes, which are groups of symptoms that happen together due to an underlying issue.

Biomedical scientists study these disorders to uncover their causes and improve treatments. If you were a biomedical scientist, what questions would you ask about these conditions? How do you think research can help doctors diagnose and treat them?

## Common Endocrine Disorders and Their Symptoms

1. **Hyperthyroidism**
   Imagine feeling like you are always on fast-forward—losing weight even though you are eating more, or your heart suddenly starts racing. That is what someone with hyperthyroidism might go through.

   a. What is it? It happens when the thyroid gland is overactive and produces too much thyroxine.

   b. Symptoms you might notice:

      - Have you ever felt shaky for no reason? That is one symptom.
      - You could also feel very warm all the time, even when it is not hot outside.
      - Fatigue or anxiety might also appear.

   c. Physical clues: If someone has a noticeable swelling in their neck (called a goitre) or eyes that seem to bulge, it might be hyperthyroidism. **Figure 4.2** shows an individual with goitre.

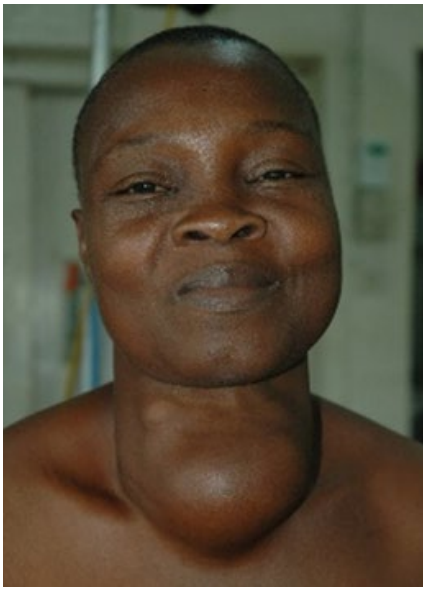


**Figure 4.2:** An individual with goitre.

2. **Hypothyroidism**
   On the other side, what if your thyroid is not producing enough hormone? This is called hypothyroidism, and it can slow your body right down.

   a. **What is it?** It happens when the thyroid gland is not active enough and does not make enough thyroid hormones. This can be treated by taking special medicine, like levothyroxine, to help bring the hormone levels back to normal.

   b. Symptoms you might notice:

      - You could feel sluggish or exhausted all the time.
      - Weight gain without changing what you eat? That is another sign.
      - Feeling cold all the time, while everyone else is fine? That is a clue too.

   c. Physical clues: People with hypothyroidism often have puffiness in their face, especially around their eyes.

3. **Gigantism**
   Have you ever seen someone who is much taller than their friends and growing rapidly? They might have gigantism, a condition caused by too much growth hormone.

   a. What is it? This happens when the body makes too much growth hormone, often due to a tumour on the pituitary gland.

   b. Symptoms you might notice:

      - Rapid growth in height and size—taller and larger than their peers.

- Large hands and feet, and their facial features might look more prominent.
- They could also feel constantly hungry or tired.

c. Physical clues: If someone has a larger forehead or nose than usual, along with big hands and feet, it could be a sign of gigantism. See **Figure 4.3**

**Figure 4.3:** Individuals with gigantism from Ghana (male) and from South Sudan (female)

4. **Dwarfism**
On the other end of the growth spectrum, people with dwarfism grow much slower than usual.

a. What is it? This is often caused by not having enough growth hormone.

b. Symptoms you might notice:

- People with dwarfism are shorter than average, usually below 147 centimetres as adults.
- They may go through puberty later than their peers, and their growth is delayed.

c. Physical clues: You might notice that someone with dwarfism looks younger or smaller than others their age. **Figure 4.4** shows an individual with dwarfism.

**Figure 4.4:** An individual with dwarfism.

5. **Diabetes Mellitus**: Have you ever noticed someone who is always thirsty, goes to the toilet a lot, or looks really tired all the time? They might have diabetes, a condition where the body cannot handle sugar properly.

    a. What is it? It happens when the body cannot produce or effectively use insulin, causing high blood sugar levels.

    b. Symptoms you might notice:

        - Constant thirst and needing to urinate frequently.
        - Feeling extremely tired, even after a good night's sleep.
        - Cuts that take a long time to heal or blurred vision.

    c. Physical clues: Sudden weight loss or gain could be a sign, along with dark patches of skin in some cases.

6. **Adrenal Gland Disorders**: Let us look at two conditions affecting the adrenal glands: Cushing's syndrome and Addison's disease.

    a. **Cushing's Syndrome**: have you ever seen someone with weight gain around their middle but thin arms and legs? They might have Cushing's syndrome.

    What is it? It happens when the adrenal glands make too much cortisol, the stress hormone.

    Symptoms you might notice:

    - Weight gain, especially around the face and abdomen.
    - Feeling tired or weak.

- High blood pressure and sometimes unusual hair growth in females.

Physical clues: A round, puffy face (often called a moon face) and a lump of fat on the upper back (buffalo hump) are tell-tale signs.

b. **Addison's Disease**: On the other hand, if someone's skin seems unusually darker, even without being in the sun, it could be Addison's disease.

What is it? This happens when the adrenal glands do not produce enough hormones.

Symptoms you might notice:

- Weight loss and loss of appetite.
- Fatigue that just will not go away.
- Nausea and sometimes vomiting.

**Physical clues**: Darkened skin, especially on areas not usually exposed to sunlight, like the palms or inside the mouth.

## Activity 4.3 Endocrine System Observation

**Materials needed:** Mobile phone, tablet, or laptop with access to the video or presentation; notebook or sheets of paper; pen or pencil.

**Steps:**

1. Click on this link to watch a video on the endocrine system and how it works.
2. Write down 5 things you find interesting or important.
3. Answer simple questions like, "Which part surprised you?" or "How might someone with this problem feel?"
4. Prepare to share what you learned with others, using notes if you are shy.
5. Try explaining one thing you learned to a family member or friend.

## Activity 4.4 Hormonal Impact Exploration

**Materials needed:** Notebook or sheets of paper; pen or pencil.

**Steps:**

1. Draw a simple chart with three columns: Time of Day, Activity, and How I Feel.
2. Throughout the day, fill in the chart with what you are doing (e.g., studying, playing, eating) and how you feel (e.g., tired, energetic, happy).

3. At the end of the day, look at your chart and think about when you felt the most energetic or the most tired.
4. Write a short sentence about how hormones might influence these changes in your mood and energy levels.

## Self-reflection

Hey there, everyone! Are you ready to reinforce what you have learned? Let us dive into a game of Hangman! You can click on this link to watch a quick video that explains how to play. It is super helpful, and it will make the rules nice and clear. Let us get started!

1. Choose Your Format: You can either play this game individually or team up with a friend or two—whatever works best for you!
2. Pick Your Words: Choose words related to endocrine glands, disorders like gigantism or Addison's syndrome, or even symptoms and physical traits, like fatigue, weight loss, or darkened skin. Get creative!
3. Take Turns or Play Solo:
   a. With a Partner or Group: One person thinks of a word while the others guess it letter by letter. Once the word is guessed, the person who thought of it can ask their partners to explain:
      - What signs and symptoms are associated with that disorder?
      - What hormones does the gland produce?
      - Are there any other disorders that might show similar symptoms or characteristics?
   b. Playing Alone: If you are going solo, write down your chosen word and see how many letters you can guess before the hangman is fully drawn. After you finish, look up the signs, symptoms, and related disorders on your own.

You can repeat this game as many times as you want, switching words each round to keep things fresh and exciting! And remember, if you or anyone else needs clarification on a term, do not hesitate to ask for help. Have fun and good luck!

# UNDERSTANDING DIABETES – THE CONCEPT OF DIABETES, AND THE DIFFERENT TYPES

Have you ever wondered how scientists study diabetes? Biomedical scientists work to understand what causes it, how it affects the body, and how to improve treatments. They test blood sugar levels, create better ways to diagnose the condition and research new medicines. Imagine you are a Biomedical scientist—what questions would you ask about diabetes? How do you think research can help people manage it better?

Did you know that your body has a special system to control sugar levels? This is called the endocrine system. Diabetes happens when something goes wrong with this system, making it hard for the body to use sugar properly.

There are two main types:

1. **Type 1 diabetes** – The body does not make insulin (a hormone that helps sugar enter cells for energy) at all because the immune system attacks and destroys the insulin-producing cells in the pancreas. This usually occurs in children and young adults, but it can develop at any age.
2. **Type 2 diabetes** – The body makes insulin, but it does not work as well as it should. It often develops due to a combination of genetic factors and lifestyle choices, such as diet and lack of exercise.

Think of insulin as a key. When you eat, your pancreas releases insulin to unlock your cells and let sugar in for energy. But in diabetes, the key is missing or broken, leaving too much sugar in the blood.

## What are the Common Symptoms of Diabetes?

Have you ever wondered how scientists figure out if someone has diabetes? Biomedical scientists look for clues in the body, just like detectives solving a mystery! When blood sugar levels are too high, the body sends warning signs. Can you guess what some of these signs might be?

Let us explore the key symptoms that help diagnose diabetes!

1. Feeling extremely thirsty: have you ever experienced a feeling of thirst that persists no matter how much you drink? This can occur because your body is trying to eliminate excess sugar by increasing urination. Consequently, you may feel thirsty all the time to compensate for the lost fluid.

2. Feeling extra tired: do you often feel very tired even after a full night of sleep? This could indicate that your body is not using sugar (glucose) properly for energy. It is as if your body's fuel tank is full but cannot utilize the fuel effectively.

3. Urinating frequently: do you find yourself visiting the restroom more often than usual? This happens because, when there is too much sugar in your blood, your kidneys attempt to flush it out through urine, leading to increased trips to the toilet.

4. Unexplained weight loss: while losing weight without trying may seem appealing, it can be concerning if it occurs for no apparent reason, especially in Type 1 diabetes. When the body lacks sufficient insulin, it begins breaking down fat for energy, resulting in weight loss.

5. Slow healing of cuts and wounds: have you noticed that your cuts or scrapes take a long time to heal? Elevated blood sugar levels can impair your body's healing abilities, causing even minor wounds to take longer to recover.

6. Blurry vision: has your vision ever become blurry without an apparent reason?

High sugar levels can cause swelling in the lenses of your eyes, making it difficult to see clearly. If this issue persists, it is important to have your eyes examined.

7. Increased infections: ff you find that you are experiencing infections more frequently than usual, it may be due to diabetes weakening your immune system. High blood sugar levels can hinder your body's ability to fight off infections.
8. Persistent hunger: have you ever felt extremely hungry, even after just eating? This sensation may occur because your body is unable to transport enough sugar into your cells for energy, tricking your brain into believing you need more food.
9. Tingling or numbness in your hands and feet: do you ever feel a strange tingling or numbness in your fingers or toes? This could be a sign of nerve damage caused by prolonged high blood sugar levels. It serves as your body's way of indicating that something is not right.

## TREATMENTS AND LIFESTYLE ADJUSTMENTS IN MANAGING DIABETES

Managing diabetes is about more than just taking medication; it also means adjusting your daily habits. Getting a handle on both aspects is key to staying healthy and feeling your best!

Did you know that staying active plays an important role in managing diabetes? It helps by:

1. lowering blood sugar: when you exercise, your muscles use blood sugar for energy. This helps bring your blood sugar down, which is super important for your overall health.
2. protecting your heart: regular physical activity can help reduce your risk of heart disease, keeping your heart strong and healthy.
3. reducing stress: exercise is a fantastic way to unwind, blow off some steam, and feel more relaxed.
4. improving insulin sensitivity: the more you move, the better your body gets at using insulin. That means it can manage blood sugar more effectively.

There are also diverse ways to manage diabetes, depending on whether you have Type 1 or Type 2. See **Figure 4.5**

### Managing Type 1 Diabetes

1. Insulin therapy: regular insulin injections or use of an insulin pump.
2. Blood sugar monitoring: frequent checking of blood glucose levels.
3. Diet management: balanced diet with controlled carbohydrate intake.

4. Physical activity: regular exercise to improve overall health.
5. Education and support: collaboration with healthcare providers and diabetes educators.

## Managing Type 2 Diabetes

1. Lifestyle changes: a healthy diet rich in whole grains, fruits, and vegetables.
2. Regular exercise: engage in physical activity to improve insulin sensitivity.
3. Weight management: Achieve and maintain a healthy weight.
4. Medication: take prescribed medications or insulin if needed.
5. Regular monitoring: check blood sugar levels regularly to track progress.

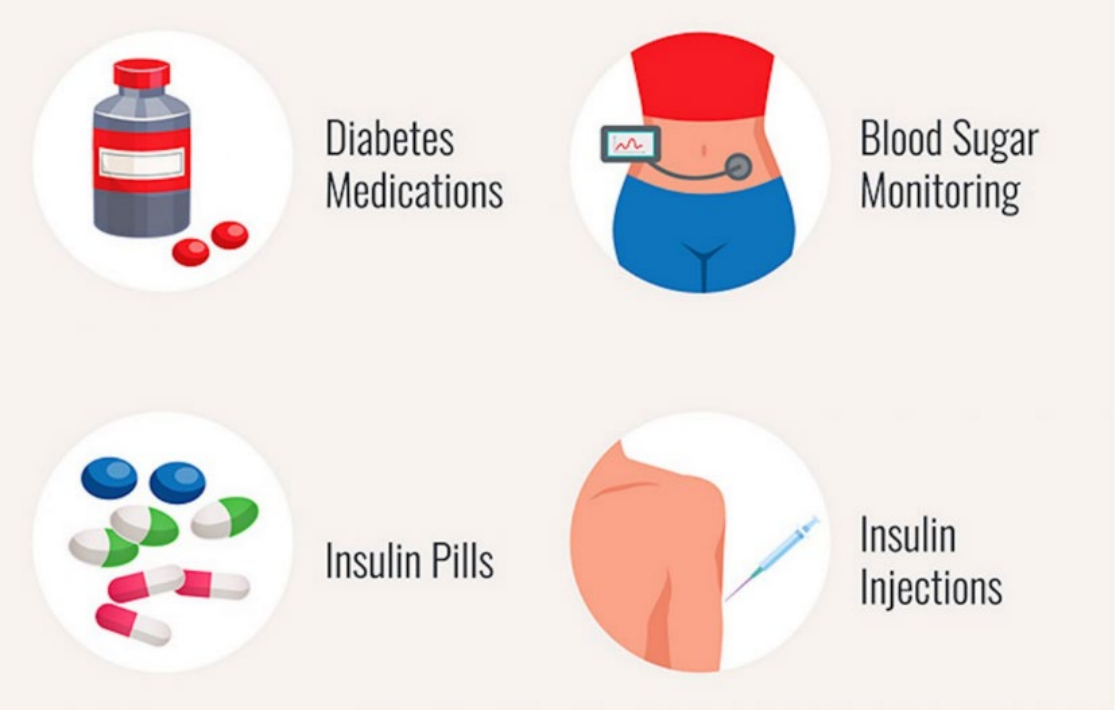



**Figure 4.5:** Treatment options for type 1 and type 2 diabetes.

# THE IMPACT OF DIABETES

If diabetes is not managed well, it can lead to some serious health problems. Let us explore what can happen if someone does not take care of their diabetes!

## Long-Term Effects

Some health issues can start even before a person knows they have diabetes. That is why it is especially important to keep track of blood sugar levels and take medication as needed.

## Health Complications

Whether someone has Type 1 or Type 2 diabetes, high blood sugar over time can cause problems for various parts of the body. Here are some areas that can be affected:

1. Eyes: people might develop blurry vision.
2. Nerves: damage can lead to numbness or tingling in the hands and feet.
3. Heart and blood vessels: this can increase the risk of heart attacks and strokes.
4. Gums and teeth: gum disease can also be a concern.
5. Kidneys: these can become damaged, making it harder for the body to filter waste.

To avoid these complications, it is important for people with diabetes to adopt healthier lifestyles and follow their Biomedical scientist's advice. This includes eating nutritious foods, exercising, and managing stress.

Learning about diabetes helps us recognise symptoms early, find better treatments, and support those living with it. How can you use this knowledge to help people in our community?

### Activity 4.4 Diabetes Awareness: Empowering Ourselves with Knowledge"

**Materials needed:** Paper (any type), pens or pencils, markers, or crayons (if available), and research materials (books or pamphlets, if available).

**Steps:**

1. Read about diabetes or listen to someone explain it.
2. Choose one topic about diabetes: causes, symptoms, treatment options, or effects on lifestyle.
3. Create a poster that includes key facts, drawings, and tips about your topic.
4. Write a few sentences about what you learned while making your poster.
5. Share your poster with friends, and family, or display it at school.

### Activity 4.5 Exploring Nutritional Choices

**Materials needed:** Paper, pen or pencil, a variety of foods (fruits, vegetables, whole grains, lean meats, or pictures), and a notebook.

**Steps:**

1. Gather different foods from home or find pictures of foods such as fruits, vegetables, grains, and proteins.

2. List the foods you collected and sort them into groups: fruits, vegetables, grains, and proteins.
3. Think about what happens when these foods enter the body. How do they provide energy and nutrients?
4. Discuss why choosing lean meats and foods low in sugar and fat is important for health.
5. Write a few sentences in your notebook about what you learned and how you can make healthier food choices.

## BACTERIA AND VIRUSES – MICROSCOPIC ORGANISMS THAT CAN CAUSE DISEASE

Let us explore the differences between bacteria and viruses! Biomedical scientists study these microscopic agents to understand how they cause disease and to develop effective treatments. Did you know that bacterial infections can be treated with antibiotics, while viral infections require different approaches, such as vaccines or antiviral drugs? By investigating the unique characteristics of bacteria and viruses, biomedical scientists contribute to the development of new diagnostic tools, treatments, and prevention strategies, helping to control the spread of infectious diseases and protect public health.

You might be surprised to learn that bacteria and viruses are microscopic organisms that can significantly impact your health. While many bacteria are beneficial, some can cause serious infections such as tuberculosis, strep throat, pneumonia, and food poisoning. It is important for you to understand that antibiotics are typically used to combat bacterial infections, but they are not effective against viral infections.

When it comes to viruses, you should know that these are non-living infectious agents that can only replicate inside the living cells of an organism. Common viral infections that you may encounter include the common cold, flu, HIV, and hepatitis. Unlike bacteria, viruses lack the cellular machinery necessary for independent survival, which is why antibiotics will not work against them.

It is time to compare and highlight the key structural differences between bacteria and viruses!

Let us start with bacteria! They are complete, living organisms. Pretty interesting, right? Bacteria have a complex structure that includes a cell wall, a cell membrane, and their own genetic material, usually in the form of a circular chromosome. This setup allows them to grow and reproduce all on their own, without needing a host. Want a closer look? Check out **Figure 4.6** for a diagram of a bacterial cell!

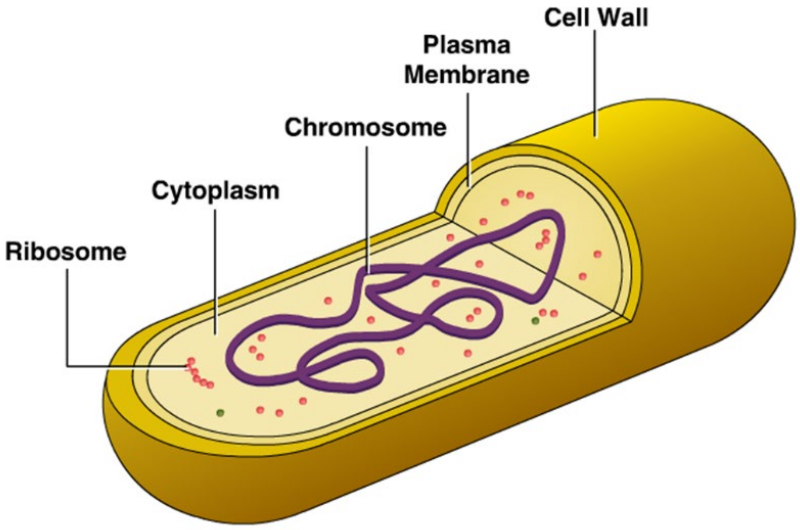



**Figure 4.6:** Schematic Diagram of a Bacterial Cell

Viruses are much smaller and simpler than bacteria and are not considered living things because they cannot survive or grow on their own. Unlike bacteria, viruses do not have cells and cannot reproduce by themselves. Instead, a virus is made up of a protein shell that protects its genetic material, which can be either DNA or RNA. To make more copies of itself, a virus must enter a living cell and take control of it. Viruses can be grouped into two types: enveloped viruses (like *lentivirus*), which have an outer layer that helps them enter cells, and non-enveloped viruses (like *adenovirus*), which do not have this layer. These differences affect how viruses spread and cause infections. See **Figure 4.7** for the structure of a virus.

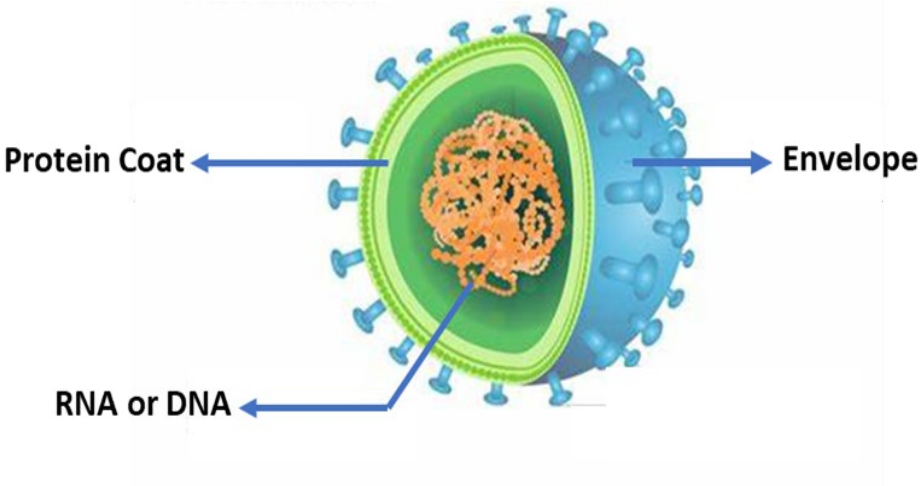



**Figure 4.7:** Structure of a virus

Biomedical Scientists study these differences to help diagnose infections, create better treatments, and find ways to prevent diseases from spreading. This knowledge helps in developing medicines and vaccines that keep people healthy.

### Activity 4.6 Exploring Bacteria vs. Viruses

**Materials needed:** Notebook or paper, pen or pencil, computer, or device with internet access (for images/videos).

**Steps**:

1. Think about what you already know about bacteria and viruses and write down a few key ideas.
2. Use online resources to explore images or videos of bacteria and viruses, and note the differences such as size, shape, and structure.
3. Create a comparison chart with two columns—one for bacteria and one for viruses—based on key features like structure, reproduction, living conditions, and examples of diseases.
4. Summarise your findings by writing or recording yourself describing the differences between bacteria and viruses.
5. Reflect on what you have learned by writing a few sentences about how bacteria and viruses affect health differently.

# BACTERIAL AND VIRAL INFECTIONS OF THE REPRODUCTIVE SYSTEM

Let us investigate the symptoms, how common, and how we treat bacterial and viral infections, especially in the reproductive system. Have you ever wondered how doctors know if it is a bacterium or a virus causing an infection?

Let us dive into the world of Sexually Transmitted Infections (STIs) and Sexually Transmitted Diseases (STDs). These terms can sound a bit complicated, but they are important to understand, especially when it comes to our health.

**STIs** refer to the presence of an infectious agent in the body, such as bacteria or viruses, that can be transmitted through sexual contact. Sometimes, you may not even notice that you have one because there might be no symptoms at first.

**STDs** occur when an STI leads to noticeable symptoms or complications. It is a step further—when the infection causes health issues.

For example, HIV is an STI while AIDS is the corresponding STD.

## Common Bacterial Infections

Now, let us look at some common bacterial infections. Are you ready? Here we go!

### Chlamydia

*Causative Agent: Chlamydia trachomatis*

*Symptoms:*

a. For women, often, there are no symptoms at first. However, if there are, you might notice abnormal vaginal discharge or a burning sensation while urinating.

b. For men, they might experience discharge from the penis or a burning feeling when they urinate.

*Complications:* if untreated, it can lead to pelvic inflammatory disease (PID) in women, which can cause infertility.

*Treatment:* antibiotics work well!

Why do you think it is important to get treated for something like Chlamydia, even if you do not have symptoms?

## Gonorrhoea

*Causative Agent: Neisseria gonorrhoeae*

*Symptoms:*

a. For women, symptoms can be mild, such as increased vaginal discharge or painful urination.

b. For men, they might feel burning when they urinate and see discharge that is white, yellow, or green.

*Complications:* if not treated; it can cause serious health problems. In women, it may lead to infections in the reproductive organs, which can cause pain and make it harder to have children. In men, it can lead to swelling and pain in the tubes that carry sperm.

*Treatment:* use of antibiotics.

Can you think of ways to spread awareness about the importance of STI testing? Jot down your ideas!

## Syphilis

*Causative agent: Treponema pallidum*

*Symptoms* are grouped into:

a. primary stage: painless sores on the genitals or mouth.

b. secondary stage: skin rashes and lesions.

c. tertiary stage: serious issues affecting the heart and brain if untreated.

*Complications:* It can lead to severe health problems.

*Treatment:* antibiotics are effective.

# Common Viral Infections

Let us move on to some viral infections now!

## Human Papillomavirus (HPV)

*Causative agent: Human papillomavirus*

*Symptoms:* you might not notice anything at first, but it can lead to genital warts and several types of cancer. An image of genital warts is shown in **Figure 4.8.**

*Prevention:* wetting the HPV vaccine is a wonderful way to protect yourself!

*Treatment:* while there is no cure for the virus itself, treatments are available for any health issues it causes.

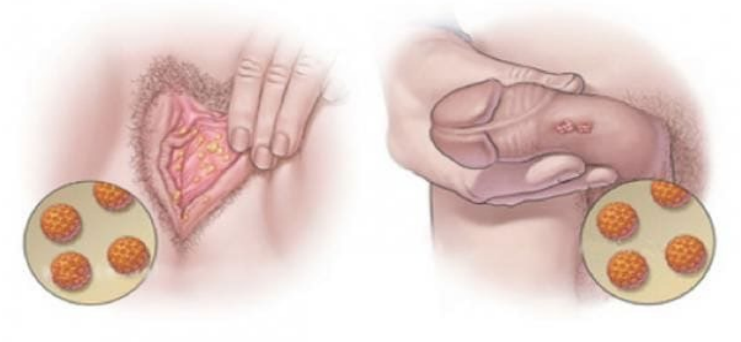


**Figure 4.8:** Genital Warts

What do you think about vaccines? Why do you think they are important in preventing diseases?

## Herpes Simplex Virus (HSV)

*Causative agent: HSV-1* and *HSV-2*

*Symptoms:* you may develop painful blisters on the genitals or mouth and feel flu-like during the first outbreak.

*Complications:* you might have recurring outbreaks, and there is a risk of passing it to newborns.

*Treatment:* antiviral medications can help manage symptoms.

Have you heard of anyone discussing herpes openly? Why do you think it is hard for people to talk about it?

## Human Immunodeficiency Virus (HIV)

*Causative Agent: Human immunodeficiency virus*

*Symptoms:* early symptoms can feel like the flu, but it can weaken your immune system over time.
*Treatment:* antiretroviral therapy (ART) helps manage the virus effectively.

## Hepatitis B and C

*Causative agents:* hepatitis B virus (HBV) and Hepatitis C virus (HCV)

*Symptoms:* many people do not notice any signs, but some may feel very tired or develop jaundice, which causes the skin and eyes to turn yellow.

*Treatment:* antiviral medications are used, and there is a vaccine for Hepatitis B.

# TREATMENT STRATEGIES FOR BACTERIAL AND VIRAL INFECTIONS

When it comes to bacterial infections, antibiotics are key. However, it is important to follow your biomedical scientists' instructions carefully to make sure the infection clears up completely. On the other hand, viral infections need different approaches—like antiviral medications or vaccines—because antibiotics do not work on viruses.

## Treatment Strategies for Bacterial Infections

1. *Antibiotics – Fighting bacteria*

    a. Antibiotics are special medicines that kill bacteria but not viruses.
    b. They work by stopping bacteria from building cell walls or making proteins.

    Example: Penicillin stops bacteria from making cell walls, so they can't survive.

2. *Combination Therapy – Teamwork Against Infection*

    Sometimes, one antibiotic isn't enough, so doctors combine two or more to fight stronger infections.

    Example: Amoxicillin is often mixed with clavulanic acid to treat infections like coughs or UTIs.

3. *Vaccination – Protection Before You Get Sick*

    Vaccines train your immune system to fight bacteria before they can make you sick.

    Example: The DTaP vaccine protects against diphtheria, tetanus, and whooping cough.

## Treatment Strategies for Viral Infections

1. *Antiviral medications:* Antiviral drugs are a bit like special keys that target specific stages of a virus's life cycle. They stop the virus from entering cells or replicating. For example, oseltamivir is an antiviral medication for flu that prevents the virus from spreading in your body.
2. *Vaccination:* Just like with bacterial infections, vaccines can help protect you from viruses too! They build up your immunity before you encounter the virus. Examples include the flu vaccine, HPV vaccine, and hepatitis B vaccine.

3. *Symptomatic treatment:* With viral infections, sometimes there is not a direct cure, so the focus is on easing the symptoms while your body fights off the virus. For example, taking acetaminophen can help reduce fever and pain, and nasal drops can make it easier to breathe when you have a cold.
4. *Combination Therapy:* Combination therapy is a key treatment for HIV (Human Immunodeficiency Virus), which attacks the immune system. If untreated, HIV can progress to AIDS (acquired immunodeficiency syndrome), the most advanced stage of the disease, where the immune system becomes too weak to fight infections. However, having HIV does not mean a person has AIDS. To prevent HIV from progressing to AIDS, doctors use antiretroviral therapy (ART). This treatment combines different medicines to slow down the virus, keeping it from multiplying and damaging the immune system. With proper treatment, people with HIV can stay healthy and live long lives without developing AIDS.

## Differences Between Bacterial and Viral Treatment

### Antibiotic Use

Antibiotics do not work against viruses like the common cold or flu. When antibiotics are misused—such as taking them unnecessarily or not completing a prescribed dose—some bacteria **change and adapt** to survive the effects of the drug. Over time, these bacteria become **resistant**, meaning the same antibiotics that once killed them no longer work. This process is a global health crisis. It makes infections harder to treat, leading to longer illnesses, more hospital stays, and even deaths. As future biomedical scientists, how do you think we can slow down this dangerous evolution of bacteria?

### Antiviral Challenges

Each antiviral is usually created to target a specific virus. For example, some antivirals help people with HIV or the flu. But we do not have antivirals for every virus out there because making them is complex.

### Vaccination

Bacterial vaccines, like the tetanus vaccine, protect against specific bacteria, while viral vaccines, such as the COVID-19 vaccine, help your immune system recognize and fight viruses before they cause illness. Have you ever received a vaccine? How do you think it protects you?

## Prevention Strategies for Bacterial and Viral Infections

***Education:*** plays a crucial role in increasing awareness about vaccination, proper antibiotic use, and infection prevention methods.

***Hygiene:*** one of the simplest yet most effective ways to prevent infections. This includes regular handwashing, safe food handling, and sanitising surfaces.

***Safe practices:*** help prevent infections at home, school, and in healthcare settings. Always use clean and sterile needles for medical purposes to stop the spread of diseases like HIV and hepatitis. At home and school, avoid sharing sharp items and properly clean and cover any cuts to prevent infection.

***Public health measures:*** such as keeping sick people away from others (quarantine), isolating infected individuals, and limiting travel, are essential during outbreaks to prevent the spread of infectious diseases..

## Activity 4.7 Understanding Bacterial and Viral Infections

**Materials needed:** Chart paper, markers, printed resources, and sticky notes.

**Steps:**

1. Create a chart that lists at least five important points about the topic using the printed resources. Think about what stands out to you!
2. Write down your thoughts about the points you listed. Why did you choose those? Feel free to share any interesting ideas that pop into your mind!
3. Reflect on any individual experiences you have related to the topic. What did you observe or learn? Sharing personal stories can make our learning more relatable!
4. Make a new chart that compares two sets of information side by side. This will help you see the similarities and differences. What surprised you the most?
5. Write down one new thing you learned today on a sticky note and stick it on your chart. It can be something you found surprising or just something you did not know before!

Want to learn how antiviral drugs work? Click on this link for a video on how antiviral medications work.

## Activity 4.8 Exploring Infections Through Creativity

**Materials needed:** Access to the internet or library for research, paper and pens, markers or coloured pencils, and a poster board or flipchart for presentation.

**Steps:**

1. Pick one viral infection (like HPV or HIV) and one bacterial infection (like Chlamydia). Let us use the internet or library to discover how each infection is treated. What are the main treatment strategies you find? Feel free to discuss your findings with a friend!

2. Jot down the key points from your research. Include the name of the infection, the treatment options, and any interesting facts that caught your attention. What surprised you the most?
3. Now, let us get creative! Use your notes to create a colourful poster or flipchart that highlights the treatment strategies for both infections. Add drawings, diagrams, or bullet points—make it fun and engaging!
4. Time to share! Present your poster to a small group of classmates. What did you learn about the treatment strategies? Do not forget to invite your classmates to ask questions or share their thoughts!
5. After everyone presents, take a moment to write down one new thing you learned from your classmates' posters. Share this cool fact with the group to wrap up the activity. What an exciting way to learn together!

### Activity 4.9 Infectious Insights!

**Materials needed:** Large sheets of paper or poster board, markers or coloured pencils, access to the internet or library for research, magazines for cut-outs (optional), glue or tape.

**Steps:**

1. Choose one bacterial disease (like Chlamydia) and one viral disease (like HPV). Use the internet or library to find out about them. What are their symptoms? How do people catch them?
2. Write down the most interesting facts you find. Share these facts with someone at home. Try to teach them something new!
3. Think of a catchy slogan for your campaign. What message do you want to share? Make it fun and exciting!
4. Grab your poster board and get creative! Use your markers and coloured pencils. Add cut-outs from magazines if you want. Make it colourful and eye-catching!
5. Show your poster to a friend or family member. Explain the diseases you chose and what you learned. Ask them to quiz you on your poster!
6. Think about what you learned. Write down one cool fact you discovered. Share it on social media or create a quiz for your classmates!

## THE BODY'S DEFENCE SYSTEM - THE IMMUNE SYSTEM

Get ready to dive into the amazing world of the immune system! You will understand how your body defends itself against harmful invaders, like bacteria and viruses. You will learn about antigens and how the immune system responds to keep you healthy.

Think of the immune system as your body's personal superhero team, always on guard to protect you from bacteria, viruses, and other invaders that can make you sick. It is made up of special cells that come together to form tissues and organs, all working as a team to keep you healthy and fight off germs.

Each part of the immune system has a role, like how some guards look out for danger while others attack invaders. The main "guard stations" are your thymus, bone marrow, lymph nodes and vessels, spleen, and even your skin. **Figure 4.9** shows an image of the immune system. Each of these organs or parts is like a base for the immune system to get its weapons and soldiers ready.

When something harmful, like bacteria, viruses, or fungi, tries to get into your body, the immune system quickly recognises it as an invader (we call these invaders pathogens). As soon as a pathogen shows up, the immune system springs into action to fight it off. It can even "remember" pathogens it has encountered before, which helps protect you in the future. This memory is also why vaccines work—they teach the immune system what certain pathogens look like, so it can recognise and defeat them faster when they appear again sometime in the future.

This teamwork makes the immune system powerful, with each part playing a specific role while working together to protect the body. Biomedical scientists study how the immune system functions to develop vaccines, medicines, and treatments that help fight diseases. Their research is essential for discovering new ways to keep us healthy and improve how we prevent and treat illnesses

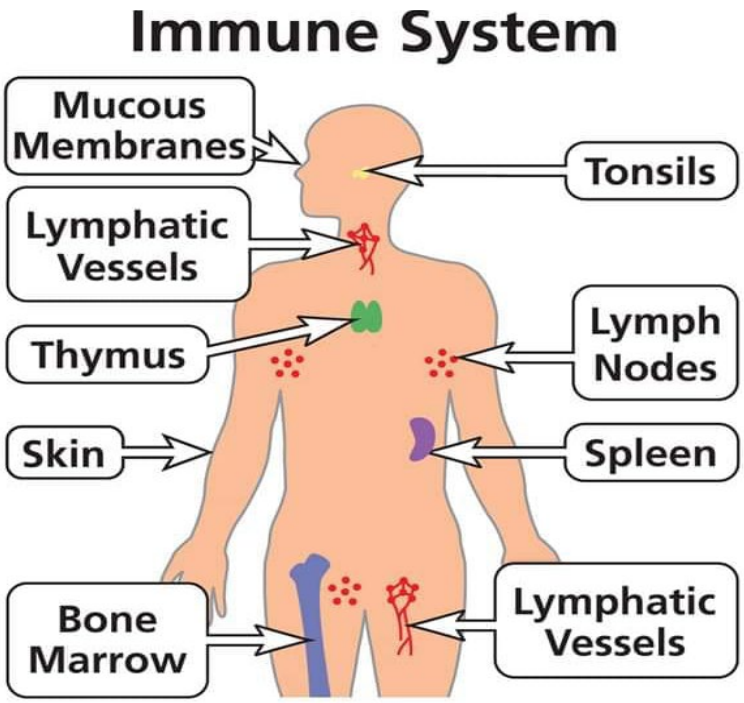



**Figure 4.9:** The Immune System

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

1. **Innate immunity:** This is your first line of defence, always ready to respond to many germs right from birth. It includes:
    a. first line of defence: physical barriers like your skin and chemical ones like stomach acid.
    b. second line of defence: this includes responses like inflammation, which helps the body react to injury or infection by increasing blood flow to the affected area. This brings immune cells that work to contain the infection, remove harmful pathogens, and begin the healing process.
2. **Adaptive immunity:** This system develops over time and learns to target specific invaders. It also has memory, so it can act quickly if the same pathogen attacks again.

## The Immune Response: How Your Body Fights Infections

The immune system protects the body by detecting and eliminating harmful bacteria, viruses, and other invaders. Here is how it works!

1. **Detection:** special white blood cells, such as macrophages, recognise and respond to harmful invaders.
2. **Defence activation:** macrophages play a key role in the immune system by engulfing (or ingesting) harmful invaders through a process called phagocytosis. They break down these invaders and display small pieces, called antigens, on their surface. This acts as a signal to other immune cells, including T cells, which help coordinate the immune response, and B cells, which produce antibodies to fight the infection.
3. **Attack and elimination:** B cells produce **antibodies**, which attach to invaders and mark them for destruction. T cells help destroy infected cells. The immune system also releases **signalling molecules** that help coordinate the response and bring more immune cells to the area.
4. **Memory and future protection:** after the infection is gone, some T cells and B cells stay in the body as **memory cells**, allowing the immune system to respond more quickly if the same invader appears again.

# ANTIGENS AND THE IMMUNE SYSTEM

Antigens are key players in how your immune system works. They help your body recognize what is harmful and trigger a response. Let us learn more about these important molecules!

## The Concept of Antigens

1. Antigens are molecules, often proteins, found on the surfaces of pathogens that signal to your immune system that something is foreign.
2. They act like name tags, helping your body decide if something is harmful or not. The name "antigen" means "antibody generator," as they prompt the production of antibodies.
3. You will find antigens on agents such as viruses and bacteria.

## Exploring How the Immune System Mounts a Response Against Antigens

When your immune system encounters an antigen, it quickly responds to protect you. Let's explore how this process works using key concepts like binding sites, ligands, and receptors.

Each antigen has a unique shape that your immune system can recognise. Immune cells have special receptors on their surface that detect antigens. When an antigen enters your body, these receptors act like security scanners, checking if it matches a known harmful substance.

If a match is found, immune cells produce antibodies, which act as ligands by binding to a specific binding site on the antigen—like a key fitting into a lock. This binding helps neutralise the threat, making it easier for immune cells, such as white blood cells, to destroy the antigen through a process called phagocytosis (see **Figure 4.10**).

After the immune system fights off an antigen, it creates memory cells to recognise and respond more quickly if the same antigen appears again. This is called immunological memory. However, some antigens can change shape through mutation, which alters their binding site. When this happens, antibodies may no longer fit properly, making it harder for the immune system to fight infections and for scientists to develop effective treatments and vaccines.

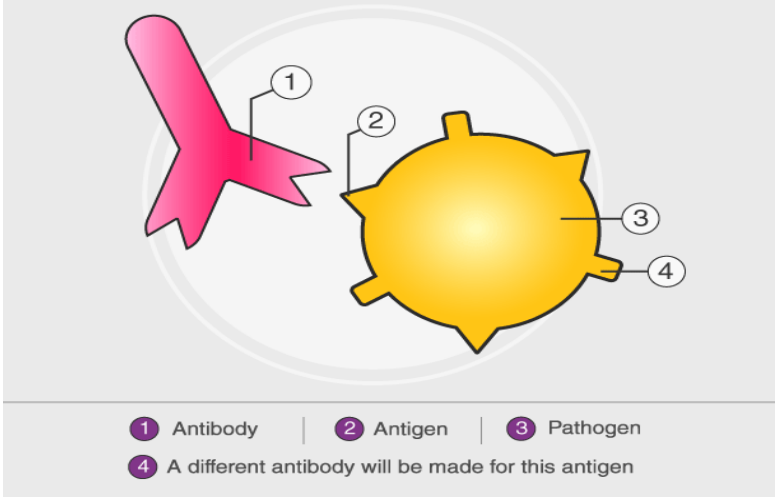



**Figure 4.10** Example of antibody-antigen structure

## Activity 4.11 Immune Response Brainstorm

**Steps**:

1. Grab a notebook and jot down your thoughts: What do you think happens when germs invade your body?
2. Imagine you are a tiny soldier in your immune system! Draft a short story or a comic strip about your adventure fighting off these invaders.
3. Share your story with a friend or family member to see if they have similar ideas!
4. Outcome: You will have a fun way to visualise the immune response and understand how your body reacts to harmful materials.

## Activity 4.12 Create Your Antigen and Antibody Models

**Steps:**

1. Gather materials like clay, cardboard, or any craft supplies you have at home.
2. Create a model of an antigen and an antibody. Make sure to include their unique shapes!
3. Label your models with terms like “binding site,” “ligand,” and “receptor.”
4. Explain to someone how the shapes of your models allow them to fit together, just like a lock and key.
5. Visually help that person to understand the relationship and specificity between antigens and antibodies!

## Activity 4.13 Immune System Role Play

**Steps**:

1. Choose a pathogen (like a virus or bacterium) and an immune cell (like a B cell or T cell).
2. Write a short script that describes the interaction between your chosen pathogen and immune cell.
3. Perform your role play for a friend or family member, explaining what happens during the immune response.

## Activity 4.14 Immune System Role-Play (Group)

**Steps**:

1. Invite your friends or family members to join this fun activity.

2. Assign roles: some will be pathogens (germs), while others will be immune cells like T cells, antibodies, and phagocytes (macrophages).
3. Use simple props like masks, cloths, or paper tags to represent different pathogens. For example, a red cloth can be a virus, and a blue one can be a bacterium.
4. Set up a "battlefield" in your living room, backyard, or classroom. The pathogens will try to invade, while the immune cells must protect the body. Antibodies can "tag" pathogens, while phagocytes (macrophages) will "engulf" and remove them.
5. Act out how the immune system recognises and fights these invaders. Make it exciting by adding sound effects or music!

## Activity 4.15 Antigen and Antibody Quiz Challenge

**Steps:**

1. Set questions from your note on antigen and antibody
2. Answer them without referring to your notes
3. Challenge a friend or family member to answer the questions.
4. For every correct answer, reward them with a fun fact about the immune system!
5. Ask them to create new questions for you to answer and keep the challenge going!

**Sample questions** (*One-word answer questions*)

a. What type of molecule helps the immune system recognise antigens?

b. Which immune cell engulfs and digests pathogens?

c. What is the term for a weakened or inactive form of a pathogen used to build immunity?

## Activity 4.16 Immune System Art Project

**Steps:**

1. Create a poster or drawing that illustrates the immune system's response to pathogens.
2. Include key components like antigens, antibodies, B cells, and T cells.
3. Use colours and labels to make it visually appealing and informative.
4. Share your artwork with your class or hang it up at home to show your understanding!

## Activity 4.17 Antigen-Antibody Matching Game

**Steps:**

1. Make a set of cards with pictures or descriptions of different antigens and antibodies. Use bright colours and fun shapes to make them visually appealing.
2. Each antigen card should have a unique shape and colour, representing its binding site, while each antibody card should match with a specific antigen.
3. Shuffle the cards and spread them out face down on a table.
4. Flip over two cards at a time, trying to find matching pairs of antigens and antibodies.
5. When you find a match, take a moment to write down why that antibody specifically binds to that antigen in your notebook.
6. After matching all the pairs, choose your favourite match and write a short paragraph explaining the significance of that antigen-antibody interaction.

## Activity 4.18 Immune Response Role-Playing Simulation

**Steps:**

1. Choose a role related to the immune response: you could be an antigen, an antibody, a pathogen, or a type of immune cell (like a T cell or B cell).
2. Create a simple costume or prop to represent your character. For example, use a hat or a sign with your character's name.
3. Write a short scenario where a pathogen enters the body. For example, "A virus invades and tries to take over the cells!"
4. Outline the steps of the immune response: how the antigen is recognised, how antibodies are produced, and how they neutralise the pathogen.
5. Perform the scenario in front of a mirror or record yourself acting it out. Describe the interactions between your character (e.g., how the antibody recognises the antigen) and how the immune response unfolds.

## Self-reflection

1. What did I learn about how antigens and antibodies specifically match, and why is thisimportant for understanding how the immune system works?
2. How did making and matching the cards help me see the connection between antigens and antibodies?
3. How can I use what I learned about the immune system in my daily life or when talking about health and disease prevention?

# HOW ANTIBIOTICS WORK IN FIGHTING BACTERIAL INFECTIONS

Antibiotics are powerful tools in modern medicine, helping to fight bacterial infections effectively. However, their success depends on understanding how they work and the characteristics of the bacteria they target. In this section, get ready to explore how antibiotics function, the challenges posed by antibiotic resistance, and the factors that influence their effectiveness against various bacterial infections. Let us dive deeper!

Antibiotics are medicines designed to treat bacterial infections by targeting specific functions or structures within bacteria, either killing them or stopping their growth. However, they do not work against viruses. Understanding how antibiotics work helps us see their importance in treating infections while also recognising the need to use them responsibly to prevent antibiotic resistance. They work by targeting specific parts of bacterial cells without harming human cells. See **Table 4.1** Here is how they do it:

**Table 4.1: Mechanism of how Antibiotics work**

| Mechanism | Description | Example |
|---|---|---|
| **Inhibition of cell wall synthesis** | Antibiotics stop bacteria from making their cell walls, leading to cell death. | Penicillin (e.g., Amoxicillin) |
| **Disruption of cell membrane function** | Some antibiotics break down the bacterial cell membrane, causing the cell contents to leak out. | Less selective, can harm human cells |
| **Inhibition of protein synthesis** | Target bacterial ribosomes (different from human ribosomes) to stop protein production. | Tetracyclines |
| **Inhibition of metabolic pathways** | Interfere with bacterial processes like folic acid synthesis, vital for DNA and RNA production. | Sulphonamides |

## Effectiveness of Antibiotics

The effectiveness of antibiotics depends on the:

a. type of bacteria: different bacteria may have different structures.

b. mode of action: how the antibiotic works.

c. resistance mechanisms: some bacteria can resist antibiotics.

d. site of infection: where the bacteria are in the body.

e. patient factors: individual health can affect treatment success.

# ANTIBIOTIC RESISTANCE

Antibiotic resistance is a growing concern in healthcare. It occurs when bacteria evolve to resist the effects of antibiotics, making infections harder to treat. Here, you will cover the strategies used by bacteria to resist antibiotics causes and consequences of antibiotic resistance, highlighting the importance of using antibiotics wisely to maintain their effectiveness.

Bacteria can use several strategies to resist antibiotics including:

1. Enzyme production – Some bacteria produce enzymes which break down antibiotics before they can work.
2. Efflux pumps – Certain bacteria have special pumps that actively push antibiotics out of their cells, preventing them from taking effect.
3. Target modification – Bacteria can change the structure of their proteins or cell walls so that antibiotics no longer bind to them properly.
4. Biofilm formation – Some bacteria form protective layers (biofilms) that shield them from antibiotics and the immune system.
5. Genetic adaptation – Bacteria can mutate or share resistance genes with each other, making them stronger against antibiotics.

## Causes of Antibiotic Resistance

There are several complex factors that contribute to antibiotic resistance. See **Table 4.2**.

**Table 4.2: Causes of Antibiotic Resistance**

| Cause | Description |
|---|---|
| Overuse of antibiotics | Using antibiotics unnecessarily or taking them too often. |
| Misuse of antibiotics | Taking antibiotics for viral infections or not finishing a prescribed course. |
| Poor infection control | Lack of hygiene in healthcare settings spreads resistant bacteria. |
| Lack of new antibiotics | Not many new antibiotics are being made, so it is difficult to treat bacteria that no longer respond to old antibiotic |

## Consequences of Antibiotic Resistance

1. Treatment challenges: resistant infections require more expensive and sometimes less effective treatments.
2. Increased mortality: higher death rates can result from antibiotic-resistant infections.
3. Economic impact: longer hospital stays and more intensive care increase healthcare costs.

# Controlled Use of Antibiotics

The controlled use of antibiotics is crucial in slowing the spread of antibiotic resistance. Misuse, such as taking antibiotics for viral infections or not completing the prescribed course, allows resistant bacteria to survive and multiply. To prevent this, antibiotics should only be used when necessary and strictly as prescribed by healthcare professionals. Ongoing research focuses on developing new antibiotics to combat resistant infections. Proper antibiotic use helps preserve their effectiveness for treating bacterial diseases in the future.

Bravo for exploring this far! Now, perform the activities below to foster your understanding of antibiotics while having fun. Let us get started!

## Activity 4.19 Video Analysis on how Antibiotics work

**Steps:**

1. Search for a lively video online that explains how antibiotics function. Look for animations or real-life examples.
2. While watching, take notes on key points about:
    a. what antibiotics are.
    b. how they treat bacterial infections.
    c. the importance of finishing the full course of antibiotics.
3. After watching, share your notes with a friend or family member. Discuss what surprised you and what you learned!
4. Make a colourful poster summarizing your learnings. Include drawings or images to illustrate antibiotics and their actions.

## Activity 4.20 Antibiotic Research Project

**Steps:**

1. Pick an antibiotic that interests you (like penicillin or amoxicillin).
2. Use books or online resources to find information on:
    a. How it works.
    b. Its uses.
    c. Any known resistance issues.
3. Prepare a short report or presentation with your findings. Use visuals to make it engage!
4. Share your findings: Present your research to a family member or in class. Explain why your antibiotic is important!

## Activity 4.21 Antibiotic Action Role-Play

**Steps:**

1. Gather Materials: Find some props like hats or signs to represent distinct roles (bacteria, antibiotics, etc.).
2. Assign Roles: Invite friends or family to join you. Assign roles for bacteria, antibiotics, and the immune system.
3. Act out a scenario where an antibiotic attacks some bacteria. Show how antibiotics inhibit cell wall synthesis or disrupt protein production.
4. After the role-play, share what happened. How did the antibiotics affect the bacteria? What strategies did the bacteria use to resist?

## Activity 4.22 Antibiotic Resistance Debate

**Steps:**

1. Research the Topic: Learn about antibiotic resistance, its causes, and its consequences using online resources or books.
2. Prepare Arguments: Think about the reasons why antibiotic resistance is a problem. Prepare arguments for both sides: those who believe antibiotic use should be strictly controlled and those who think it should remain accessible.
3. Invite friends or family to participate in a fun debate.
4. Take turns presenting your arguments and counterarguments.
5. After the debate, share what you learned. How does antibiotic resistance affect healthcare? What can individuals do to help?

## Self-reflection

1. What new insights did I gain about how antibiotics work and why it is important to complete the full course of treatment?
2. How can I apply what I learned about antibiotics to make informed choices regarding my health and the use of medications in the future?

# GLOBAL AND SOCIAL IMPACT AND CONTROL OF SOME COMMON INFECTIOUS DISEASES

Infectious diseases caused by bacteria and viruses significantly affect individuals and communities worldwide. They can lead to serious health issues, economic challenges, and social changes. Understanding these impacts is crucial for promoting better health and well-being in society.

# Global Prevalence and Social Impact and Control of Common Infectious Diseases

Infectious diseases like tuberculosis (TB) and COVID-19 have wide-ranging effects on global health and society. These diseases not only impact health but also strain economies and affect daily life. Let us explore the details of these diseases and their consequences. See **Table 4.3** for more information about TB and COVID-19

**Table 4.3:** Covid-19 and TB

| Disease | Causative Agent | Mode of Transmission | Signs and Symptoms | Global Prevalence | Disease Control |
|---|---|---|---|---|---|
| **Tuberculosis (TB)** | *Mycobacterium tuberculosis* | Airborne droplets from coughing, sneezing, or spitting | Prolonged cough (sometimes with blood), chest pain, weakness, weight loss, fever, night sweats | 10.6 million cases reported in 2022 worldwide | Treatable with antibiotics; BCG vaccine for infants |
| **COVID-19** | SARS-CoV-2 | Close contact, respiratory droplets, contaminated surfaces | Common symptoms:<br>Fever, chills, sore throat, runny nose, fatigue<br>Less common symptoms:<br>muscle aches and heavy arms or legs, severe fatigue or tiredness, headache, sore eyes,<br>dizziness, shortness of breath and tightness in the chest | The virus spread rapidly across the globe, resulting in a pandemic that has affected every country. Over 750 million cases reported as of July 2023 (WHO) | Vaccination, testing, and public health measures |

**Note:** Explore online for current statistics and information regarding global prevalence and disease control of TB and COVID-19.

# Global and Social Impact of Infectious Diseases

Infectious diseases caused by bacteria, like tuberculosis (TB), and viruses, like COVID-19, can deeply affect individuals and communities. They can lead to poverty, strain healthcare systems, and disrupt economies. Understanding these impacts is essential for improving public health and community well-being.

1. **Global Impact**

    a. *Public health crises:* infectious diseases can cause widespread outbreaks and pandemics, putting immense pressure on healthcare systems. For example, the COVID-19 pandemic and historical events like the Black Death have led to significant loss of life and overwhelmed medical resources.

    b. *Economic consequences:* infectious diseases can create serious economic challenges. They result in high healthcare costs and loss of productivity due to illness. For instance, the COVID-19 pandemic caused job losses and economic downturns, while managing diseases like HIV/AIDS and TB can be both expensive and time-consuming.

    c. *Global trade and travel:* outbreaks disrupt international trade and travel. Countries may enforce travel bans and quarantine measures, which can affect global supply chains and economies.

    d. *Research and development:* the fight against infectious diseases drives innovation in medicine. This includes developing vaccines and treatments, which require significant funding and investment.

    e. *International collaboration:* pandemics highlight the need for countries to work together. Organisations like the World Health Organization (WHO) help coordinate efforts to manage outbreaks and share vital information.

2. **Social Impact**

    a. *Stigmatisation and isolation:* people affected by infectious diseases often face stigma and discrimination, which can lead to social isolation. This can make it harder for public health efforts to be effective.

    b. *Impact on daily life:* infectious diseases can disrupt everyday activities, such as school and work. For example, schools may close, and students with TB or HIV/AIDS might miss classes, affecting their education and future opportunities.

    c. *Psychological effects:* the stresses from outbreaks can lead to mental health issues like anxiety and depression. Individuals dealing with chronic diseases like TB may experience fear and low self-esteem due to physical changes.

    d. *Pressure on healthcare facilities:* managing infectious diseases increases the burden on healthcare systems, making it hard to provide care for everyone. Vulnerable groups often face higher infection rates and worse health outcomes because of limited access to healthcare.

    e. *Community resilience and solidarity:* on a positive note, outbreaks can bring communities together. People often unite to support those affected and promote public health measures, leading to lasting changes in hygiene practices and healthcare policies.

All too soon another section has ended. Well done young explorer! Challenge yourself with the activities and review questions. Feel free to consult your notes and online for help! Go wrap up!

## Activity 4.23 Research and Infographic Creation

**Steps:**

1. Choose a Disease: Select a bacterial or viral disease to research (e.g., tuberculosis, influenza, COVID-19, HIV/AIDS).
2. Conduct Research: Use resources like books, the internet, and articles to gather information on:
    a. Symptoms
    b. Transmission
    c. Prevention
    d. Global and Social Impact
3. Design a simple infographic summarising your findings using visuals and bullet points for clarity.
4. Share your findings with someone like friends, family members or your community.

## Activity 4.24 Personal Reflection Essay

**Steps:**

1. Choose one infectious disease that interests you.
2. Draft a 1-2 page essay discussing the social impacts of this disease. Consider aspects like stigma, economic effects, and community responses.
3. Include personal insights: Reflect on how this disease might affect individuals and communities and share any personal thoughts or feelings you have about it.

## Activity 4.25 News Article Analysis

**Steps:**

1. Find an article: Search for an up-to-date news article about an infectious disease (e.g., COVID-19 updates, outbreaks of TB).
2. Analyse the content: Take notes on the following:
    a. The main points and findings of the article
    b. How the article discusses the global and social impact of the disease
    c. Any solutions or recommendations provided
3. Write a summary of your analysis in a short paragraph, highlighting key insights from the article.

## Activity 4.26 Community Awareness Campaign

**Steps:**

1. Choose an infectious disease to focus on (e.g., tuberculosis, COVID-19).
2. Design a Campaign: Create materials for a community awareness campaign. This could include:
   a. Posters with key facts and prevention tips
   b. Social media posts to raise awareness
   c. A short presentation to share with friends or family
3. Present your campaign: Share your campaign materials with classmates or family members, explaining the importance of awareness and prevention.
4. Take up the challenge to educate the community at large and share your experience of the outcome with friends or family.

# EXTENDED READING

- Autism video: https://youtu.be/hBj_6KFcjqg?si=WSYtfNp17JpGQ6T0
- Chronic pain: https://youtu.be/e3h6xqCtiuA?si=fRxNnb674o6mPow0
- Parkinson's video: https://youtu.be/cs-kiu5bRY8?si=Lw6troMGroeApX3K

# REVIEW QUESTIONS 4.1

## Carefully read and answer the questions that follow

### 1. Case Scenario: Living with a Nervous System Disorder

Adjoa is a 55-year-old woman who has been diagnosed with Parkinson's disease. Over time, she has experienced tremors, difficulty walking, and muscle stiffness. In addition to these physical challenges, she sometimes feels anxious and frustrated because her condition affects her ability to perform daily tasks independently. Her family and doctor are working together to find ways to support her physically and emotionally.

*Questions:*

a. How does Parkinson's disease affect both Adjoa's body and emotions?

b. What role does the nervous system play in controlling movement, and how does Parkinson's disease interfere with this process?

c. How might Adjoa's emotional well-being impact her overall health and quality of life?

**2.** Look at the data below: It shows how movement ability decreases in Parkinson's patients over 10 years. At what year does movement ability fall below 50% of normal?

Data: Movement Ability in Parkinson's Disease Over Time

*(Hypothetical data: Movement ability decreases over time for a patient with Parkinson's disease.)*

| Years After Diagnosis | Movement Ability (% of Normal) |
|---|---|
| 0 | 100% |
| 2 | 85% |
| 4 | 70% |
| 6 | 50% |
| 8 | 30% |
| 10 | 15% |

### 3. Case Scenario: Understanding an Endocrine Disorder

Ama, a 17-year-old student, has been feeling unusually restless and tired. She notices that her heart beats very fast, she sweats a lot even when it's not hot, and she has been losing weight despite eating normally. She also feels anxious and sometimes shaky. Worried about her symptoms, she visits a doctor, who suspects a problem with her thyroid gland.

*Questions:*

a. List two other symptoms that a person with Ama's condition might experience.

b. Based on her symptoms, identify the endocrine disorder the doctor suspects.

c. Explain how the thyroid gland's function relates to Ama's symptoms.

d. Suggest a possible treatment and explain how it would help manage her symptoms.

**4.** Look at the table below: It shows how thyroid hormone (T3 and T4) levels change over time in patients with hyperthyroidism compared to normal levels.

**Table:** Thyroid Hormone Levels Over Time

| Month | Normal T3 (pg/mL) | Hyperthyroid T3 (pg/mL) | Normal T4 (ng/dL) | Hyperthyroid T4 (ng/dL) |
|---|---|---|---|---|
| 1 | 1.2 | 2.5 | 8.0 | 15.5 |
| 2 | 1.3 | 2.8 | 8.2 | 16.0 |
| 3 | 1.2 | 3.1 | 8.1 | 16.8 |
| 4 | 1.3 | 3.5 | 8.0 | 17.2 |
| 5 | 1.2 | 3.8 | 8.1 | 17.5 |
| 6 | 1.3 | 4.0 | 8.2 | 18.0 |

*(Hypothetical data: T3 and T4 levels in normal and hyperthyroid patients over six months.)*

*Question:*

a. How much higher is the T3 level in a person with hyperthyroidism at month 6 compared to the normal level?

b. If a doctor wants to lower the T4 level of a hyperthyroid patient back to 8.2 ng/dL, by how much does it need to decrease from month 6? Show your calculations.

## 5. Case Scenario: Ama's Diabetes Journey

Ama is a 45-year-old woman who has recently been diagnosed with Type 2 diabetes. She has a family history of diabetes, and her doctor explains that both genetics and lifestyle factors contributed to her condition. Ama often feels tired, experiences frequent thirst, and has trouble maintaining a healthy weight. Her doctor advises her to adopt a balanced diet, exercise regularly, and monitor her blood sugar levels. However, Ama finds it difficult to change her habits and is unsure how to manage her condition effectively.

*Questions:*

a. What are some common symptoms and risk factors that may have contributed to Ama's diagnosis of Type 2 diabetes?

b. How might Ama's genetics and lifestyle choices have influenced her development of Type 2 diabetes?

c. Propose a community awareness campaign to help individuals like Ama manage and prevent Type 2 diabetes.

## 6. Case Scenario: Adjoa's Science Project on Bacteria and Viruses

Adjoa is a junior high school student who loves science. She recently learned that bacteria and viruses are different types of microorganisms, but she is still trying to understand how they are different. Her teacher asked her to research their structures and how they affect humans. While reading, Adjoa found out that bacteria are living organisms, while viruses need a host to survive. She wants to create a simple project to explain these differences to her classmates.

*Questions:*

a. Name one structural feature that bacteria have but viruses do not.

b. Name one structural feature that viruses have but bacteria do not.

c. How does each feature help bacteria or viruses survive?

d. If Adjoa wanted to explain to her classmates how bacterial and viral infections are treated differently, what key points should she include?

**7.** The graph below shows the growth of a bacterial infection over time compared to a viral infection.

Graph: Growth of Bacterial vs. Viral Infections Over Time

*(Hypothetical data: Number of pathogens detected in the body over 10 days.)*

| Day | Bacteria Count ($\times 10^3$ cells) | Virus Count ($\times 10^3$ particles) |
|---|---|---|
| 1 | 2 | 10 |
| 3 | 8 | 25 |
| 5 | 20 | 40 |
| 7 | 50 | 60 |
| 10 | 100 | 75 |

*Questions:*

a. Which type of infection (bacterial or viral) grows faster in the first five days? Show your calculations.

b. By what percentage does the bacterial count increase from day 1 to day 10?

c. If an antibiotic reduces bacterial growth by 50% by day 10, what would be the new bacterial count?

### 8. Case Scenario: Akosua's Health Lesson

Akosua, a 15-year-old student, recently attended a health education class where she learned about infections that can affect the reproductive system. She heard terms like sexually transmitted infections (STIs) and sexually transmitted diseases (STDs) but was unsure about the difference between them. Her teacher explained that some infections are caused by bacteria and others by viruses. Akosua wants to understand more so she can take care of her health and educate her friends.

*Questions:*

a. Name two bacterial infections and two viral infections that can affect the reproductive system.

b. What is the difference between a sexually transmitted infection (STI) and a sexually transmitted disease (STD)?

c. Suggest ways that Akosua and her friends can stay informed and protect their reproductive health.

**9.** The table below shows the number of reported cases of chlamydia (bacterial infection) and herpes (viral infection) in a given community over five years.

Reported Cases of Chlamydia and Herpes (per 1,000 people)

| Year | Chlamydia Cases | Herpes Cases |
|---|---|---|
| 2019 | 150 | 100 |
| 2020 | 180 | 120 |
| 2021 | 200 | 140 |
| 2022 | 230 | 160 |
| 2023 | 250 | 180 |

*Questions:*

a. Calculate the percentage increase in reported cases of each infection from 2019 to 2023.

b. Explain why chlamydia cases are rising faster than herpes cases and discuss the impact on reproductive health.

### 10. Case Scenario: Kwame's Immune System Discovery

Kwame is a junior high school student who recently caught the flu. His doctor told him that his body is fighting the infection by making special proteins called antibodies. These antibodies help recognize and attack harmful substances called antigens. Kwame is curious about how his body knows which germs to fight and how it protects him from getting sick again.

*Questions:*

a. What are antigens and antibodies?

b. How do antibodies help the body fight infections?

c. Explain how vaccines help the body fight diseases.

**11.** The data below shows how antibody levels change over time after exposure to a virus.

Antibody Production Over Time (in arbitrary units)

| Days After Infection | First Exposure Antibody Levels | Second Exposure Antibody Levels |
|---|---|---|
| 0 | 0 | 0 |
| 5 | 10 | 20 |
| 10 | 40 | 80 |
| 15 | 70 | 120 |
| 20 | 90 | 140 |
| 25 | 100 | 150 |
| 30 | 95 | 145 |
| 35 | 80 | 130 |
| 40 | 60 | 110 |

*Questions:*

a. Calculate the time it takes for the immune system to reach peak antibody production and compare responses between first and second exposures.

b. Calculate the percentage increase in peak antibody levels between first and second exposure.

c. Explain why the second exposure results in a stronger and faster immune response.

## 12. Case Scenario: Antibiotic Resistance in a Clinical Setting

Ama is a biomedical scientist working in a hospital laboratory. A patient with a severe bacterial infection is not responding to the prescribed antibiotics. Ama conducts tests to determine which antibiotics are effective against the bacteria. The lab results indicate that the bacteria are resistant to multiple antibiotics, making treatment more challenging.

*Questions:*

a. What are antibiotics, and what type of microorganisms do they target?

b. Explain the mechanisms by which antibiotics work to eliminate bacterial infections.

c. Why might the patient's infection persist despite trying different antibiotics?

## 13. Case Scenario: Aisha's Community Challenge

Aisha lives in a small town where some people have been diagnosed with diseases like tuberculosis (TB) and COVID-19. She notices that many people avoid those who are sick, and some patients feel ashamed or isolated. Aisha wants to understand why these diseases cause fear and how her community can support affected individuals.

*Questions:*

a. Name two bacterial diseases and two viral diseases that affect global health.

b. Why might people with diseases like COVID-19 and tuberculosis face social stigma?

c. How can communities help reduce fear and misinformation about these diseases?

d. Propose two strategies to support individuals living with these diseases and help them feel accepted in society.

**14.** The data below shows the proportion of bacterial and viral diseases.

Reported Cases of Infectious Diseases in a Community (Last Year)

| Disease | Type | Reported Cases |
|---|---|---|
| Tuberculosis | Bacterial | 5,200 |
| Pneumonia | Bacterial | 3,800 |
| COVID-19 | Viral | 12,500 |
| Influenza | Viral | 8,600 |
| HIV/AIDS | Viral | 4,700 |
| Typhoid Fever | Bacterial | 2,400 |

*Questions:*

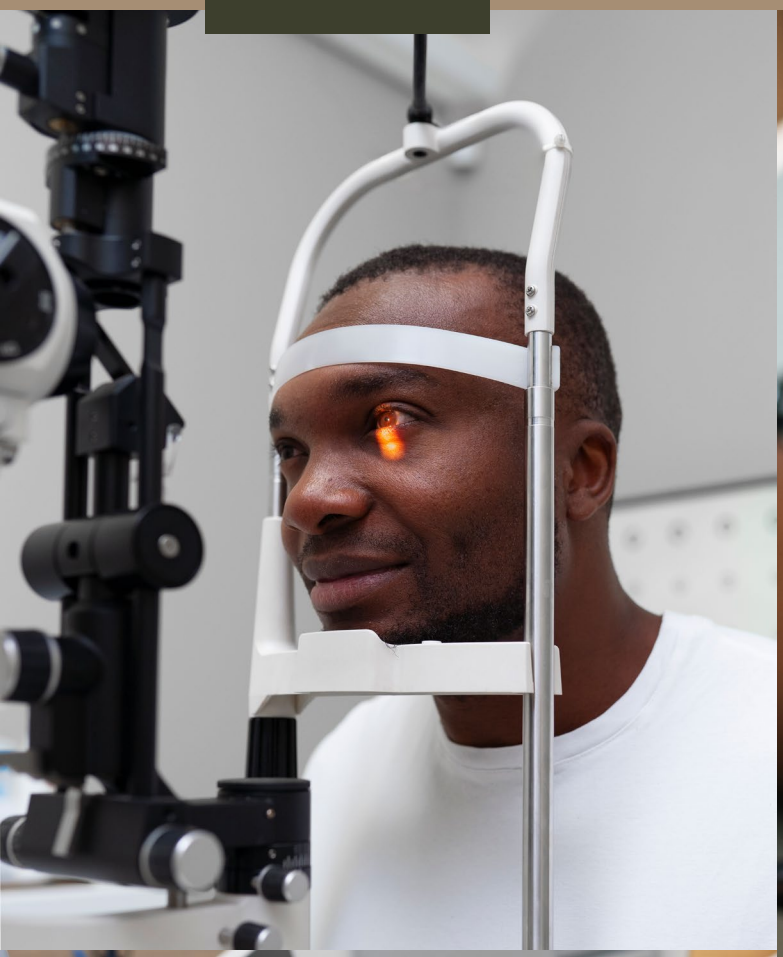
a. Calculate the percentage of bacterial vs. viral infections and determine which type contributes more to disease burden.

b. Calculate the percentage of total infections caused by bacterial and viral diseases.

c. Compare the disease burden and suggest why some diseases might have higher reported cases than others.

SECTION 5

# DIAGNOSTIC AND THERAPEUTIC DEVICES



# BIOMEDICAL INTERVENTION

## Diagnostic and Therapeutic Devices

## INTRODUCTION

Welcome to another section! Prepare to embark on an exciting journey into the world of diagnostic and therapeutic devices within biomedical intervention. Have you ever considered how groundbreaking technology transforms clinical diagnosis and enhances healthcare delivery? Over here, you will learn the vital role of diagnostic devices, exploring their innovative designs and essential components that make them significant changes in medicine.

You will also discover how therapeutic devices, like prostheses and orthoses, can transform the lives of individuals with disabilities. The latest treatments for cancer and the strategies used to manage its physical and emotional effects will be investigated.

As you dive into this engaging material, think about the profound impact these advancements have on patient care and the exciting possibilities they create in regenerative medicine. Get ready to ask questions, share your insights, and connect these concepts to the real world—your journey into the future of healthcare starts now!

### Key Ideas

- Cancer treatment approaches involve therapies like chemotherapy and radiation, focusing on a team-based care model that addresses physical and emotional needs.
- Device design principles focus on making devices correct and easy to use, ensuring devices meet safety standards
- Key components of diagnostic devices, such as sensors, processors and displays, work together to collect and analyse health data in tools like glucose checks and electrocardiogram (ECG) machines.
- Regenerative medicine can transform treatment for patients with disabilities by using stem cell therapy and tissue engineering to repair damaged tissues and organs.
- Technology improves healthcare by enabling ongoing patient monitoring with wearable devices, making communication easier with electronic health records, and providing care through telemedicine.
- Therapeutic strategies for disabilities include prostheses like limb replacements and orthoses such as braces that are personalised to improve movement and independence.

# THE ROLE OF TECHNOLOGY IN HEALTHCARE DELIVERY

The use of technology in healthcare has changed how medical services are provided, making them more correct, efficient, and accessible. For example,

1. advanced diagnostic tools, such as imaging systems, genetic testing, and wearable health devices, enable early detection and precise diagnoses.
2. innovative treatments, including robotic surgery, and targeted drug delivery systems, provide personalised and effective care.
3. continuous patient monitoring through tools like remote monitoring devices, and mobile health apps, ensures proactive management of health conditions.

Let us examine how technology improves speed, accuracy and access in medical services!

## Exploring How Technology is Used in Healthcare Delivery

Just as technology improves our daily lives, it brings similar innovations to healthcare. It has transformed healthcare, leading to better patient care and outcomes. This investigation explores how technology is applied in three key areas of healthcare: diagnostics, treatments, and monitoring. It will also cover drug delivery and development!

### Diagnostics

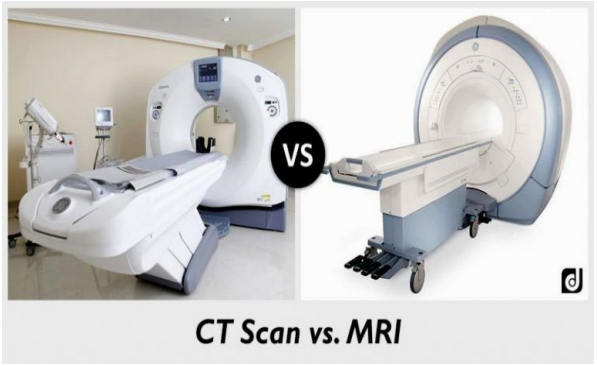
The term diagnostic refers to anything related to assessing a disease or condition. Technology has advanced or improved diagnostic tools. Improvements in diagnostic tools have made it easier to detect health conditions. Diagnostic tools are put into three categories:

a. ***Imaging tools:*** have you ever had an X-ray or MRI scan? These tools create images of the inside of the body for medical analysis and treatment. Technology has enhanced imaging tools by providing clearer and more correct medical images for better diagnosis. Some common imaging tools (see **Figure 5.1**) are:

   - X-ray machines are used to examine bones and detect fractures.
   - Computed Tomography (CT) scans: provide detailed cross-sectional images of the body for diagnosing various conditions.
   - Ultrasound machine: commonly used for prenatal scanning and assessing soft tissues like the heart and liver.
   - Magnetic Resonance Imaging (MRI) machine: used to produce detailed images of soft tissues, organs, and structures within the body.
   - Mammography machines: specifically for breast cancer screening.

**X-ray machine**

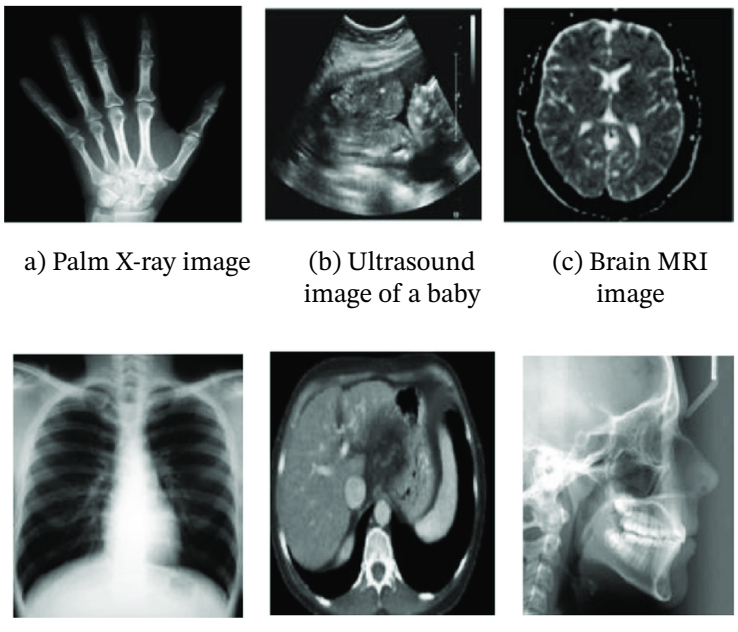
**Ultrasound** machine




**CT Scan and MRI**

**Mammogram machine**

**A**



a) Palm X-ray image (b) Ultrasound image of a baby (c) Brain MRI image

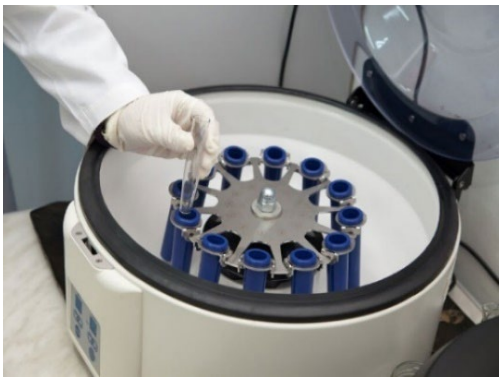
(d) Chest X-ray image (e) Brain CT scan image (f) Dental X-ray image and mammogram

**B**

**Figure 5.1:** Some Imaging tools (A) and scan results (B)

b. ***Laboratory analysis tools:*** Laboratory analysis tools are instruments and methods used to examine samples like blood, urine, or tissue in a lab to diagnose diseases, check health, and conduct research. Technology has made laboratory tools more effective. Some examples of tools (see **Figure 5.2**) used for laboratory analysis include:

- clinical centrifuges: separate blood components for analysis.
- clinical laboratory incubators: keep best or favourable conditions for growing microbial cultures.
- cell counters: count and analyse cells in blood samples.
- chromatography machines: used for separating and analysing compounds in various samples.
- haemoglobin analysers: measure haemoglobin (blood protein) levels to diagnose anaemia.



**Clinical centrifuge**

**Clinical laboratory incubator**


**Cell counters**

**Chromatography machine**

**Haemoglobin analyser**

**Figure 5.2:** Laboratory Analysis Tools

c. ***Point-of-Care Technology (POCT):*** devices are tools used to provide diagnostic results and support clinical decisions rapidly or quickly.

**Did you know?**

*POCT devices are small and portable! For example, urinalysis strips provide quick assessments right at your doctor's office.*

These devices can be categorised into:

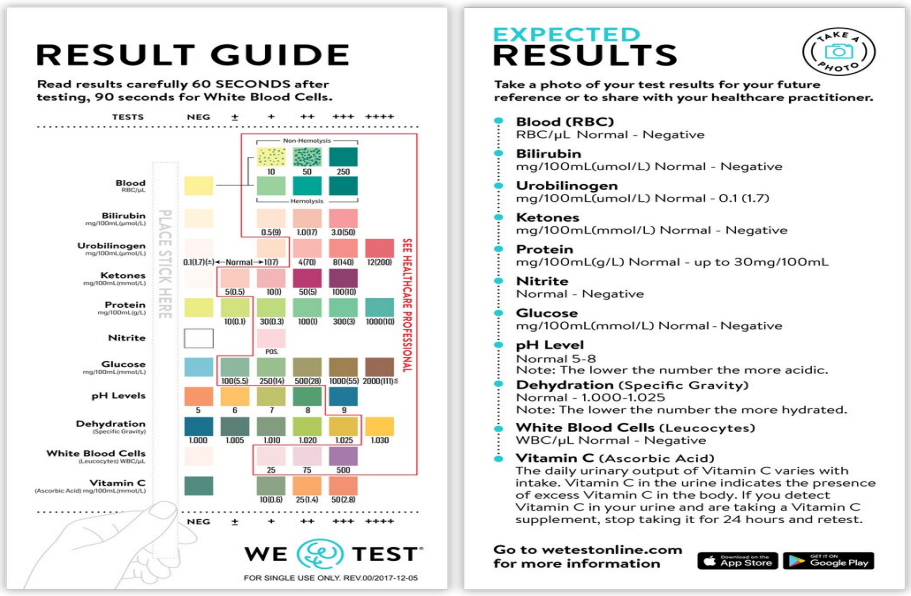
- Paper-based diagnosis: involves simple tests that use paper to check for diseases or health conditions. Examples are urinalysis strips, liver function check strips, initial pregnancy testing kits and home glucose testing devices —see **Figure 5.3**
- Fully integrated devices: advanced medical devices that combine several functions into one unit for easy diagnosis. Examples include smart glucose monitors that track blood sugar levels in real-time and send data to smartphones or healthcare providers, biochips like surface acoustic wave (SAW) biochips which can detect HIV in blood samples (see **Figure 5.3**).
- Wearable devices: This category features items like diabetes patches and wristband sensors that check substances like glucose and lactate in real time (see **Figure 5.7 B**).

Most wearables and fully integrated devices work by turning biological signals into electrical signals. They use biological components alongside sensors to detect chemicals or biological substances in the body.

**Dipstick in urine**

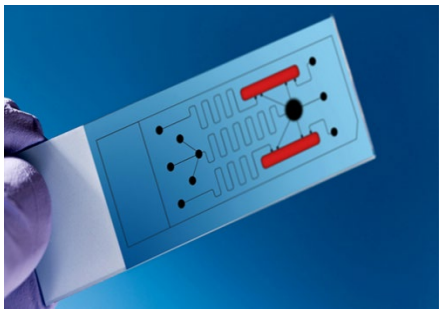
**Allow it to rest**

**Compare dipstick to chart**




**Typical chart: various substances tested and their normal range**

You can test your urine: to do a urine test with a dipstick, first dip the stick into the urine sample and then take it out after a few seconds, tapping it to shake off any extra liquid. Wait a few minutes for the colours to change, then compare the colours on the dipstick to the chart that came with it to see the results. Write down your findings and throw away the dipstick using local rules. See a Biomedical scientist if within the red line



**Biochip for blood sample**


**Liver function test strip**


**Glucose level check**

**Pregnancy test kits**

**Figure 5.3:** POCT devices

## Treatment

Treatment technologies are changing how diseases are managed. Have you heard of surgical robots? These devices allow surgeons to perform precise operations with enhanced views of the surgical area.

Let us investigate some treatment technologies!

a. Surgical robots: are machines with robotic arms that hold small instruments and high-definition cameras.

- These cameras offer magnified 3D views of the surgery area. Surgeons control the robots from a console.
- They are used in brain and heart surgeries.


**Figure 5.4:** Robotic surgery

b. Radiation therapy machines: target and kill unhealthy cells using high-energy radiation.

**Did you know?**

*These machines are also known as radiotherapy machines! They are used to treat cancer by shrinking tumours, killing cancer cells, or slowing down their growth.*

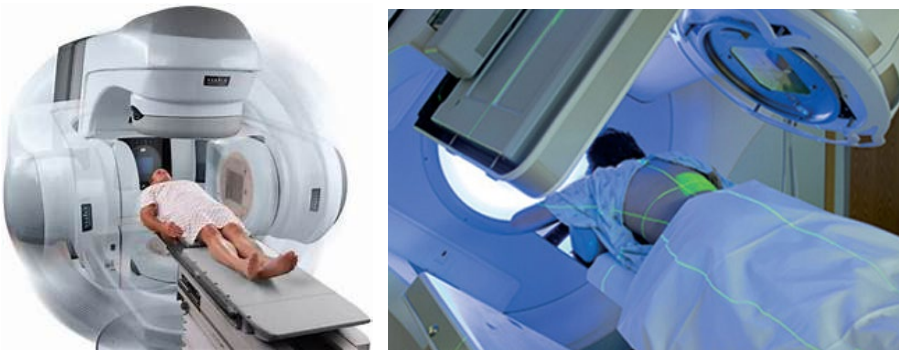


**Figure 5.5:** Patient undergoing radiotherapy treatment

c. Dialysis machines: help people with kidney failure by filtering their blood. They use a part called a dialyser, or artificial kidney, with membranes that act as filters. Blood passes through these membranes, which remove waste and send it into a special fluid called dialysate. The machine has safety checks to make sure the process is safe and works well.

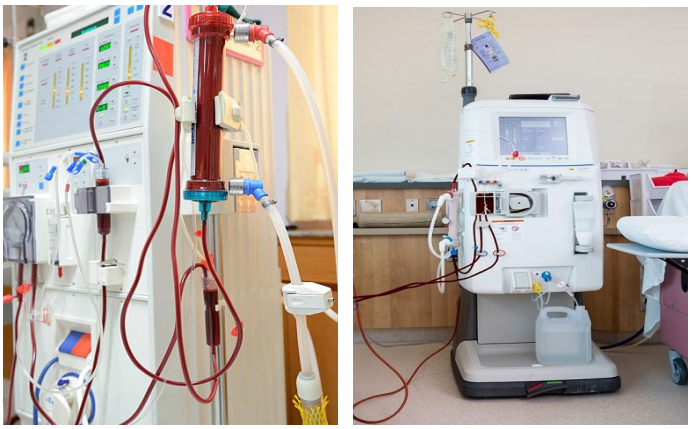


**Figure 5.6:** Dialysis machines

## Monitoring

Monitoring technology provides real-time health management. Do you use a fitness tracker? These devices can check heart rates, calories burned, and more. See **Figure 5.7**

Examples Include:

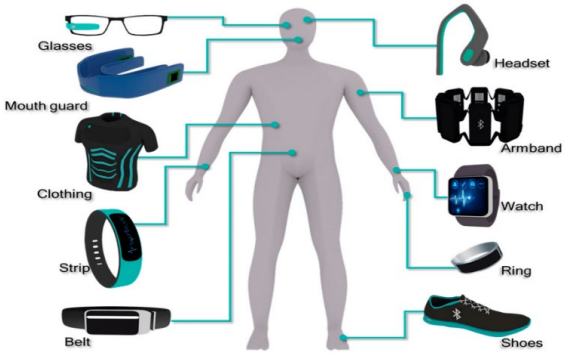
a. wearable health trackers: measure various health metrics (see **Figure 5.7 D**).

b. telemedicine devices: enable remote consultations, allowing doctors to assess patients without being in the same room (see **Figure 5.7 C**).



**A** **B**

Heart rate is 62 beats per minute (A) while the distance covered is 10.6km with 2654 steps and energy (calories) burnt is 2042 kcal.




**C** **D**

**Figure 5.7:** A healthcare provider interacting with a client using telemedicine device (C), Various Wearable health trackers (D)

## Drug Discovery and Development

Technology also speeds up drug discovery. Have you thought about how long it takes to create a new medicine? Robotics and computer modelling can reduce this time significantly, making it easier to design safe and effective drugs.

Splendid work done! Can you name any health monitoring devices you or someone you know uses? What treatment technology excites you the most, and why?

Next, explore the activities to increase your understanding of the concepts!

## Activity 5.1 Field Visit or Virtual Tour: Medical Technology

**Steps:**

1. Plan the visit – reach out to a local hospital or medical lab to inquire about any available tours or observation sessions. If that is not possible, search for reputable online resources that offer virtual tours or video demonstrations of medical equipment.
2. Prepare for the visit by researching a few key medical devices, such as blood pressure monitors, MRI machines, or glucose meters. This will help you recognise the equipment and understand its functions during your visit.
3. Observe carefully and take notes on each device. Focus on how it runs, its purpose, and how healthcare professionals use it.
4. If you are on a live tour, ask questions whenever possible. If you are watching a virtual tour, write down questions or reflections to discuss with a peer or teacher later.
5. Share what you learned, noting anything that surprised you or deepened your understanding of medical technology.

## Activity 5.2 Technology and Disease

**Steps:**

1. Research key technologies used for diagnosing and treating diseases, such as thermometers, blood pressure monitors, glucose meters, or diagnostic imaging tools.
2. Write down some questions or thoughts related to how these technologies work and what health indicators they measure (like heartbeat or blood sugar).
3. If possible, join or start a discussion with classmates, friends, or a study group. Share your thoughts on how these measurements could signal health issues and ask others for their perspectives.
4. Summarise what you learned from the discussion, including any new insights into how technology helps us diagnose or manage disease.

## Activity 5.3 Research and Present: Healthcare Technologies

**Steps:**

1. Choose one healthcare technology to study. This could be telemedicine, wearable devices, point-of-care devices, imaging techniques, drug discovery, or robotic surgery.
2. Gather information on the following aspects of the technology:

a. What it is and how it works.
b. How it is applied in healthcare.
c. Its benefits and challenges in patient care.
d. Its future potential and any ethical considerations.

3. Write a brief case scenario where the technology could be used in a healthcare setting (e.g., a wearable device tracking patient health data for chronic disease management).
4. Practise presenting your findings aloud or record yourself explaining the case study and key points.
5. Reflect on the experience and think about the ethical and practical implications of the technology.

### Activity 5.4 Self-Reflection on Technology in Healthcare

**Steps:**

1. After completing the previous activities, review your notes and consider what you have learned about each technology's pros, cons, and future impact.
2. Write a brief list of the most significant insights you have gained, including any ethical concerns (like privacy, accessibility, or biases in technology).
3. Write a reflection on how you see technology shaping healthcare in the future, what its benefits and limitations might be, and any ethical considerations.
4. Conclude by summarising your thoughts on the impact of technology in healthcare and how it could evolve.

## DIAGNOSTIC DEVICES AND THEIR FUNCTIONAL COMPONENTS

Have you ever wondered how diagnostic devices work and what makes them so effective in healthcare? In this exploration of diagnostic devices, you will discover their key components and why they are important for healthcare. These parts work together like a car to ensure everything runs smoothly. Sensors detect signals, and processors analyse data to provide correct results. You will also look at the principles behind their design, showing how engineering and biology improve patient care, just like a well-tuned engine keeps a car running well.

Let us examine the fascinating world of a specific diagnostic device! You will explore the components of an X-ray machine and how each part contributes to its function (see **Table 5.1** and **Figure 5.8**).

**Table 5.1:** Key Components of an X-ray Machine

| Part | Function |
|---|---|
| X-ray source (X-ray tube) | Produces X-rays using high voltage to accelerate electrons in a vacuum tube. |
| Image detector | Captures the X-rays that pass through the patient to create an image. |
| User interface | Allows radiologists to use the system and adjust settings. |
| Processor/Image reader | Enables radiologists to view and analyse the X-ray images. |

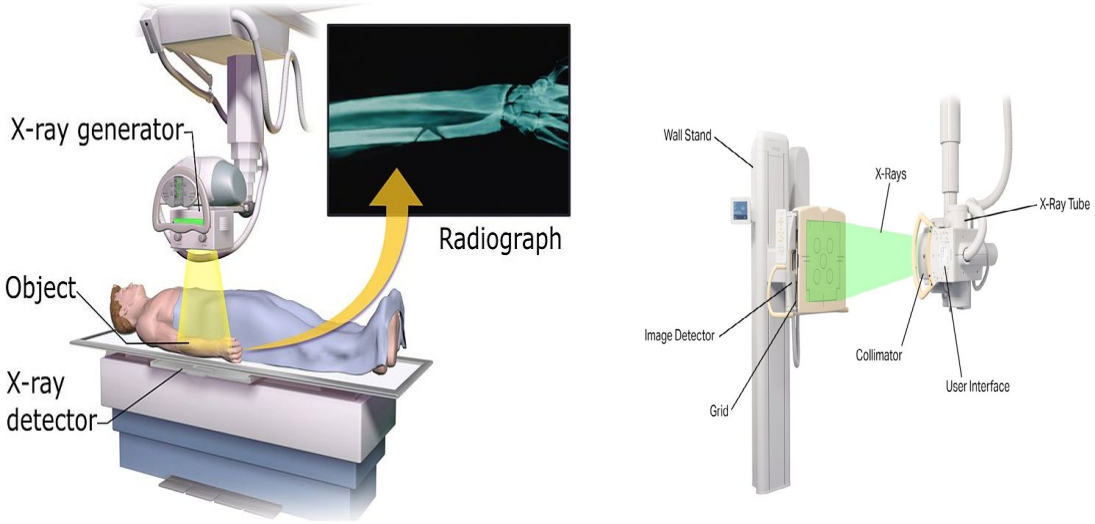



**Figure 5.8:** Components of an X-ray machine

Can you think of a time when you might need an X-ray? What do you think the doctor looks for in the images? Go ahead and examine the components of other X-rays!

## UNDERSTANDING BIOLOGICAL PRINCIPLES AND THE TECHNOLOGY USED TO BUILD SOME TYPES OF DIAGNOSTIC DEVICES

Have you ever wondered how technology helps check your health? Here, you will explore bioinstrumentation which combines engineering and biology. Bioinstrumentation is a branch of biomedical engineering that creates devices to measure and treat biological systems. Diagnostic devices often use sensors to monitor signals like heartbeats and muscle contractions for diagnosis and treatment (see **Table 5.2**).

**Table 5.2:** Key Concepts in bioinstrumentation

| Concept | Description |
|---|---|
| Biological signals | Signals that provide information about bodily functions and can be measured. |
| Sensors | Devices that capture and amplify biological signals, such as thermometers and ECG machines. |
| Spectroscopy | Analyses how light interacts with biological molecules to find substances. |
| Amplification techniques | Methods like PCR increase tiny amounts of genetic material for detection. |
| Imaging techniques | Techniques such as X-rays, ultrasound, and MRIs create images of the body for diagnosis. |

What kind of biological signals do you think are most important for doctors to check? Why?

## Types of Biological Signals Used in Diagnostics

Let us explore some specific biological signals used in diagnostics:

1. ***Electrical activity of the heart:*** measured by an ECG using electrodes on the skin. ECG measures heart rate (using three electrodes placed on the chest) which can vary during exercise, stress, and fatigue.
2. ***Brain electrical signals:*** assessed by electroencephalogram (EEG), which uses electrodes on the scalp to check brain activity.
    a. Advanced devices, called brain-computer interfaces (BCIs), can turn brain signals into computer commands.
    b. EEG is also used to study how the brain responds to things like music and to investigate issues like sleep problems and epilepsy.
3. ***Muscle electrical activity***: Measured through electromyography (EMG) for rehabilitation or recovery purposes.
    a. EMG is a way to measure the electrical signals made by your muscles.
    b. It helps doctors understand how muscles work and is often used to help people recover after an injury.

    So, why do you think it is important to check the electrical activity of the heart or brain?

## Principles of Diagnostic Device Design

Let us embark on an exciting journey to uncover the principles that make various diagnostic devices effective! Ready to explore how they work? Let us kick off!

1. Imaging devices: X-ray machines, ultrasound, and MRI scanners all rely on fascinating principles like wave absorption and magnetism.

    a. X-ray machines: Ever wondered how doctors see your bones? X-ray machines emit electromagnetic radiation, which travels in waves. These waves can easily pass through soft tissues like skin but are absorbed by denser materials, such as bones. Pretty cool, right?

    b. Ultrasound machines: Think of these as the "echo makers" of the medical world! Ultrasound machines use sound waves that bounce off different tissues and organs. These echoes are then transformed into images that appear on a screen, allowing doctors to visualise what is happening inside you.

    c. MRI machines: Have you ever seen a movie where someone gets scanned in a big machine? That is an MRI! It uses powerful magnetic and radio waves to create detailed images of your body. As you lie inside, the magnet aligns your body's atoms, and the radio waves cause these atoms to send out signals, forming a 3D picture. Is it not that interesting? See **Figure 5.5**

    In summary, X-rays are fantastic for spotting bones, MRIs show soft tissues and organs in detail, and ultrasound is perfect for looking at fluid-filled organs.

2. **Laboratory equipment**: Now, let us shift gears to the lab! Tools like blood analysers and genetic testing devices, including Polymerase Chain Reaction (PCR) machines, have evolved dramatically thanks to innovative principles.

    a. Blood analyser: do you know that this device is also referred to as a haematology analyser? It provides a complete blood count (CBC) like red blood cell (RBC) count, white blood cell (WBC) count, and platelet count and measures haemoglobin levels. It works using two main principles: electrical (like measuring electrical resistance) and optical (like using lasers and light to analyse the blood). The principle used depends on the specific test being performed. (See **Figure 5.9** for an image of a blood analyser)

    Curious to learn more? Check out the extended material section for deeper insights into how blood analysis works!

    b. PCR machines: Have you ever wondered how scientists make millions of copies of DNA? This is done using the PCR machine (see **Figure 5.9**)
    Here is how it works:

    - It uses an enzyme called DNA polymerase to create new strands of DNA that match a template strand.
    - The magic happens in a compartment called a thermocycler. It has a thermal block with holes for small tubes that hold the PCR mixtures. It is called a thermocycler because it changes temperatures! The machine heats up and cools down to help make more copies of the target DNA. Imagine it as a roller coaster ride for DNA!
    - Real-world use: PCR is super important for testing diseases like COVID-19. It helps scientists quickly find the virus by amplifying its genetic material.

- Do you want to see how it all works? Check out the link for DNA replication and PCR process in the extended material

**Blood Analyser** **PCR machine**

**Figure 5.9:** Examples of laboratory equipment

Fantastic! You have examined diagnostic devices. Understanding the components and principles behind diagnostic devices is essential for appreciating their role in healthcare. But before you embark on this journey, do you know that your body makes an exact copy of its DNA each time a cell divides? It is like an incredible biological photocopier and this amazing process is called DNA replication!

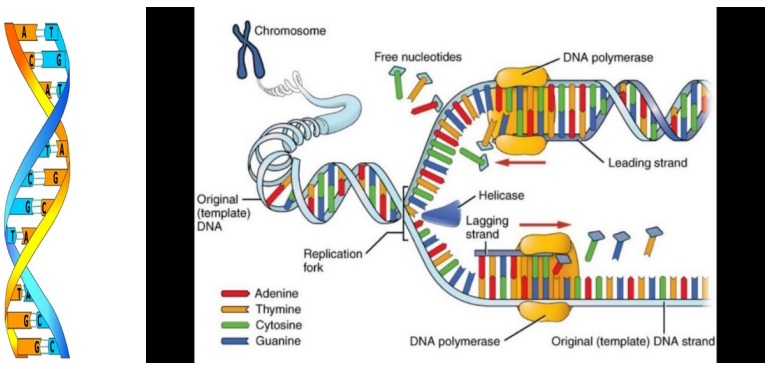
First, the process starts with an enzyme called helicase, which "unzips" the original DNA molecule by breaking the bonds between its two strands. Imagine it like a zipper opening!

Next, another enzyme, DNA polymerase, comes into play. It adds matching bases (free nucleotides) to each strand. Here is a fun pairing to remember:

- Adenine (A) pairs with Thymine (T).
- Cytosine (C) pairs with Guanine (G).

This pairing ensures that the new strands match the original DNA strands perfectly, resulting in the formation of two identical DNA molecules. See **Figure 5.10.**

It is worth mentioning that occasionally, a change in the DNA sequence, referred to as a mutation, may disrupt this process.




**A** **B**

**Figure 5.10:** DNA molecule **(A) and** DNA Replication **(B)**

Now, explore these activities to gain a deeper understanding of the components of diagnostic devices and the principles of bioinstrumentation

## Activity 5.5 Disassemble and Reassemble a Diagnostic Device

**Materials needed**: A diagnostic device (glucometer or ECG monitor), small screwdrivers and tools for disassembly, safety goggles, notebook and pen for observations

**Steps**:

1. Put on your safety goggles and gather your tools.
2. Carefully disassemble the device, keeping track of each part.
3. In your notebook, draw the device and label each part as you find it.
4. Reassemble the device and write down how you think each part contributes to its function.
5. What surprised you about the components? Share your findings with a friend or family member to explain how the device works!

## Activity 5.6 Explore Accuracy, Sensitivity, and Specificity

**Materials needed**: Access to online resources or textbooks with diagrams of diagnostic devices, printed images or models of devices (like X-ray machines, blood analysers, etc.), chart paper and markers.

**Steps**:

1. Search for diagnostic devices and find examples that show how accurate (correct), sensitive (able to detect small changes), and specific (focused on one thing) they are.
2. Create a chart with three columns: Accuracy, Sensitivity, and Specificity.
3. For each device you research, write down how it shows these principles and why they matter.
4. After completing your chart, present your findings to a family member or friend. Ask them to guess which devices you described based on the principles you outlined!

## Activity 5.7 Create a Diagnostic Device Poster

**Materials needed**: Poster board or large paper, markers, coloured pencils, or paints, access to research materials (books, internet)

**Steps**:

1. Choose a diagnostic device (e.g., X-ray machine, MRI, or ECG monitor).
2. Research its components and functions.
3. Create a visually appealing poster that includes:
    a. A labelled diagram of the device
    b. Descriptions of each part and its function
    c. Fun facts or interesting information about the device
4. Once your poster is complete, share it with your classmates, friends, or family. Ask them to quiz you on the functions of the components!

## Activity 5.8 Bioinstrumentation Principles Experiment

**Materials needed:** Stopwatch or timer, notebook and pen, access to a smartphone or computer for research (optional)

**Steps**:

1. Research how to measure your heart rate manually.
2. Find your pulse on your wrist or neck and use the stopwatch to time how many beats you feel in 15 seconds.
3. Multiply that number by 4 to calculate your heart rate in beats per minute (BPM).
4. Record your findings in your notebook and compare them to the average resting heart rate for your age group.
5. Share your results with a friend or family member and challenge them to measure their heart rate too. Share with them any differences and what factors might affect heart rate, such as exercise or stress!

## Activity 5.9 Research on a Diagnostic Device

**Materials needed:** Computer or tablet with internet access, notebook and pen, presentation software (e.g., PowerPoint, Google Slides)

**Steps**:

1. Choose a diagnostic device (e.g., ECG machine, pulse oximeter, glucometer).
2. Use online articles, videos, or virtual simulations to find information about the device's components and how they work.
3. In your notebook, make a table with the following columns:
    a. Part name
    b. Function
    c. Contribution to device operation. Use the table below as a guide.

| Part name | Function | Contribution to Device Operation |
|---|---|---|
| Sensor | Detects specific signal | Converts biological signals to electrical data |
| Amplifier | | |
| Processor | | |
| Display | | |

4. Create a short presentation summarising your findings, including your table.
5. Present your research to a family member or friend and explain how each part works.
6. After your presentation, ask your audience for feedback

**Self-reflection**

1. How has my understanding of diagnostic devices changed, and what new insights have I gained about their components and functions?
2. In what ways do I see the principles of bioinstrumentation affecting healthcare and patient outcomes in the future?

# PROSTHETICS VS. ORTHOTICS: UNDERSTANDING THE DIFFERENCE

When it comes to helping people who have disabilities, prostheses and orthoses are two important tools. They are designed to make life easier and help people get back to doing the things they love. Let us take a closer look at each one and how they help people.

Prosthetics and orthotics are both amazing tools that help people move, but they work in diverse ways.

## Prosthetics

Used when someone has lost a body part, like a leg or an arm, and they need an artificial replacement, such as a prosthetic limb. This can happen because of a birth condition, an accident, or even a medical need like an amputation (surgical removal of a limb). So, prosthetics replace missing parts. See **Figure 5.11**

1. Prosthetic limbs help people walk and do daily tasks after losing an arm or leg.
2. Prosthetics can replace body parts, like a breast after a mastectomy (surgical removal of breasts) or artificial eyes and ears.
3. Prosthetics boost confidence and allow for more independence.

**Prosthetic leg and arm** **Lower limb prosthesis** **Upper limb prothesis**

**Figure 5.** 11: Prosthetic devices

## Orthotics

On the other hand, are devices that support or correct a body part that is still there but needs some extra help. For example, a knee brace is an orthotic—it supports the knee to improve movement. Dental braces also count as orthotics because they help align teeth Thus, orthotics support and correct body parts. Pretty interesting, right? See **Figure 5.12**. Orthoses:

1. provide support to alleviate pain.
2. correct alignment issues and prevent further injuries.
3. improve overall comfort during daily activities and sports.
4. help maintain an active lifestyle.


**Knee brace** **Ankle support** **Back brace** **Dental braces**

**Figure 5.12:** Orthotic devices

## Examining Different Categories of Assistive Technology

Both prosthetics and orthotics tools fall under the broader category of assistive devices. Assistive Technology (AT) is all about helping people with disabilities achieve greater independence in their daily lives by providing tools and devices to make things easier. Let us break it down into three main types such as mobility, communication and sensory aids!

1. **Mobility aids:** have you ever wondered how mobility aids like canes, crutches, walkers and wheelchairs work? These devices give people who have difficulty moving around the freedom to do so on their own. Therefore, mobility aids help with movement. They boost confidence and provide independence. **Figure 5.13** shows examples of mobility aids.

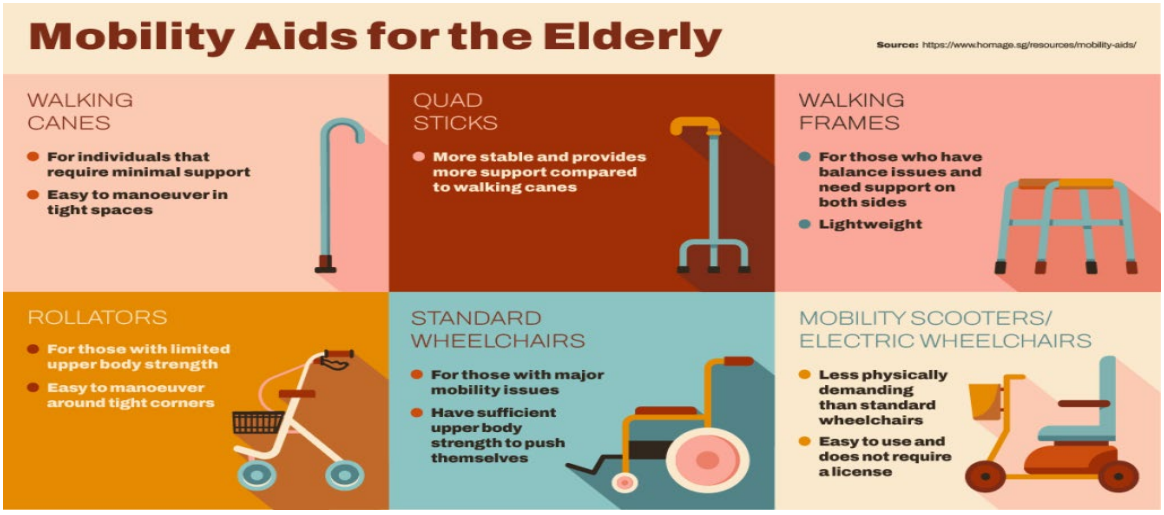
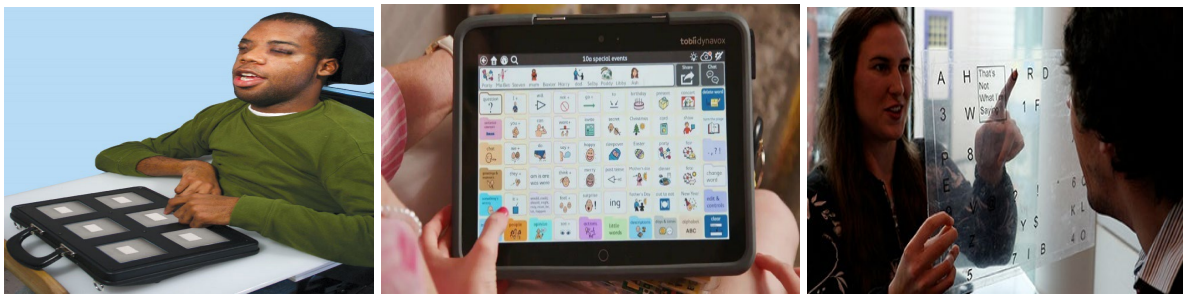



**Figure 5.13:** Mobility aids

Mobility aids also include various types of prosthetics and orthotics designed to assist movement. For example,

a. **leg prosthetics**: artificial limbs for below-knee, above-knee, and hip amputees.
b. **ankle-foot orthoses (AFOs)**: support the ankle and foot, improving stability and mobility.

2. **Communication aids**: imagine having a way to communicate if you have trouble with speech or hearing. Communication aids can include visual tools, digital devices, and tactile (touch-based) tools that make it easier for individuals to express themselves and understand others. It could be as simple as a tablet that reads out typed words or a visual board to point out needs and preferences. See **Figure 5.14**

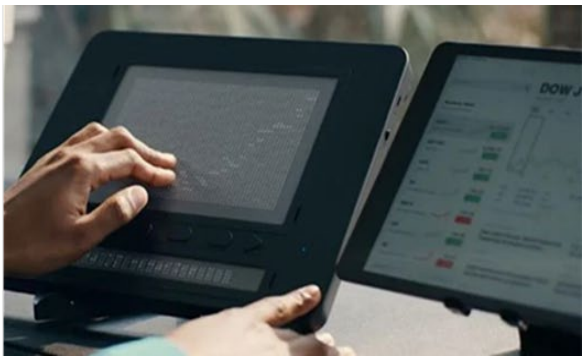


**Tactile** **Speech generating device** **Eye gaze board**

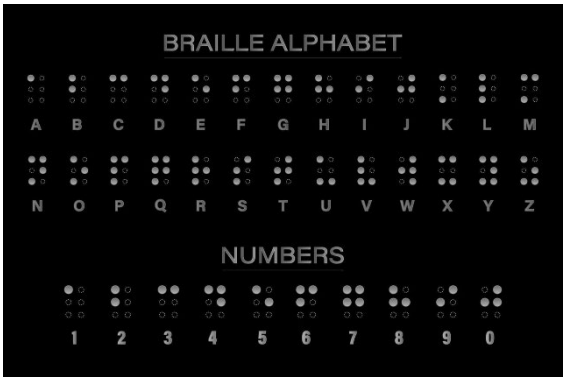
**Figure 5.14:** Communication aids

3. **Sensory aids**: support people with visual or hearing impairments, allowing them to experience the world more fully. Braille helps people who are visually impaired read by touch, screen readers convert text to speech, and hearing aids amplify sounds for those with hearing difficulties. Imagine the difference a hearing aid might make for someone in a crowded room. **Figure 5.15** shows examples of sensory aids.

**Hearing aid**



**Braille screen reader**




A blind child in a primary school receives instruction in using the Braille alphabet

**Figure 5.15:** Sensory aids

These assistive devices help improve quality of life in amazing ways! Which type of AT do you think would make the biggest impact for someone in your community?

Can you think of any other examples of prosthetics or orthotics that people you know might use for mobility?

Get ready to explore the activities to boost your understanding of prosthetics and orthotics!

## Activity 5.10 Exploring and Understanding Prosthetic and Orthotic Devices

**Materials needed:** Access to the Internet or library resources, a notebook and a pen.

**Steps:**

1. Start by researching the definitions and uses of "prosthesis" and "orthosis" online or in a textbook (link1 and link2). Make notes on how each type of device is used to support or restore functions.
2. Find and view images or videos that show real-life examples of prosthetic and orthotic devices (link1 and link2). Take notes on specific types you find interesting and how they help people in everyday life.
3. Reflect on how different health issues, like injuries or the loss of limbs, can affect a person's mobility or ability to perform tasks. Think about how prosthetic and orthotic devices could help in these cases.
4. Write a summary of what you learned, focusing on the purpose of these devices and their importance to those who need them.

## Activity 5.11 Investigating Limb Function Loss and Assistive Solutions

**Materials needed**: Pen, paper, or digital device, access to research materials (internet, books).

**Steps:**

1. Find out why people lose limb function. Look at causes like disease, accidents, or birth defects.
2. Choose 3 examples of limb loss and note the cause for each.
3. Think about what type of device could help each person. Would they need a prosthesis (replacement) or an orthosis (support)?
4. Write down how the devices could help with tasks like walking or lifting.
5. Summarise your findings in a short report. Include your examples and explain which device would help and why.
6. If possible, add pictures or diagrams to explain your points.

## Activity 5.12 Exploring Prosthetics for Movement and Independence

**Materials needed**: Paper, markers, and Internet access for research.

**Steps:**

1. Picture this situation: Sam, a 25-year-old runner, lost part of his leg in an accident. He wants to use a prosthetic leg to help him walk and run again.
2. Answer these questions on paper:
    a. What problems might Sam face after losing his leg?
    b. If you were Sam, what would you do to stay active?
    c. How could a prosthetic leg help Sam feel more independent?

3. Draw a simple sketch of a prosthetic leg that could help Sam run again. Think about its shape and materials.
4. Look up two examples of prosthetic legs for runners. Write down any ideas from your drawing that are similar or different from the real ones.
5. Write a few sentences on what you learned about how prosthetics support movement and independence.

**Self-reflection**

1. How has learning about prostheses and orthoses changed my view on how they help people with disabilities?
2. How can I use what I learned to support people who need them?

# INTRODUCTION TO CANCER AND ITS DIFFERENT TYPES

Usually, our cells are like well-behaved learners – they grow, divide, and stop when they are supposed to. But in cancer, some cells start breaking all the rules. When it comes to treating cancer, there are several different approaches, each with its own physical, mental, and emotional effects on patients. Here, you will be guided through how these treatments work and the impact they can have.

You have heard about it before, but what exactly is it? In simple terms, cancer refers to a group of diseases characterised or marked by the uncontrolled (not controlled) growth of cells in the body.

**Did you know?**

*Cancerous (cancer) cells usually come from normal, healthy cells! They become cancerous when they start to multiply (grow) uncontrollably without signals (messages) from the body, which leads to the formation of tumours (lump or masses of cells). Tumours can be either benign (not harmful) or malignant (harmful) — See* ***Figure 5.16***

1. Benign tumours: these are the calm, non-trouble-making tumours. They are slow-growing tumours that stay in one place and do not spread to other parts of the body. Think of them like a small bump on your skin – not causing much trouble like skin tags or warts.
2. Malignant tumours: these are the serious ones. They spread to other parts of the body and can be dangerous. Malignant tumours are what people are usually talking about when they mention cancer. The name of the cancer usually comes from where it starts, like in the breast (breast cancer), the skin (skin cancer), or the blood (leukaemia).

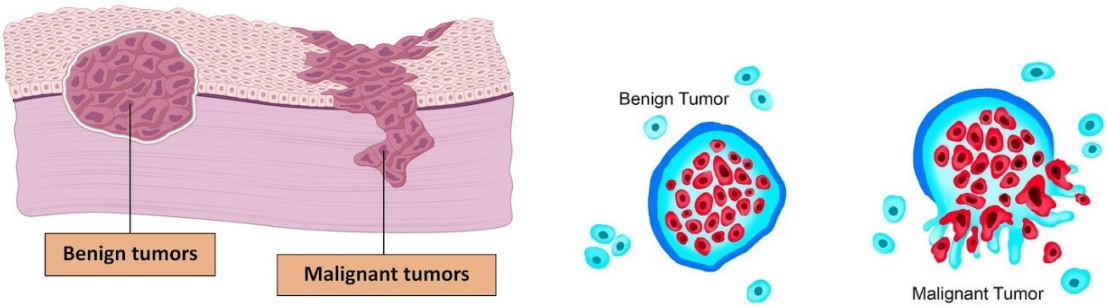



**Figure 5.16:** Tumours: Benign confined while malignant metastasised (spreads out)

### Did you know?

*Mutations can lead to cancer, but not all mutations result in cancer. A mutation is a change in the DNA sequence of an organism.*

## Cancer Cells vs Normal Healthy Cells

So, what sets cancer cells apart from the healthy cells in your body? Here is an overview of how cancer cells "break the rules"

1. No "Stop" button: healthy cells know when to stop growing, like how you stop eating when you feel full. However, cancer cells do not receive these signals! They continue to grow and divide, which is why tumours keep getting bigger (see **Figure 5.17**).

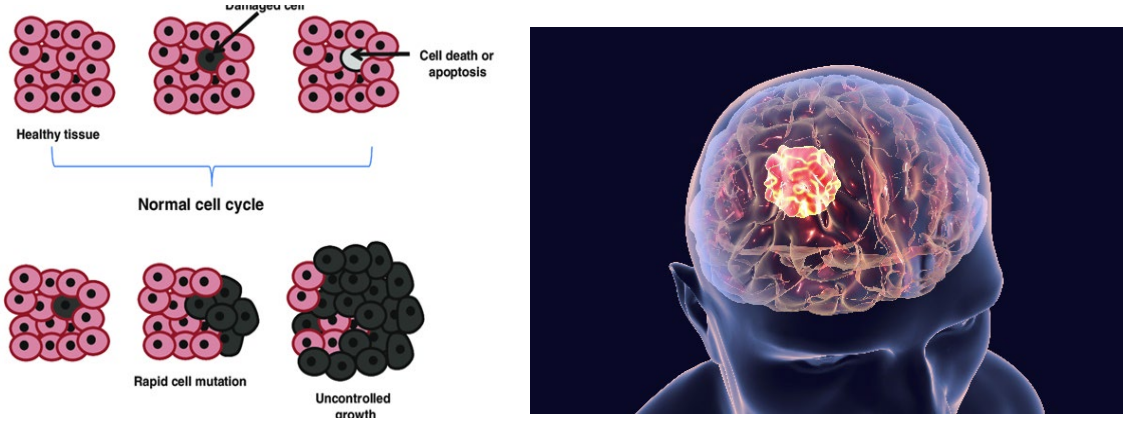



**Figure 5.17:** Healthy cell growth vs. cancer cell growth

2. No "Start" signal needed: normally, cells require a signal to begin growing, like waiting for a green light to cross the street. However, cancer cells do not wait for any signals—they simply start multiplying on their own.
3. Ignoring personal space: cells communicate with each other by sending chemical signals. Healthy cells stop their growth when they meet other cells. But cancer cells keep pushing into other cells and tissues, causing damage as they go.

4. No self-repair: healthy cells can usually repair themselves or shut down when they get damaged. However, cancer cells do not bother with repairs—they just keep growing, even when they are damaged.
5. Not growing up properly: cancer cells reproduce so quickly that they do not have time to mature and specialise (differentiate) to perform their functions in the body, unlike healthy cells that do. They just multiply without a purpose.

Have you ever wondered why this is important? By studying these differences, scientists can discover new treatments to slow down or stop these out-of-control cells. Let us explore how this research can lead to better cancer therapies!

# TREATMENT OPTIONS FOR CANCER

Detecting cancer early makes a huge difference in how well treatment can work. But did you know that the type of treatment depends on a few key things? Biomedical scientists look at the specific type of cancer, how advanced it is, and even the patient's health and personal preferences.

Oncology is the branch of medicine that specialises in the diagnosis, treatment, and management of cancer.

Sometimes, one type of treatment might be enough. Other times, especially if the cancer is in a later stage or is a tougher type, a single approach might not do the job. When that happens, doctors will mix and match different treatments to make sure the cancer is tackled as effectively as possible.

## Exploring Treatment Modalities Used to Combat Cancer

Let us go deeper into some of the main ways doctors treat cancer – it is fascinating how many different approaches they can take. Explore four of such treatment modalities (different options)!

1. ***Surgery:*** involves removing cancerous tumours or as much of them as possible, aiming to end the cancerous mass. However, it may not always be a choice, especially if the cancer is in a delicate area or has spread too far. When successful, surgery can be a powerful method to prevent further spread of cancer.
2. ***Radiation therapy:*** uses high doses of radiation to damage the DNA in cancer cells. Without DNA, cancer cells cannot grow, which often makes the tumour shrink. Radiation therapy is very precise; trained professionals use special machines to target just the cancer, trying to protect as much healthy tissue as possible. Have you ever had an X-ray? It is similar but with a much stronger dose of radiation to reach the cancer cells.

3. ***Chemotherapy:*** uses powerful drugs to kill cancer cells throughout the body. Sometimes doctors use just one chemotherapy drug, but other times they combine a few for a stronger effect. The specific drugs depend on where the cancer started and whether it has spread. For example, someone with breast cancer that has spread to the lungs might get a different combination than someone just with lung cancer.
4. ***Immunotherapy:*** Your body already has an immune system that fights off invaders, like viruses and bacteria. Cancer Immunotherapy (or immuno-oncology) boosts the immune system's ability to recognise and fight cancer. This treatment might use cancer vaccines, special viruses that target tumours, or antibodies that attack cancer cells directly. Some types even involve changing immune cells to make them super effective against cancer.

Each treatment has its own strengths, and sometimes doctors combine a few of these to make the most impact.

Curious about how they decide which treatments to use together? Or do you want to learn more about how immunotherapy works with our immune system? Click on link1, link2 and link3 to keep exploring – there is a lot to learn about how doctors battle cancer!

## EMOTIONAL AND MENTAL IMPACT OF CANCER

Let us analyse what it is like for someone going through cancer – from the diagnosis all the way through treatment and survival. Cancer brings a lot of changes and affects people in more ways than you might first imagine. Here are some of the challenges people often face:

1. Physical challenges: cancer can cause some tough physical symptoms. People might have ongoing pain, lose weight unexpectedly, or feel incredibly tired. Anaemia, which makes someone feel weak, can also be common. Other changes might include things like unusual lumps, trouble breathing, or even body changes, like in breast cancer, where someone might need to have a mastectomy (a surgical procedure that involves the removal of one or both breasts, typically to treat or prevent breast cancer). Have you ever thought about how exhausting it must feel to deal with these symptoms on top of everything else? These challenges can vary depending on the type and stage of cancer, and they often change throughout the journey.
2. Mental and emotional challenges: getting a cancer diagnosis can feel like the world is crashing down – it is a lot to handle emotionally. Many people describe it as feeling like a "death sentence," which brings a mix of fear, sadness, and anxiety. Right from the start, patients might feel a flood of emotions, like fear of the future, worry about the changes ahead, or sadness about things they might miss. It is completely normal for people to experience depression, panic, and even post-traumatic stress as they process what they are going through. There is also the constant fear of recurrence – the worry that even after treatment, the cancer might come back.

# Support Systems Available to Help Patients Cope with These Challenges

Let us explore some ways cancer patients can get support to handle the challenges that come with treatment and recovery.

Depending on whether someone is dealing with physical, emotional, or mental challenges, there are different strategies that can really help.

## Coping with Physical Challenges

1. Dealing with pain and fatigue: pain and constant tiredness can be tough, but there are many ways to manage them. Pain relievers or special medications, like nerve blockers, can be effective because they stop pain signals before they even reach the brain. Have you ever tried relaxation techniques like meditation? Things like massages, meditation, and even gentle stretching exercises can help ease fatigue and help the body relax.
2. Managing weight loss: nutrition is key for cancer patients, especially if they are losing weight unexpectedly. A nutritionist or dietitian can work with them to build a meal plan that helps them stay strong. Sometimes food supplements are recommended. In more serious cases, when eating is too difficult, patients might get nutrition through a tube, which makes sure they are still getting the nutrients they need.
3. Handling anaemia: anaemia can make someone feel extremely weak. Doctors often recommend dietary supplements like iron, folic acid, or vitamin B12, which help produce healthier red blood cells. In other cases, patients might need blood transfusions or even a bone marrow transplant to replace damaged stem cells.

## Coping with Emotional and Mental Challenges

1. Using medications for anxiety and depression: many people with cancer feel anxious or depressed, which is completely understandable. Medications like antidepressants can help make these feelings more manageable, especially if they become overwhelming.
2. Talking it out (psychotherapy): sometimes, just having a safe space to talk through emotions can make a huge difference. Therapy or counselling can help people understand and process their feelings, and they can learn techniques for handling negative thoughts.
3. Joining support groups: these groups bring together people who are going through similar experiences. Have you ever talked to someone who just “gets it”? That is what these groups are for – people can share what they are going through, learn from each other, and feel less alone in the process.

Well done! Perform the activities here to boost your understanding of the concepts.

## Activity 5.13 Understanding the Growth of Normal and Cancer Cells

**Materials needed**: A video or animation that shows how cancer cells grow and spread, a worksheet or paper, markers, coloured pencils or a drawing app.

**Steps**:

1. Start by reading from textbooks or watching an introductory clip about cell growth.
2. From your search, make note on:
   a. How normal cells grow and stop when they should
   b. How cancer cells grow without stopping
   c. How cancer cells can form lumps (tumours) and spread to other parts of the body

   (Click on link1, link2, link3 to watch videos aside from the ones you searched).
3. Use markers, coloured pencils or a drawing app to make two simple drawings: one of normal cells that grow and stop at a limit, and another of cancer cells that keep growing and form a tumour.
4. Share your experience with a friend or family member, about why it might be harmful if cells keep growing without stopping.

## Activity 5.14 Cancer Fighters: The Treatment Journey

**Materials needed**: Access to videos (link1, link2, link3, link4 for video resources), notebook.

**Steps:**

1. Start by watching the videos (link1, link2, link3, link4) that explain each cancer treatment. As you watch, take notes on:
   a. the main process of each treatment.
   b. how each treatment targets cancer cells.
   c. any side effects or challenges patients may face with these treatments.
2. Write down key details you learned from the videos for each treatment.
3. Pick one cancer treatment and create a simple poster or drawing to explain how it works. Make it colourful!
4. Share your poster with someone or post it on social media to educate people.

## Activity 5.15 Understanding the Impact of Cancer Treatments

**Materials needed:** Computer or textbook for research, paper or digital device for writing.

**Steps:**

1. Look up the side effects of chemotherapy and radiation therapy, focusing on both physical (e.g., hair loss, nausea) and emotional effects (e.g., anxiety, memory issues).
2. Draw a table with two columns: physical effects and emotional effects.
3. Write a short paragraph about how these side effects could affect a person's life.
4. Watch a short video on YouTube (link1 and link2) about the side effects of chemotherapy or radiation therapy and note one new fact you learned.
5. Write a brief message offering support to a friend going through cancer treatment, acknowledging the challenges they might face.

## Activity 5.16 Creating a Pamphlet for Self-reflection

**Materials needed**: Notebook, textbook or computer, pens.

**Steps:**

1. Choose a type of cancer (e.g., breast cancer, lung cancer, etc.).
2. Conduct research using books, printouts, or local resources such as community health workers or school materials.
3. Focus your pamphlet on:
    a. types of treatment available (e.g., chemotherapy, surgery, radiation).
    b. how each treatment works in simple terms.
    c. side effects (e.g., fatigue, hair loss, nausea).
4. Write your findings in a simple pamphlet format, using a few sheets of paper folded together, or make a digital version if available.
5. Include visuals or diagrams to improve understanding and do not forget to share your pamphlet!

## Activity 5.17 Patient Testimonial on Cancer

**Materials needed:** Patient testimonials from books, newspapers, or online sources.

**Steps:**

1. **Find a patient testimonial:** Look for a patient testimonial from books, newspapers, or online videos on platforms like YouTube (e.g., link1 and link2) or other free platforms, or use a locally available video.
2. **After reading or listening**, take notes on:
   a. the type of cancer the patient had and the treatments that were used.
   b. how the video can help others understand cancer.
3. **Share your findings** with a family member or friend!

## Self-reflection

1. How has learning about cancer changed my perspective on health and wellness?
2. In what ways can I support friends or family members who may be affected by cancer?

# FUTURE APPLICATIONS OF REGENERATIVE MEDICINE FOR PATIENT WITH DISABILITIES

Imagine a future where scientists can create new organs or tissues and repair injuries using the body's own cells—how might this affect the lives of those with disabilities? It could help them regain movement or strength and live more independently without needing as many external devices as possible. Let us uncover the potential of regenerative medicine in transforming healthcare!

## Regenerative Medicine

When people lose organs or tissues due to disease or injury, it can be difficult for their bodies to recover on their own. This need has inspired scientists to find new ways for the body to heal itself naturally without the need for organ transplants (surgical transfers of organs). What organ transplant have you heard about?

Regenerative medicine is an exciting area of science focused on repairing (fixing), replacing, or regenerating (growing back) damaged or unhealthy tissues in the body. This field combines engineering (designing and building) and life sciences (the study of living things) to help people recover from injuries and illnesses. Unlike traditional methods that use machines or devices, Biomedical scientists employ regenerative medicine, which uses biologics (natural substances) to restore function.

## Current Applications of Regenerative Medicine

Let us examine some ways regenerative medicine is being used today! The simplest and most common application of regenerative medicine is transplanting human tissues.

Transplants of human tissues can be done using:

1. Autografts: this is when a patient's tissue is used.
2. Allografts: this involves taking tissue from another person.
3. Xenografts: this is when tissue is taken from an animal.

In cases where a genetic mutation causes a disease, regenerative techniques like gene and cellular therapy can be employed. This approach often involves the use of stem cells. Stem cells are special cells which can develop or differentiate into distinct types of cells in the body. Here are two main types:

a. **Embryonic stem cells:** these come from an embryo and can become any type of cell, like nerve or blood cells.

b. **Adult stem cells:** these are found in places like bone marrow and can help replace damaged cells, but they do not create new tissues like embryonic cells do.

Curious to learn more? Watch a video on stem cells and how they are used in regenerative medicine!

## Analysing Other Applications of Regenerative Medicine

1. ***Skin grafts for burn victims***: a surgery where healthy skin is taken from one part of the body and placed over burned skin. While minor burns heal on their own, more serious burns might need skin grafts.
2. ***Bone marrow transplants for blood cancers***: used to treat cancers like leukaemia and lymphoma. They involve high doses of stem cells, which help replace unhealthy blood cells.

## Disabilities That Could Benefit from Advancements in Regenerative Medicine

Regenerative medicine focuses on improving the body's ability to heal itself. It is particularly useful when healing is severely hindered by age, disease, or severe injury.

Below are examples of how regenerative medicine can help various disabilities:

1. For individuals with musculoskeletal (muscle and bone) injuries that lead to movement disabilities, physical rehabilitation (therapy) plays a crucial role in improving quality of life, often incorporating the use of prosthetic devices to restore function.

**Challenges with prosthetics:** They may not fully address large tissue losses.

2. For people with large tissue damage after a musculoskeletal injury, using scaffolds (support structures) or extracellular matrices (materials that support cell growth) can help with healing. This technique is called tissue engineering. It provides a 3D structure that encourages the body to repair itself.

   **Example: Peripheral nerve injury**

   - Problem: large gaps in nerves can prevent reconnection of nerve endings.
   - Use of scaffolds helps communication between nerve ends. Animal studies show improved healing with this technique. See **Table 5.3** for other examples.

**Table 5.3:** Examples of disabilities that could potentially receive help from regenerative medicine

| Disability | Potential Regenerative Solutions |
|---|---|
| **Amputation** | Tissue engineering may enable limb regrowth or improve prosthetic integration. |
| **Severe burns** | Regenerative techniques could promote skin healing and reduce scarring. |
| **Muscle disease** | Regenerative therapies could repair or regenerate muscle tissue. |
| **Heart disease** | Advances may help repair damaged heart tissue after heart attacks. |

Great exploration! Before you move on, section 5 has ended. Get ready to embark on a journey to complete the activities. Let us get started!

## Activity 5.18 Regenerative Medicine: Build, Fix, and Heal!

**Materials needed**: Paper and pen/pencil, recycled materials (e.g., small pieces of paper or cardboard for models), notebook or scrap paper for notes.

**Steps:**

1. If you have access to a video or article on regenerative medicine, watch or read it. If not, here is a quick summary:
   - cell therapy: using cells (often stem cells) to repair damaged tissues or organs.
   - tissue constructs: applying patches, like skin grafts, to heal injuries.
   - artificial organs: developing lab-made organs to replace those that no longer work.
2. Use small pieces of paper, cardboard, or any available materials to create a simple model for each strategy:
   a. For cell therapy, cut small pieces of paper to stand for cells, and imagine placing them on a “damaged” area.

b. For tissue constructs, layer paper or cardboard to make a "skin patch" that could cover an injury.

c. For artificial organs, shape a small piece of paper or cardboard into a simple organ shape, like a kidney or heart.

3. Once your models are ready, practice explaining each strategy aloud as if you are teaching someone. Feel free to share your model!

## Activity 5.19 Exploring Regenerative Medicine Techniques

**Materials needed**: Internet access, paper, and pen for taking notes.

**Steps:**

1. Find pictures or videos about regenerative medicine techniques like stem cell therapy, skin grafts, or artificial organs.
2. Jot down key points about how each technique helps people heal and what medical issues it addresses.
3. Consider health challenges in your community and note which techniques could help solve these problems.
4. Write a summary or sketch your ideas, then share them with a friend or family member for feedback.

## Activity 5.20 Creating Word Clouds on Regenerative Medicine

**Materials needed**: Internet access (if available) or paper, manila cards, markers and a list of terms related to regenerative medicine (optional)

**Steps:**

1. A word cloud shows words in varied sizes. The bigger the word, the more important it is. Look at an example (like **Figure 5.18**) to understand how it works.

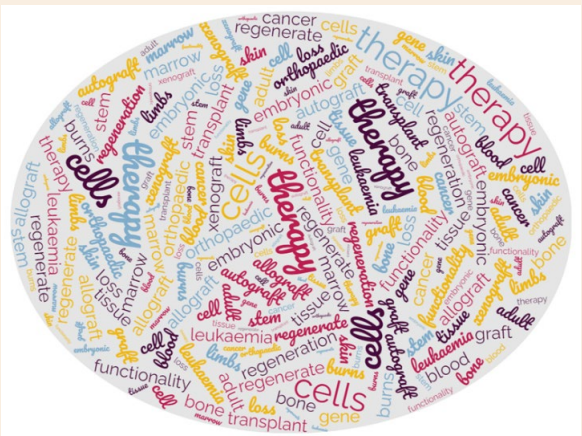



**Figure 5.18: Word cloud**

2. Search for important words related to regenerative medicine, such as "stem cells," "skin grafts," "bio-printing," and "regeneration." If you cannot use the internet, you can use a textbook or ask for a list of terms.
3. If you have internet access:
    - Use a website like WordClouds.com to make your word cloud.
    - Type in the words you found, and the website will create the cloud for you.
    - If you do not have internet access:
    - Use manila cards and markers.
    - Write the key words on the cards and arrange them on a wall or large paper to make a word cloud.
4. Look at your word cloud and think about the most important words. Why do you think these words matter in regenerative medicine? Share your word cloud with someone else and explain your choices.
5. Write down what you learned from creating the word cloud. Think about how this activity helped you understand regenerative medicine better.

### Self-reflection

1. How has my view of regenerative medicine changed, and what do I think it could do for people with disabilities?
2. Can I think of a specific disability that could receive help from regenerative medicine? How does this affect my feelings about the future of healthcare?

## EXTENDED READING

- Examine the components of X-ray machines here
- Explore the distinct types of cancer treatments using https://www.cancer.gov/about-cancer/treatment/types
- Explore the role of technology in healthcare delivery here
- To read more on blood analysis, visit this site 10 Important Blood Tests: What They Show, Why They Are Done, More
- Use this link https://thisvsthat.io/dna-replication-vs-pcr or search online to explore DNA replication and PCR processes
- Want to read more on protheses and orthoses? Use this link.
- What is regenerative medicine? Read more using https://www.webmd.com/a-to-z-guides/what-is-regenerative-medicine

# REVIEW QUESTIONS 5.1

1. List two examples of healthcare devices or technologies for each of the following categories.
   a. Preventive healthcare
   b. Rehabilitation (recovery from injury)
   c. Health monitoring at home
2. What is diagnostic imaging?
3. What is the main difference between a prosthesis and an orthosis?
4. Name two examples of prosthetic devices.
5. Name two examples of orthotic devices.
6. What is the purpose of a mobility aid?
7. What are the two types of tumours?
8. What is the basic difference between cancerous cells and healthy cells?
9. Name any common example of a benign tumour.
10. What is one key characteristic of malignant tumours?
11. What is the basic definition of regenerative medicine?
12. Name one type of stem cell used in regenerative medicine research.
13. What is the purpose of using stem cells in medical treatments?
14. How can tissue engineering be used to replace damaged organs or tissues?
15. Briefly explain the purpose and function of the following medical diagnostic devices.
   a. MRI machine
   b. ECG
   c. PCR (Polymerase Chain Reaction) machine
16. Complete the table by explaining how each of the following components functions within the system:

| Part | Function(s) |
|---|---|
| X-ray Source | |
| Image Detector | |
| User Interface | |
| Image Processor | |
| Power Supply | |

17. Explain how a prosthetic limb can help someone with a missing leg.
18. Describe the function of an orthosis for someone with weak joints.
19. In what ways do prostheses and orthoses improve daily life?
20. How does a prosthetic device differ from an orthotic device?
21. What are the different treatment options available for cancer patients? Provide examples of treatments that can be combined.
22. What is the purpose of chemotherapy in cancer treatment?
23. How does radiation therapy differ from surgery in treating cancer?
24. Name two differences between a regular X-ray machine and a radiotherapeutic X-ray machine.
25. Describe the difference between the following:
    a. Allografts and xenografts
    b. Embryonic stem cells and adult stem cells
26. Explain how stem cells can be used to treat diseases and injuries.
27. How does the process of tissue regeneration differ from the use of artificial organs?
28. Conduct a survey of healthcare technology needs in a local clinic or hospital, showing one area where technology is lacking. Draft a report discussing the potential impact on patient care and outcomes if this gap were addressed with modern technology.
29. An ultrasound machine is producing unclear images and has low signal quality. Based on your understanding of the device's components and bioinstrumentation principles, show any one part that might be causing this problem. Discuss your reasoning for this diagnosis.
30. How might wearing an ankle brace help an athlete with a past injury?
31. Explain how using a prosthetic arm could help someone in performing daily tasks.
32. How do prosthetics and orthotics address both physical and emotional needs?
33. Choose a specific type of cancer and create a case study outlining the patient's journey from diagnosis to treatment outcome.
34. What physical side effects might a cancer patient experience from chemotherapy or radiation therapy?
35. How might the emotional and mental challenges of cancer treatment affect the patient's quality of life?
36. Analyse the role of immunotherapy in cancer treatment and how it can be combined with other therapies for better outcomes.

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

37. Should governments invest in regenerative medicine research to improve public health, or are the risks and costs too high?

38. How might advances in regenerative medicine affect healthcare accessibility and inequality?

SECTION 6

# RESEARCH AND DESIGN IN BIOMEDICAL SCIENCE

# BIOMEDICAL INNOVATION

## Research and Design in Biomedical Science

## INTRODUCTION

Welcome to an exciting exploration of the innovative side of biomedical science! In this section, you will embark on a journey that sharpens your critical thinking skills and deepens your understanding of scientific data.

As you investigate this fascinating field, you will learn to **critique and compare scientific data presented in popular media with data presented in scientific journals**. This vital skill will empower you to differentiate between general claims and research-based findings, ensuring you can confidently navigate the challenging field of information.

But there is more! You will dive into statistics, **applying knowledge of specified statistical analysis methods to analyse the results of experimental studies**. Imagine unravelling data mysteries and drawing correct conclusions—like being a detective in the lab!

This interactive approach encourages a mindset of inquiry and curiosity, equipping you with the tools necessary to tackle real-world scientific challenges. Get ready to enhance your skills and make informed judgments in the ever-evolving world of biomedical science!

### Key Ideas

- Scientific journals use complex language for scientists, while popular media simplifies findings for a general audience.
- Scientific journals ensure accuracy through a peer-review process where experts evaluate research before publication.
- Popular media can distort information through biases, such as exaggeration and corporate interests, which may mislead the public.
- Understanding independent and dependent variables is crucial, as independent variables are changed by the researcher and dependent variables are measured outcomes from the change.
- Important statistical terms, such as mean, median, mode, range, and standard deviation, help researchers interpret data clearly.
- Using charts like bar charts, pie charts and scatter plots makes it easier to understand the results and relationships in the data, improving communication of findings in biomedical research.

# DIFFERENCES BETWEEN SCIENTIFIC JOURNALS AND POPULAR MEDIA SOURCES WHEN IT COMES TO PRESENTING SCIENTIFIC DATA

In today's information age, navigating scientific data can be overwhelming as it influences your daily life. How can you make informed decisions about health trends and environmental issues? This calls for critiquing! To critique a paper means to analyse and evaluate (or examine and assess) its content, methodology (how the research was conducted), and conclusions (the results reached), pointing out strengths (positive aspects) and weaknesses (negative aspects) while providing constructive feedback (helpful comments for improvement).

By comparing data in popular media with that in scientific journals, you can separate fact from fiction. For example, when a news article claims a diet leads to rapid weight loss, checking scientific research can reveal its true effectiveness.

Have you ever wondered how science gets reported in the news versus in research papers? Well, scientific journals and popular media both share scientific data, but they do it differently. See **Table 6.1** to explore the key differences!

**Table 6.1:** Key differences between scientific journals and popular media

| Aspect | Scientific Journals | Popular Media |
|---|---|---|
| Audience | Written for scientists | Written for the public |
| Language | Complex and technical | Simple and accessible |
| Focus | Detailed methodologies and results | Main findings and implications |

How do these differences affect your understanding of scientific information? Let us examine some examples!

## Examples of Scientific Data in Scientific Journals vs. Popular Media Sources on the Same Topic

Check out these two examples of scientific data related to caffeine presented in both a scientific journal and a popular media source!

### Scientific Journal

Title: "The Effects of Caffeine on Cognitive Performance in Adolescents"
Data: "Participants were randomly assigned to receive 200 mg of caffeine. Cognitive performance was assessed using standardised tests. Analysis of variance revealed a significant main effect of caffeine on reaction time ($F(1, 48) = 4.23$, $p = .045$)."

## Popular Media Source

Headline: "Coffee Can Boost Brainpower in Teens"
Data: "A new study shows that drinking coffee can help teenagers think faster and more clearly."

Which presentation grabs your attention more—the detailed scientific journal or the catchy popular media headline?

Now, let us analyse and compare the two examples given above in detail!

1. **Clarity and specificity**: presenting information clearly (easy to understand) and specific (exact and detailed), allowing the audience to grasp the intended message without confusion (or ambiguity).

   *Scientific journal:*

   The data is presented in a precise manner, including specific figures such as the dosage of caffeine (200mg) and the statistical results (F-value and p-value). The F value and p-value show that the groups being compared are significantly or noticeably different. This level of detail allows readers to understand the exact findings and their significance.

   *Popular media source:*

   The information is more general and lacks specific data. Phrases like "can help teenagers think faster and more clearly" are vague and do not provide any quantitative measures or statistical evidence. This reduces clarity and specificity.

2. **Context and methodology**: understanding the background and setting of a study (context) as well as the approach and techniques used to conduct the research (methodology), which together help clarify the purpose and reliability or validity of the findings.

   *Scientific journal:*

   The article explains the method used in the study such as random assignment of participants and the use of standardised tests to assess cognitive performance. This gives readers insight into how the research was conducted and the reliability of the results.

   *Popular media source:*

   The article does not provide any details about how the study was conducted. There is no mention of the sample size, methodology, or controls, which leaves readers without context about the reliability or validity of the findings.

3. **Tone of the paper**: refers to the author's attitude (feeling) expressed through their writing style (how they write) and word choice (the words they use), affecting how the audience (readers) understands the message.

*Scientific journal:* The tone is objective and factual. It presents the findings without emotional language, focusing on statistical analysis to support the conclusions drawn. This tone is typical of academic writing, aiming to inform based on evidence.

*Popular media source:* The tone is more sensationalised (exaggerated). The headline "Coffee Can Boost Brainpower in Teens" uses persuasive language that appeals to emotions and curiosity rather than delivering a measured analysis. This approach aims to capture attention rather than provide a detailed understanding of the research.

Your turn! Search for other examples and find the differences between the two sources based on the following criteria:

a. Clarity and specificity: how detailed is the data?

b. Context and methodology: does it explain how the study was conducted?

c. Overall tone: is it objective or exaggerated?

## The Importance of Rigorous Peer Review

Did you know that scientific journals use a peer-review process? This means that other experts evaluate the research before it is published to ensure that it is correct and reliable. Here is how it works:

1. *Initial review:* an editor assigns the manuscript to experts who check for originality and clarity.
2. *Constructive feedback:* reviewers suggest improvements or corrections.
3. *Final decision:* the editor decides whether to publish based on reviewer feedback.

This process ensures that only correct and reliable studies are shared!

## Potential Biases That Can Occur in Popular Media

When it comes to popular media, various biases can shape how information is presented, potentially leading to a distorted understanding of scientific findings. Now, examine some common biases in popular media:

1. Confirmation bias: happens when people look for and trust information that supports what they already believe.
2. Selection bias: happens when some stories or viewpoints are chosen over others, leading to a distorted view of the issue.
3. Sensationalism: exaggerating stories to attract attention. Sensationalism is a problem because media outlets exaggerate stories to get attention, which can mislead people.
4. Corporate bias: influencing reports based on business interests. This can affect reporting because media outlets may focus on stories that benefit their sponsors.

Well done for the exploration! Get ready to enhance your skills and make informed decisions with some activities!

## Activity 6.1 Article Comparison Analysis

**Materials required**: Access to a computer or device to find articles, notebook or digital document for notes.

**Steps**:

1. Research two articles on the same topic—one from a scientific journal and one from popular media. After, you can check out these articles:
    a. scientific journals: Nature, PNAS, ScienceDaily.
    b. popular media: NPR, National Geographic, Live Science.
2. Read both articles carefully and answer the following questions.
    a. Who is the author and what are their qualifications?
    b. Does the article provide evidence to support its claims?
    c. Language and style: How does the language differ between the two articles?
3. Share your findings with a friend or colleague.

## Activity 6.2 Create a Scientific Article Review Checklist

**Materials required**: Notebook or digital document for checklist creation.

**Steps**:

1. Look up the typical steps involved in reviewing a scientific article. Consider aspects like:
    a. author credibility
    b. study design and method
    c. data analysis and results
    d. peer review status
2. Create your checklist in a notebook or digital document.
3. Use your checklist to review the articles from activity 6.1. How do they measure up against your criteria?

## Activity 6.3 Bias Identification Exercise

**Materials required**: Popular media article from Activity 6.1, notebook for writing.

**Steps**:

1. Read the popular media article you selected in Activity 6.1.
2. Look for examples of:
    a. confirmation bias
    b. selection bias
    c. sensationalism
    d. corporate bias
3. Write a short paragraph describing how these biases might affect the reader's understanding of the science presented.

## Activity 6.4 Peer Review Process

**Materials required**: Notebook or digital document for writing, access to information about the peer review process.

**Steps:**

1. Research the 'Peer Review Process' on the internet or in textbooks.
2. Surf the internet and watch a video on how peer review works in scientific publishing.
3. Click here for another video! Summarise the steps involved in your notebook.
4. Share your findings with a colleague or family member.

## Activity 6.5 Evaluating Credibility in Scientific Reporting

**Materials required**: Access to articles, notebook for notes and evaluations.

**Steps:**

1. Find one scientific journal article and one popular media article on the same topic, such as nutrition or infections. Use local resources like:
    a. scientific journals**:** [Ghana Medical Journal], [BMC Public Health].
    b. popular media: [Ghana Web Health], [Myjoy online health].
2. Read both articles and take notes on:
    a. trustworthiness: who wrote it? Are they an expert?

b. evidence: does it mention studies or reliable sources?
c. accuracy: does it match what you know from trusted sources?
d. depth of information: how detailed is the information presented?

3. In your notebook, draw a table to compare the articles based on the points above.

# BASIC STATISTICAL CONCEPTS RELEVANT TO ANALYSING DATA IN BIOMEDICAL RESEARCH

Statistical analysis methods are techniques used to collect, analyse, and interpret data to understand patterns and make informed decisions. Here, you will explore how to apply specific statistical analysis methods to interpret the results of experimental studies. Ready to explore how different techniques can reveal new findings? Let us get started!

Essential statistical concepts for analysing biomedical research data include measures of central tendency, variability, and hypothesis testing. For example, in assessing a new medication's effectiveness, understanding the mean helps healthcare professionals evaluate overall outcomes, while the standard deviation shows variability among patients, allowing for more personalised treatment decisions.

## Understanding Variables

Let us start with the basics! A variable is any characteristic, number, or quantity that can be measured or counted. In research and experiments, variables can change or vary, hence the name. The two common types of variables are:

1. Independent variable
2. Dependent variable (see **Table 6.2**)

**Table 6.2:** Types of variables

| Variable Type | Description | Example |
|---|---|---|
| Independent Variable | The factor (variable) you change or control in an experiment. | Amount of fertiliser applied to plants. |
| Dependent Variable | The outcome (variable) you measure in response to changes. | Height of the plants. |

**Did you know?**

*To ensure reliable results that are due only to the independent variable, you need to keep certain factors constant. These factors are called control variables!*

Can you think of an independent variable and a dependent variable in your everyday life?

## Example Study: Fertiliser and Plant Growth

Imagine a study testing how fertiliser affects plant growth (see **Table 6.3**). Here is a dataset:

**Table 6.3:** Effect of fertiliser on plant growth

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

In this example,

a. independent variable: the amount of fertiliser (this is what you are changing).

b. dependent variable: the plant height (this is what you are measuring).

c. control variables (factors that should be kept constant to ensure a fair test) include:

   type of plant, type of soil, amount of water given, amount of sunlight received, temperature of the environment, pot size (if using pots), and duration of the experiment.

   Keeping these variables, constant ensures that any changes in plant height are due to the fertiliser amount and no other factors. 🌱

What do you think happens to plant height as the amount of fertiliser increases? Why is it important to understand these concepts?

- As the independent variable (the amount of fertiliser) increases, we expect the dependent variable (plant height) to rise, but only up to a certain point.
- This relationship helps researchers find the right balance of nutrients for healthy plants. By understanding this, farmers can improve their crop yields and make a positive impact on food production!

## Statistical Terms Used in Scientific Research

Understanding these basic statistical concepts and how to analyse data is essential in biomedical research. By finding variables, applying statistical methods, and visualising data, you can draw meaningful conclusions from experiments.

In biomedical research, statistics help us understand data. Researchers perform statistical calculations using software like:

a. GraphPad Prism: helps scientists to study and display data for visualisation.
b. Excel: a tool for organising and calculating information.
c. SPSS: used for analysing data in social science.
d. MATLAB: a program for math calculations and coding.

Now, let us investigate the basic key statistical concepts!

## Measures of Central Tendency

These are statistical tools that describe the centre or typical value of a dataset. They help summarise a large set of numbers with a single value that stands for the entire group. The three main measures of central tendency are:

1. **Mean**: the average of all the numbers in a dataset. You find it by adding up all the values and then dividing by the number of values.

   Example: For the numbers 2, 3, and 5, the mean is $(2 + 3 + 5) / 3 = 10 / 3 = 3.33$

   One application: used to calculate the average body mass index (BMI) of a group to identify health trends.

2. **Median**: the middle value when the numbers are arranged in order. If there is an even number of values, the median is the average of the two middle numbers.

   Example: For the odd number of values 1, 3, 3, 6, 7, the median is 3 (the middle value). For an even number of values like 1, 2, 3, 4, the median is $(2 + 3) / 2 = 2.5$.

   One application: often used in clinical studies to find the median survival time of patients.

3. **Mode**: the number that appears most often in a dataset. A dataset can have one mode, more than one mode (bimodal or multimodal), or no mode at all if all values are unique.

   Example: In the numbers 1, 2, 2, 3, the mode is 2 because it appears most often.

   One application: used to find the most common symptoms during a disease outbreak, helping health officials prioritise responses.

   Your turn! Here is a set of numbers: 5, 7, 7, 10, 12, find the mean, median, and mode.

   (Expected answers: Mean = 8.2, Median = 7 and Mode = 7)

## Measures of Variability

These are statistical tools that describe how spread out or varied a set of data is. They help to understand the extent to which data points differ from each other. Common measures of variability include:

1. **range**: difference between the highest and lowest values in a dataset.
2. **variance**: average of the squared differences from the mean, showing how much the values vary.
3. **standard deviation (SD)**: square root of the variance, showing how much the data points typically differ from the mean in the same units as the data.

Try this out! Imagine you are measuring the blood glucose levels of two groups of patients: Group A: 75, 77, 76, 74, 75 mg/dL and Group B: 50, 90, 75, 100, 60 mg/dL. Find the range, variance and SD.

**Hint:**

| Statistic | Group A | Group B |
|---|---|---|
| Range (Highest-Lowest) | 77 – 74 = 3 | 100 – 50 = 50 |
| Mean | = 75.4 | = 75 |
| Squared differences | $(75-75.4)^2$, $(77-75.4)^2$, $(76-75.4)^2$, $(74-75.4)^2$, $(75-75.4)^2$ | $(50-75)^2$, $(90-75)^2$, $(75-75)^2$, $(100-75)^2$, $(60-75)^2$ |
| Variance | | |
| SD | $\sqrt{\text{Variance}} \approx 1.02$ | $\sqrt{\text{Variance}} \approx 18.44$ |

Both groups might have similar average glucose levels, but notice how the values differ:

- In Group A, the glucose levels are close to the average, so the standard deviation is small, meaning there's slight variation in the group.
- In Group B, the glucose levels vary a lot, with some much lower and others much higher than the average. This results in a higher standard deviation, which shows greater variability in blood glucose levels.

## Hypothesis Testing (p-value)

This is a statistical method used to figure out whether there is enough evidence to support a specific claim or hypothesis about a population based on sample data. This is a way to see if there is a real difference between the groups being studied. It begins with two ideas such as:

1. the null hypothesis, which says there is no difference between the groups being studied.
2. the alternative hypothesis, which says there is a difference in the groups.

A p-value is calculated to check the evidence against the null hypothesis; for instance,

- if the p-value is less than 0.05 ($p < 0.05$), it usually means there is a significant difference, and you reject the null hypothesis.
- if the p-value is greater than 0.05 ($p > 0.05$), it suggests there is no significant difference, and the null hypothesis is not rejected.

Example: In a study on "The Effects of Caffeine on Cognitive Performance in Adolescents," the p-value is 0.045, which suggests a significant difference.

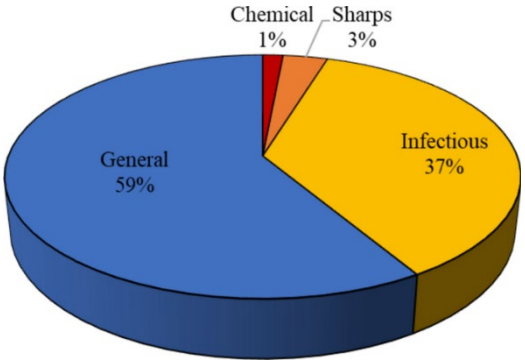
## OBSERVING AND ANALYSING SAMPLE DATA SETS

Experiments are usually repeated multiple times (often three or more) to ensure accuracy. Software like Excel and GraphPad Prism helps calculate important parameters, including standard deviation, mean, and p-value for comparing data samples.

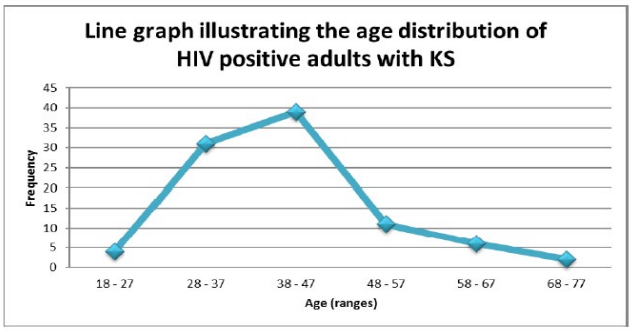
Once the data is collected, it can be visually represented using tools like Databox, PowerBI, and Tableau to create engaging visuals that make interpreting results easier. Common types of graphs used for visualisation (displaying data) include bar charts, pie charts, histograms, line charts and scatter plots (see **Table 6.4** and **Fig. 6.1**).

**Table 6.4:** Types of Charts for Visualisation

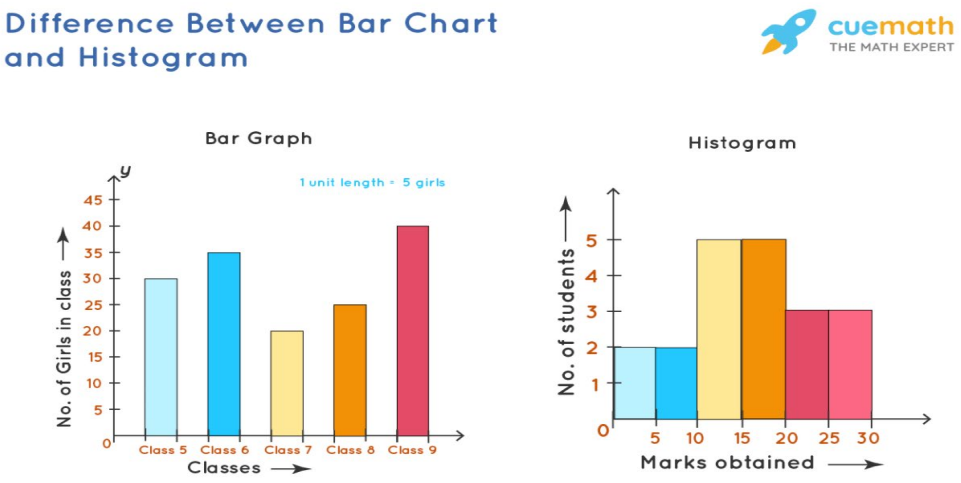
| Chart Type | Description |
|---|---|
| Bar chart | Displays categories with rectangular bars, making it easy to compare separate groups or values. Bars have equal spacing between them to represent categorical data. |
| Histogram | Bars do not have spaces between them because they represent continuous data. |
| Pie chart | Illustrates parts of a whole, representing proportions of various categories as slices of a circle. |
| Line chart | Displays trends over time by connecting data points with a line, useful for showing changes and patterns. |
| Scatter plot | Illustrates relationships between two variables by plotting points on a grid, helping to find correlations. |



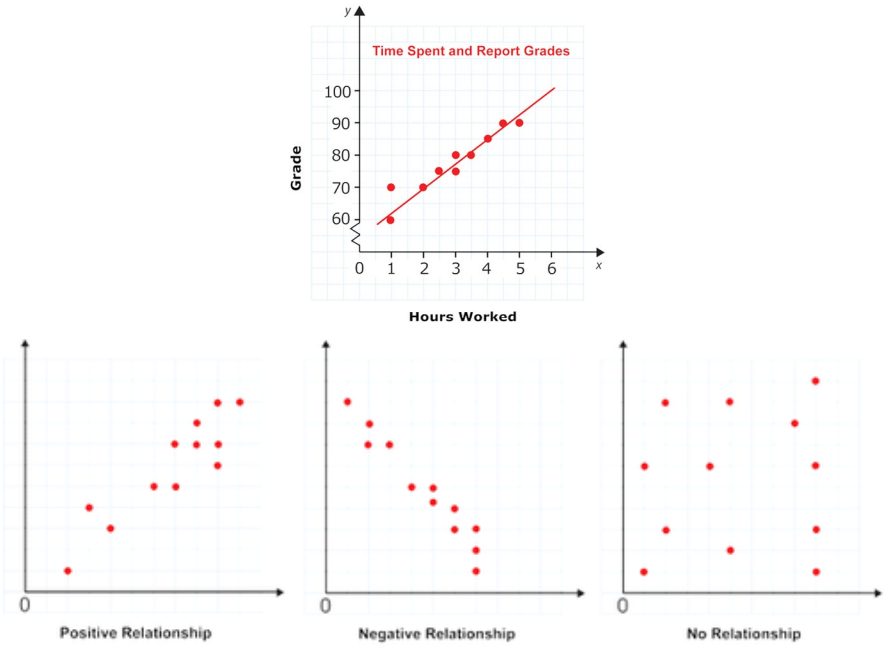

**Pie chart**




**Line chart**




***Bar Graph and Histogram***




***Scatter plot***

**Figure 6.1:** Types of data visualisation charts

Want to explore more? Choose a type of chart you like and create a simple chart using data from the fertiliser example or any data from Biomedical science. How does visualising data help you understand it better?

Excellent work done for completing this last section! Before you start the activities, think about this: if you could choose one statistical method to uncover insights in research, which one would it be and why? How might these skills enhance your studies or future research?

## Activity 6.6 Finding Variables in a Biomedical Study

**Steps**:

1. Find a simple biomedical study online of from textbooks, such as one about the effects of a new medication or a diet on health outcomes.
2. Write down the independent variable (the factor being changed) and the dependent variable (the outcome being measured). What should be the control variables here?
3. Share your findings with a friend or family member on how changing the independent variable might affect the dependent variable.

## Activity 6.7 Calculating Measures of Central Tendency

**Steps**:

1. Use the dataset, 78, 85, 92, 88, 76, 95 to complete a, b and c.
    a. Add all numbers in the dataset and divide by the count of numbers.
    b. Find the middle number when the dataset is arranged in order.
    c. Find the number that appears most often.
2. Predict the measures of central tendency for a, b and c above!
3. Jot down your note to include what these measures tell you about the data set.
4. Answer key:

    a. Mean = 85.67  b. Median = 88  c. Mode = N/A (no repeating scores).

## Activity 6.8 Exploring Measures of Variability

**Materials needed**: data set (start with data set in activity 6.7), notebook or digital document.

**Steps**:

1. Using the same dataset in activity 6.7, calculate the range, variance and standard deviation. How to do this;
    a. Subtract the smallest score from the largest. What does this value stand for?
    b. Find the average of the squared differences from the mean (85.67) such as:
    c. $(78-85.67)^2 = (-7.67)^2 \approx 58.78$
    d. $(85-85.67)^2 = (-0.67)^2 \approx 0.45$, etc.
    e. Next, add the results in (b) above: (58.78+0.45+40.07+5.43+93.51+87.07) /6. Predict the name of this value!
    f. Calculate the square root of (c) above. What does this value stand for?
2. Educate someone on why understanding variability is important in data analysis.
3. Answer key:

    Range = 19, Variance = 47.55, Standard deviation ≈ 6.896.

## Activity 6.9 Visualising Data with Changing Scales

**Steps**:

1. Create a scatter plot or histogram: use a simple graphing tool (like Excel or an online graphing tool) to plot the previously calculated data set.
2. Change the y-axis scale: change the scale of the y-axis (ordinate) to see how it affects the appearance of the data.
3. Write a short paragraph and share the importance of choosing proper scales when presenting data.
4. Answer key: Changing the scale can exaggerate or diminish the perceived differences in data points, leading to potential misinterpretations.

## Activity 6.10 New Supplement's Effect on Blood Sugar

**Materials needed**: Access to Excel or statistical software, notebook or digital document.

**Steps**:

1. You will study how a new dietary supplement affects blood sugar levels. There are two groups of participants:
    a. Supplement group takes the new supplement.
    b. Placebo group: takes a sugar pill that has no effect.

2. Write a hypothesis based on what you think will happen. For example: "The new supplement will lower blood sugar levels compared to the placebo."
3. Review the data: Here is the blood sugar data (in mg/dL) collected after 8 weeks:
    a. Supplement Group: 130, 125, 120, 115, 115
    b. Placebo Group: 135, 140, 138, 137, 139
4. Calculate the Mean (Average) Blood Sugar Levels
    a. For the Supplement Group:
        i. Add the numbers: $130 + 125 + 120 + 115 + 115 = 605$
        ii. Divide by the number of values (5): $605 \div 5 = 121$
    b. For the Placebo Group:
        i. Add the numbers: $135 + 140 + 138 + 137 + 139 = 689$
        ii. Divide by the number of values (5): $689 \div 5 = 137.8$
5. Find the variables
    a. Independent variable: the type of treatment (supplement vs. placebo).
    b. Dependent variable: blood sugar levels of the participants.
6. Write a brief note on any limitations of the study, such as:
    a. the number of participants (is it large enough?)
    b. the duration of the study (Was 8 weeks long enough to see effects?)
7. Write a summary of your results. Did the data support your hypothesis? What conclusions can you draw about the supplement's effect on blood sugar levels?

## Self-reflection

1. Why is it important for me to clearly define the independent and dependent variables in a biomedical study?
2. Why is it important for me to calculate and understand the mean, median, and mode of a dataset? How do these measures help me summarise and interpret data in a meaningful way? How can I apply the concept of statistical tools to my everyday life or future studies?

# EXTENDED READING

- Use The Awareness and Practice of Self-Medication Among the General Public in Jeddah and Makkah - PMC to explore scientific journals.
- 4 Questions For Researchers and Institutions Involved In Human Subjects Research - NIH Extramural Nexus can provide you key questions for researchers.
- Check out this to read more on how data is utilised Embracing Diversity: The Imperative for Inclusive Clinical Trials | HMS Postgraduate Education from Havard University.

# REVIEW QUESTIONS 6.1

## Read the case study carefully and answer questions 1 to 5

**Case Study: The Effects of Caffeine on Cognitive Performance in Adolescents**

Researchers conducted a study to investigate the impact of caffeine on cognitive performance in adolescents. They recruited 60 healthy adolescents between the ages of 13 and 17 and randomly assigned them to two groups: a caffeine group and a placebo group.

The caffeine group received a 200mg caffeine supplement, while the placebo group received a placebo (inert substance) capsule. All participants were then asked to complete a series of cognitive tests measuring attention, memory, and problem-solving abilities.

The researchers collected the test scores for each participant and calculated the mean scores for each group. The mean score for the caffeine group was 85, with a standard deviation of 5. The mean score for the placebo group was 80, with a standard deviation of 6.

To figure out if the difference in mean scores between the two groups was statistically significant, the researchers conducted hypothesis testing. The p-value from the t-test was 0.02.

## Multiple-Choice Questions

1. What is the independent variable in this study?

   A. Age of the participants
   B. Caffeine consumption
   C. Cognitive test scores
   D. Standard deviation

2. What is the dependent variable in this study?

   A. Age of the participants
   B. Caffeine consumption
   C. Cognitive test scores
   D. Standard deviation

3. Based on the information provided, what is the mean score for the placebo group?

   A. 75
   B. 80
   C. 85
   D. 90

4. The p-value reported in the study is …

   A. 0.20
   B. 0.10
   C. 0.05
   D. 0.02

5. Based on the p-value of the study, which of the following conclusions can be drawn about the effectiveness of caffeine on cognitive performance, and what implications does this have for the null hypothesis?

   A. The null hypothesis should be accepted, showing no effect of caffeine on the cognitive performance of adolescents.

   B. The study design may have flaws that affect the comparison between the groups being studied by the researchers.

   C. There is a significant difference between the groups, suggesting that caffeine influences cognitive performance.

   D. There is no significant difference between the groups, showing that caffeine does not affect cognitive performance.

## Essay Type Questions

1. What is one characteristic of scientific articles?
2. Name one popular media outlet that covers health news.
3. Describe how scientific journals and popular media differ in their audience.
4. What role does evidence play in scientific articles?
5. How does peer review improve the quality of research published in scientific journals?
6. Evaluate the reliability of a health article based on the following factors:

   A. The author's qualifications

   B. The sources cited in the article

   C. The date of publication

7. Research a current topic in biomedical science (e.g., vaccine development or mental health treatments) and compare how it is reported in popular media versus scientific journals. Discuss the implications of these differences for public understanding and health decisions.

# ANSWERS TO REVIEW QUESTIONS 1.1

**1.**

a. Microscope
b. To confirm the presence of the *Plasmodium* parasite and diagnose malaria.
    i. Conduct community-wide malaria screening to detect early cases.
    ii. Collaborate with health officials to implement a community spraying program to reduce mosquito populations.

**2.**

a. Typhoid fever
b. To show if the water source was contaminated and to figure out if it was causing the spread of typhoid fever
c. Implement a water purification system and educate the community on hygiene practices, such as using treated water and proper handwashing techniques

**3.**

a. Sickle cell disease
b. To show the couple the possible genetic outcomes for their children, including the risk of inheriting sickle cell disease.
c. The counsellor can suggest genetic testing before pregnancy, consider prenatal testing for early detection, or explore the choice of in-vitro fertilisation with genetic screening.

**4.**

a. Hypertension (high blood pressure)
b. Because the patient often forgets to take their medication, a reminder app could help improve their adherence to the treatment plan.
c. The pharmacist could organise monthly educational workshops to teach patients about the importance of diet and exercise in managing hypertension or create a support group for patients to share their experiences and coping strategies.

**5.**

a. Tuberculosis (TB)
b. Because they were exposed to elevated levels of silica dust, which weakened their lungs and increased their susceptibility to tuberculosis
    i. Implement a regular dust monitoring and control program in the mining area.
    ii. Provide periodic training on the use of protective equipment and the importance of lung health.

**6.**

a. Forensic pathology
    i. Autopsy examination: A thorough internal and external examination of the body to find injuries, diseases, or abnormalities.

ii. Toxicology analysis: Testing body fluids and tissues to detect the presence of toxins, drugs, or poisons.

b. Plausible causes of death include blunt force trauma to the head or poisoning. The pathologist can figure out the exact cause by correlating the head injury's severity with internal damage and comparing it to the concentration of the toxic substance found in the body. If the toxic substance is present in lethal amounts, it might suggest poisoning as the primary cause, while a significant head injury could cause trauma-related death.

**7.**

a. Blood Spatter Analysis.

b. Circular blood patterns show that the blood fell at a 90-degree angle, suggesting a stationary source or vertical drop. Elongated patterns show that the blood fell at an angle, suggesting movement or force applied, such as from a swinging object or a person in motion.

c. The circular blood patterns on the wall suggest that the victim was standing close to the wall when initially injured. The elongated bloodstains on the floor indicate the victim or perpetrator was moving, during a struggle. Blood spatter analysis can help figure out the direction of movement, weapon position, and the sequence of events that occurred during the attack.

**8.**

a. Dental records, which include teeth structure, dental fillings, braces, and other unique dental work.

i. Teeth are extremely durable and can survive high temperatures, making them ideal for identification in cases of fire or severe trauma.

ii. Each person's teeth have unique features such as dental fillings, restorations, or braces that make them easily identifiable when compared to dental records.

b. The forensic odontologist compares the patterns, size, and shape of dental fillings or braces found on the recovered teeth with the individual's dental records. This includes matching the type of dental work, the positioning of teeth, and any specific dental treatments recorded. If a match is found, it confirms the person's identity, even if other body parts are unrecognisable.

**9 and 10:.** Refer to rubrics for key features needed for each essay question

**11.** a. The primary goal is to test a new drug aimed at slowing the progression of Alzheimer's disease.

b. Patient consent ensures that participants understand their rights and the potential risks involved in the study.

c. These personal connections may foster a trusting atmosphere, which can enhance the quality of data collected and improve the overall experience of the participants.

d. Dr. Smith designs and conducts the trial while checking the effects of the medication on consenting patients.

e. Their ability to provide care while conducting research may lead to more comprehensive monitoring of patient responses, improving the quality of data collected.

**12.** Forensic science involves applying scientific principles to legal matters. Biomedical science aids this process through techniques like DNA analysis, toxicology, and blood analysis to investigate crimes and find victims.

**13.** Roles such as pathologists analyse tissue samples to diagnose diseases, while clinical researchers develop new treatments. Their work is vital for improving patient outcomes and advancing medical knowledge.

**14.** Forensic science uses biomedical techniques like DNA profiling to match suspects to crime scenes and toxicology to figure out causes of death, enhancing the accuracy of investigations.

**15.** An overview might include careers like precision medicine specialists, who use genetic information to tailor treatments, and telehealth providers, reflecting a shift towards digital healthcare solutions in the future.

**16.** The project could involve studying the effectiveness of new DNA sequencing technologies in solving cold cases. The methodology would include collecting samples, analysing them with advanced sequencing, and comparing results with existing databases to find potential matches. Expected outcomes may include improved identification rates and insights into unresolved cases.

# ANSWERS TO REVIEW QUESTIONS 2.1

## Multiple-choice questions and short-answer questions

**1.** D **2.** A **3.** C **4.** A **5.** C **6.** A

**7** a. pathogen b. Personal Protective Equipment c. a bacterium

## Essay type

**1-2:.** Refer to notes on ***Description of Features of the Biosafety Levels and Proper Practice***

**3.** The worker should immediately notify colleagues, contain the spill using right materials, and follow the lab's spill response procedures while wearing PPE.

**4.** Waste should be segregated into biohazard bags, properly labelled, and disposed of according to local regulations and laboratory protocols (guidelines) for biohazardous waste.

**5.** Not following biosafety protocols in a BSL-3 lab could lead to grave consequences such as laboratory-acquired infections, contamination of the lab environment, and potential outbreaks in the community.

**6.** Training can enhance awareness of risks, ensure proper use of PPE, and reinforce protocols for handling pathogens, leading to a safer work environment, and reducing the likelihood of accidents.

**7.** The technician should receive immediate retraining on PPE guidelines, a review of the incident should be conducted to understand the reasons for the violation, and proper corrective actions should be implemented to prevent future occurrences.

**8.**

a. *Staphylococcus aureus* is classified as Biosafety Level 2 (BSL-2). Dr. Patel should wear the appropriate PPE, including gloves, lab coat, and eye protection. She should also work in a BSC for procedures that may create aerosols (airborne particles ) and ensure proper waste disposal of any contaminated materials.

b. Dr. Patel should at once isolate the mislabelled samples and notify her supervisor. She should clearly label the samples as "do not use" until they can be correctly identified and assessed. Additionally, she should inform her colleagues about the situation to prevent any accidental exposure.

c. Dr. Patel can start a training session for all lab staff on the importance of correct labelling. Implementing a double-check system where two staff members verify sample labelling before storage can also help. Furthermore, she could advocate the use of digital tracking systems for sample management to reduce human error in labelling.

**9.**

a. The nurse should at once report the issue to the hospital's infection control officer. She should ensure that the waste is clearly marked as biohazardous and temporarily secure it to prevent any accidental contact until it can be properly disposed of.

b. The hospital can set up regular training sessions for staff on proper waste disposal practices. Additionally, creating a clear waste management protocol and choosing specific areas for biohazardous waste disposal can enhance safety. Providing adequate disposal containers and ensuring they are regularly emptied is also crucial.

c. The hospital can launch an awareness campaign that includes posters, workshops, and informational sessions highlighting the risks associated with improper waste disposal. Involving staff in safety drills and providing incentives for compliance can also motivate adherence to biosafety practices.

**10.**

a. The student should immediately notify the lab supervisor and cordon off the area to prevent others from entering. Using proper PPE, such as gloves and a lab coat, the student should then cover the spill with absorbent materials, like paper towels or a spill kit, to hold it.

b. After holding the spill, the student should disinfect the area with a suitable disinfectant, ensuring that it covers the spill entirely. Once the area is clean, the contaminated materials should be disposed of in biohazard waste containers. The area should then be checked for safety before resuming work.

c. The university can implement regular safety training for students and staff, focusing on proper handling techniques and spill response. Establishing clear protocols for lab safety and ensuring that spill kits are readily available in all labs can further enhance safety. Regular inspections of lab practices can also help find areas for improvement.

**11.**

a. The university lab used a Class II biosafety cabinet.

b. The student quickly responded by using disinfectant.

c. The consequence of not reporting the incident promptly could lead to an increased risk of contamination and failure to implement necessary safety measures.

**12.**

a. The research facility used a Class III BSC

b. The researcher neglected to wear the required PPE

c. After the incident was documented, a safety review was conducted.

# ANSWERS TO REVIEW QUESTIONS 3.1

## Case scenario 1

a. The frontal lobe

b. The cerebellum contributes to Kwame's performance by coordinating his balance, motor skills, and muscle coordination. This helps him maintain his balance while running, changing direction, and executing complex movements on the field

c. Sensory input from Kwame's eyes (visual information) and ears (auditory information) plays a crucial role in his decision-making by providing him with real-time data about his surroundings. His eyes help him track the ball, opponents, and teammates, while his ears allow him to hear cues, like the sound of the ball or instructions from teammates. This sensory information is processed by the brain, helping Kwame make quick, informed decisions.

d. The frontal lobe and cerebellum work together to enhance Kwame's football performance. The frontal lobe plans and makes decisions about movements and strategies, while the cerebellum ensures those movements are smooth, coordinated, and precise. For example, as Kwame decides to make a quick pass or dodge an opponent, the frontal lobe initiates the action, and the cerebellum fine-tunes the coordination and balance required to execute the move successfully. This interaction allows for effective and efficient performance on the field.

## Case scenario 2

a. The occipital lobe

b. The temporal lobe helps Ama by enabling her to recall memories of past artwork and emotional experiences that inspire her current painting. It also plays a role in processing sounds and emotions, adding depth to her creative expression.

c. The occipital lobe processes the visual information Ama sees while painting, such as colours, shapes, and the overall composition. At the same time, the temporal lobe brings in memories and emotional responses to past artworks and experiences. These two lobes work together as the occipital lobe provides the raw visual data and the temporal lobe connects it with emotional and experiential contexts, helping Ama create meaningful and personal artwork.

d. Emotional memory plays a crucial role in Ama's artwork, as it connects her current creative process with past experiences and emotions. The temporal lobe helps Ama recall these emotional memories, influencing her artistic choices, such as colour selection, composition, and the mood she wishes to convey. Emotional memory allows Ama to infuse her artwork with personal meaning, making her paintings more expressive and reflective of her feelings and experiences.

## Case scenario 3

a. The parietal lobe helps Kofi process touch sensations and spatial awareness, which are important for understanding concepts like distance, size, and spatial relationships, all of which are key in solving mathematical problems.

b. Kofi's difficulty in integrating sensory information may affect his ability to understand abstract mathematical concepts that require spatial reasoning (such as geometry) and the ability to manipulate numbers mentally. It could also make it harder for him to use tactile feedback (e.g., using physical objects or tools like rulers and protractors) to grasp concepts.

c. Kofi can use strategies such as hands-on learning with physical objects (e.g., blocks, measuring tools, or geometric shapes) to engage his parietal lobe and improve spatial awareness. Additionally, using visual aids like diagrams, graphs, and interactive math software can help his brain process sensory information more effectively, reinforcing concepts through multiple senses. Regular practice with these activities can strengthen his brain's ability to integrate spatial and tactile information.

d. A tailored learning plan for Kofi could include the following activities:

- Hands-on exercises: Use physical objects like blocks or geometric shapes to help him visualise mathematical concepts such as area, volume, and spatial relationships.
- Interactive learning tools: Utilise math apps or software that allow him to manipulate objects on a screen (e.g., 3D models or virtual graphing).
- Real-world math applications: Encourage activities like measuring objects around the house, estimating distances, or creating simple floor plans to strengthen spatial reasoning.
- Drawing and sketching: Have Kofi draw geometric shapes, angles, or simple diagrams to improve his ability to visualise and understand space.
- Frequent feedback: Regular check-ins with his teacher to assess progress, adjust strategies, and provide encouragement will help keep him engaged and focused.

These activities will help Kofi improve his ability to integrate sensory information and strengthen the functions of his parietal lobe, ultimately enhancing his performance in mathematics.

## Case scenario 4

a. The hippocampus in the temporal lobe helps Mama Adwoa form and remember memories.

b. Cognitive exercises like memory games help her brain stay active, improve memory, and make it easier to remember things by strengthening the brain's memory areas..

c. Mama Adwoa's family plays an important role by engaging her in memory games and storytelling, both of which help stimulate her hippocampus. These activities provide mental exercise, encourage social interaction, and offer emotional support, all of which contribute to better memory retention. By making the experience enjoyable and social, her family can help reduce feelings of frustration and improve her overall cognitive health.

d. Memory exercises help Mama Adwoa remember things better, slow down memory problems, and make her feel more confident. With family support, these exercises can help her stay happy, improve her brain health, and keep her more independent.

## Case scenario 5

a. The immediate action the student took was to pull their hand away from the hot surface.

b. The sensory input involves sensory neurons detecting the heat and sending signals to the spinal cord, while the motor output involves motor neurons carrying signals back to the muscles to retract the hand.

c. The spinal cord processes the reflex action by at once sending a signal to the muscles to react, allowing for a quicker response because it bypasses the brain.

## Case scenario 6

a. The hormone released by the pancreas is insulin.

b. Insulin helps regulate blood sugar levels by helping the absorption of glucose into cells, thus lowering blood sugar levels after a meal.

c. Maintaining balanced blood sugar levels is crucial for overall health, as imbalances can lead to conditions such as diabetes and obesity.

# ANSWERS TO REVIEW QUESTIONS 4.1

## 1. Case Scenario: Living with a Nervous System Disorder

a. How does Parkinson's disease affect both Adjoa's body and emotions?

- Body: Parkinson's disease makes it hard for Adjoa to move. She may have shaking hands (tremors), stiff muscles, and trouble walking. These symptoms make daily activities, like eating or dressing, more difficult.
- Emotions: Adjoa may feel sad, frustrated, or anxious because she cannot do things as easily as before. Losing independence can affect her happiness.

b. What role does the nervous system play in controlling movement, and how does Parkinson's disease interfere with this process?

- The nervous system sends messages from the brain to the muscles, telling them how to move.
- In Parkinson's disease, some brain cells that produce dopamine (a chemical that helps with smooth movement) stop working.
- This causes shaking, stiffness, and slow movement because the brain cannot properly control the muscles.

c. How might Adjoa's emotions affect her overall health and life?

- If Adjoa feels sad or stressed, her condition might feel worse.
- If she feels supported and encouraged, she might be able to stay more active and happier.
- Emotional health is important for overall well-being, just like physical health!

**2.** At what year does movement ability fall below 50% of normal?

Looking at the movement ability data:

- At year 6, movement ability is 50%.
- At year 8, movement ability drops to 30%.

Since the ability goes below 50% after year 6, the answer is: Between year 6 and year 8 (around year 7).

## 3. Case Scenario: Understanding an Endocrine Disorder

a. List two other symptoms that a person with Ama's condition might experience.

- Increased hunger but continued weight loss
- Feeling very hot even in cool temperatures

b. Based on her symptoms; identify the endocrine disorder the doctor suspects.

The doctor suspects hyperthyroidism, a condition where the thyroid gland produces too many hormones, making the body work faster than normal.

c. Explain how the thyroid gland's function relates to Ama's symptoms.

- The thyroid gland produces hormones (T3 and T4) that control how fast the body uses energy (metabolism).
- In hyperthyroidism, too much thyroid hormone speeds up body functions, causing fast heartbeat, sweating, weight loss, restlessness, and shakiness.

d. Suggest a possible treatment and explain how it would help manage her symptoms.

- Anti-thyroid medication: Slows down the production of thyroid hormones.
- Radioactive iodine therapy: Reduces the activity of the thyroid gland.
- Beta-blockers: Help control symptoms like a fast heartbeat and shakiness, but do not treat the thyroid itself.

**4.** Thyroid Hormone Levels Over Time

a. How much higher is the T3 level in a person with hyperthyroidism at month 6 compared to the normal level?

- Normal T3 at month 6 = 1.3 pg/mL
- Hyperthyroid T3 at month 6 = 4.0 pg/mL
- Difference: 4.0 - 1.3 = 2.7 pg/mL

The T3 level is 2.7 pg/mL higher in a person with hyperthyroidism.

b. If a doctor wants to lower the T4 level of a hyperthyroid patient back to 8.2 ng/dL, by how much does it need to decrease from month 6? Show your calculations.

- Hyperthyroid T4 at month 6 = 18.0 ng/dL
- Target T4 level = 8.2 ng/dL
- Amount to decrease: 18.0 - 8.2 = 9.8 ng/dL

The doctor needs to reduce the T4 level by 9.8 ng/dL to bring it back to normal.

**5. Case Scenario: Ama's Diabetes Journey**

a. What are some common symptoms and risk factors that may have contributed to Ama's diagnosis of Type 2 diabetes?

Symptoms of Type 2 Diabetes:

- Feeling very thirsty often
- Feeling tired all the time
- Going to the toilet frequently to urinate
- Having blurry vision

- Slow healing of wounds or cuts
- Losing weight without trying

Risk Factors:

- Family history: If a parent or grandparent has diabetes, the risk is higher.
- Unhealthy diet: Eating too many sugary and fatty foods can lead to diabetes.
- Not exercising: Sitting too much and not moving enough increases the risk.
- Being overweight: Too much fat in the body makes it hard for insulin to work properly.
- Getting older: The risk increases with age, but even young people can get Type 2 diabetes.

b. How might Ama's genetics and lifestyle choices have influenced her development of Type 2 diabetes?

- Genetics (Family History): Ama's family members had diabetes, meaning she was already at risk of getting the disease.
- Lifestyle Choices:
    * Eating unhealthy foods: Too much sugar and unhealthy fats make it harder for the body to control blood sugar.
    * Not exercising enough: Exercise helps the body use insulin properly, but if Ama does not move enough, her body might struggle to regulate blood sugar.
    * Being overweight: Too much fat in the body stops insulin from working well, which can cause diabetes.

c. Propose a community awareness campaign to help individuals like Ama manage and prevent Type 2 diabetes.

Campaign Title: Stay Active, Eat Healthy!

*Goals:*

- Teach people about diabetes and how to prevent it.
- Show people how to eat healthy and make better food choices.
- Encourage people to exercise and stay active.
- Offer free health check-ups for early detection of diabetes.
- Provide support for people with diabetes to help them manage it better.

*Activities:*

- School Health Talks: Invite doctors or nurses to talk about diabetes in schools.

- Exercise Clubs: Organize group activities like skipping rope, football, and dancing.
- Healthy Eating Challenges: Encourage families to eat more fruits, vegetables, and whole grains.
- Community Walks: Organize walks to raise awareness about diabetes.
- Social Media Campaigns: Share simple messages and videos on healthy living.

## 6. Case Scenario: Adjoa's Science Project on Bacteria and Viruses

a. Name one structural feature that bacteria have but viruses do not.

*Cell wall (Bacteria have a cell wall, while viruses do not.)*

b. Name one structural feature that viruses have but bacteria do not.

*Protein coat (capsid) (Viruses have a capsid that protects their genetic material.)*

c. How does each feature help bacteria or viruses survive?

- *Cell wall (Bacteria): The cell wall gives bacteria shape and protection, helping them survive in different environments.*
- *Capsid (Viruses): The capsid protects the virus's genetic material and helps it attach to and enter host cells.*

d If Adjoa wanted to explain to her classmates how bacterial and viral infections are treated differently, what key points should she include?

- Bacterial Infections:
  * Treated with antibiotics (e.g., penicillin).
  * Some bacteria can develop antibiotic resistance if medicines are misused.
- Viral Infections:
  * Cannot be treated with antibiotics.
  * Some viruses have antiviral medicines (e.g., for HIV or flu).
  * Vaccines can prevent certain viral infections (e.g., polio, COVID-19).
  * The body's immune system fights viruses over time.

## 7. Growth of Bacterial vs. Viral Infections Over Time

a. Which type of infection (bacterial or viral) grows faster in the first five days? Show your calculations.

- Bacterial Growth from Day 1 to Day 5:
  - Day 1: $2 \times 10^3$ cells
  - Day 5: $20 \times 10^3$ cells

- Increase: 20 - 2 = 18 × $10^3$ cells

- Viral Growth from Day 1 to Day 5:
  - Day 1: 10 × $10^3$ particles
  - Day 5: 40 × $10^3$ particles
  - Increase: 40 - 10 = 30 × $10^3$ particles
- Conclusion: The virus grows faster because it increased by 30 × $10^3$ in five days, while bacteria increased by 18 × $10^3$.

b. By what percentage does the bacterial count increase from day 1 to day 10?

- Day 1 count = 2 × $10^3$
- Day 10 count = 100 × $10^3$
- Increase = (100 - 2) = 98 × $10^3$
- Percentage increase:

  Therefore, bacterial count increases by 4,900% over 10 days.

c. If an antibiotic reduces bacterial growth by 50% by day 10, what would be the new bacterial count?

- Day 10 bacterial count: 100 × $10^3$
- 50% reduction:
- New count after treatment: 50 × $10^3$ cells.

## 8. Case Scenario: Akosua's Health Lesson

a. Name two bacterial infections and two viral infections that can affect the reproductive system.

- Bacterial Infections: Chlamydia, Gonorrhoea
- Viral Infections: Herpes (HSV), Human Papillomavirus (HPV)

b. What is the difference between a sexually transmitted infection (STI) and a sexually transmitted disease (STD)?

- STI (Sexually Transmitted Infection): A person may have an infection (bacteria, virus, or parasite) without showing symptoms.
- STD (Sexually Transmitted Disease): When an infection leads to noticeable symptoms or health complications, it becomes a disease.
- Key Difference: All STDs start as STIs, but not all STIs develop into STDs.

c. Suggest ways that Akosua and her friends can stay informed and protect their reproductive health.

- Attend health education programs in school or community centres.

- Use protection (e.g., condoms) to reduce the risk of infections.
- Get vaccinated (e.g., HPV vaccine) to prevent certain viral infections.
- Go for regular check-ups to detect infections early.
- Access reliable information from doctors, teachers, or health websites like WHO and CDC.
- Encourage open discussions with trusted adults or health professionals.

### 9. Reported Cases of Chlamydia and Herpes

a. Calculate the percentage increase in reported cases of each infection from 2019 to 2023.

- Chlamydia:
- Herpes:
- Answer:
  - Chlamydia increased by 66.7%
  - Herpes increased by 80%

b. Explain why chlamydia cases are rising faster than herpes cases and discuss the impact on reproductive health.

- Reasons for the Increase in Chlamydia Cases:
  - Many people with chlamydia have no symptoms, so they unknowingly spread it.
  - Lack of regular screening means infections go undetected and untreated.
  - Easier transmission through unprotected sexual contact.
- Impact on Reproductive Health:
  - Untreated chlamydia can cause infertility, pelvic inflammatory disease (PID), and complications during pregnancy.
  - Herpes is lifelong and causes painful sores, but it does not usually cause infertility.
  - The increasing cases of both infections highlight the need for better education, testing, and prevention efforts.

### 10. Case Scenario: Kwame's Immune System Discovery

a. What are antigens and antibodies?

- Antigens are harmful substances like viruses, bacteria, or toxins that trigger an immune response.

- Antibodies are special proteins produced by the immune system to recognize and attack antigens.

b. How do antibodies help the body fight infections?

- Antibodies attach to antigens, marking them for destruction by immune cells.
- They neutralize pathogens by preventing them from entering cells.
- Some antibodies help immune cells (like white blood cells) destroy infected cells.

c. Explain how vaccines help the body fight diseases.

- Vaccines introduce a weakened or inactive form of an antigen into the body.
- The immune system responds by producing antibodies and memory cells.
- If exposed to the real infection later, the immune system quickly produces antibodies to fight the disease.

## 11. Antibody Production Over Time

a. Time taken to reach peak antibody production and comparison between exposures

- First Exposure: Peak antibody level (100 units) occurs at Day 25.
- Second Exposure: Peak antibody level (150 units) occurs at Day 25.
- The second exposure results in a stronger and faster response, as antibodies are produced at a much higher rate.

b. Percentage increase in peak antibody levels between first and second exposure

The peak antibody level increased by 50% after the second exposure.

c. Why does the second exposure result in a stronger and faster immune response?

- After the first infection, memory cells remain in the body.
- These memory cells recognize the antigen quickly and produce antibodies much faster upon second exposure.
- This helps the immune system fight the infection more efficiently, reducing the severity of illness.

## 12. Case Scenario: Antibiotic Resistance in a Clinical Setting

a. What are antibiotics, and what type of microorganisms do they target?

- Antibiotics are medications used to kill or inhibit the growth of bacteria.
- They specifically target bacterial infections and do not work against viruses, fungi, or parasites.

b. Explain the mechanisms by which antibiotics work to eliminate bacterial infections.
Antibiotics work through different mechanisms, including:

- Inhibiting Cell Wall Synthesis – Prevents bacteria from building a protective cell wall, leading to their destruction (e.g., Penicillin, Cephalosporins).
- Blocking Protein Synthesis – Prevents bacteria from making essential proteins, stopping their growth (e.g., Tetracyclines, Macrolides).
- Disrupting DNA or RNA Synthesis – Interferes with bacterial genetic material, preventing replication (e.g., Fluoroquinolones).
- Inhibiting Metabolic Pathways – Blocks bacterial enzymes needed for survival (e.g., Sulphonamides).

c. Why might the patient's infection persist despite trying different antibiotics?
The infection may persist due to antibiotic resistance, which occurs when bacteria evolve and survive despite antibiotic treatment. Possible reasons include:

- Bacterial Mutations – Genetic changes make bacteria resistant to antibiotics.
- Overuse/Misuse of Antibiotics – Taking antibiotics unnecessarily (e.g., for viral infections) or not completing doses leads to resistance.
- Biofilm Formation – Some bacteria form protective layers, making them harder to eliminate.
- Efflux Pumps – Certain bacteria develop pumps to remove antibiotics from their cells before they can take effect.

In Ama's case, the bacteria are multi-drug resistant (MDR), making treatment difficult and requiring alternative therapies, such as combination antibiotics or new-generation drugs.

## 13. Case Scenario: Aisha's Community Challenge

a. Name two bacterial diseases and two viral diseases that affect global health.

- Bacterial Diseases:
  * Tuberculosis (TB) – Affects the lungs and spreads through airborne droplets.
  * Typhoid Fever – Affects the digestive system and spreads through contaminated food and water.
- Viral Diseases:
  * COVID-19 – A respiratory disease caused by the SARS-CoV-2 virus.
  * HIV/AIDS – A viral infection that weakens the immune system over time.

b. Why might people with diseases like COVID-19 and tuberculosis face social stigma?

- Fear of Transmission – Many people avoid TB and COVID-19 patients due to misconceptions about how easily they spread.
- Lack of Awareness – Some believe these diseases result from personal faults or lifestyle choices.
- Historical Association with Poverty – TB, for example, has often been linked to poor living conditions, creating social discrimination.
- Visible Symptoms – Chronic coughing, weight loss, or other symptoms may lead to embarrassment and exclusion.

c. How can communities help reduce fear and misinformation about these diseases?

- Health Education Campaigns – Educate people on how these diseases spread and how they can be prevented.
- Encourage Testing and Treatment – Promote regular health check-ups and make treatments accessible.
- Use Trusted Community Leaders – Religious and social leaders can help combat stigma through awareness.
- Promote Empathy and Support – Encourage community-based programs that provide emotional and financial support for affected individuals.

d. Propose two strategies to support individuals living with these diseases and help them feel accepted in society.

- Community Support Groups – Establish peer support networks where affected individuals can share their experiences and receive encouragement.
- Anti-Stigma Campaigns – Use media and schools to spread messages of acceptance, focusing on real stories of recovery and hope.

## 14. Analysis of Infectious Disease Data

a. Calculate the percentage of bacterial vs. viral infections.

Total bacterial cases: 5,200 + 3,800 + 2,400 = 11,400
Total viral cases: 12,500 + 8,600 + 4,700 = 25,800
Total reported cases: 11,400 + 25,800 = 37,200

- Bacterial infections percentage:
- Viral infections percentage:

Thus, viral infections contribute more to the disease burden in this community (69.4%) than bacterial infections (30.6%).

b. Calculate the percentage of total infections caused by bacterial and viral diseases.

- Tuberculosis:
- Pneumonia:

- Typhoid Fever:
- COVID-19:
- Influenza:
- HIV/AIDS:

c. Compare the disease burden and suggest why some diseases might have higher reported cases than others.

- COVID-19 has the highest number of cases (33.6%), likely due to its high transmissibility and frequent outbreaks.
- Influenza is also widespread (23.1%), as it spreads easily through respiratory droplets, especially in crowded areas.
- TB (14%) and HIV/AIDS (12.6%) are lower but still significant due to their long-term impact and slower transmission.
- Typhoid Fever (6.5%) has the lowest cases, likely due to improved water sanitation in some areas.

# ANSWERS TO REVIEW QUESTIONS 5.1

**1.**

a. Vaccination equipment, and screening tests (e.g., mammography).

b. Physical therapy equipment, mobility aids (e.g., crutches, wheelchairs).

c. Digital thermometer, home blood pressure monitor.

**2.** Diagnostic imaging is a medical technique used to visualise the internal structures of the body to diagnose and check various health conditions.

**3. For 3 to 6: refer to notes on prosthetics and orthotics**

**7. For 7 to 10, refer to notes on cancer.**

**11. Refer to notes on regenerative medicine.**

**12.** Embryonic stem cell, adult stem cell.

**13.** Stem cells are used in treatments to promote the repair and regeneration of damaged tissues, as they can develop into different cell types, potentially reversing damage caused by injury or disease.

**14.** Refer to notes on future of regenerative medicine

**15.**

a. Uses magnetic fields and radio waves to produce detailed images of organs and tissues.

b. Monitors the electrical activity of the heart to detect heart conditions.

c. Amplifies DNA sequences, useful in diagnostics for detecting diseases like COVID-19.

**16. Refer to Table 5.1**

**17.** A prosthetic leg allows a person with an amputation to regain balance, mobility, and the ability to walk, enhancing independence and quality of life.

**18.** An orthosis, like a knee brace, provides stability and support to weak joints, helping prevent further injury and reducing pain during movement.

**19.** They enhance mobility, reduce pain, and enable individuals to perform daily tasks independently, improving both physical and mental well-being.

**20.** A prosthetic device replaces a lost body part, while a brace supports an existing part to correct or enhance its function.

**21. For 21 to 24,** refer to notes on treatments and therapies for cancer.

**25.** Refer to note on the future of regenerative medicine.

**26.** Stem cells can be directed to develop into specific cell types needed to repair damaged tissue. For example, in diseases like heart disease, stem cells can be used to regenerate damaged heart tissue, while in injuries, they can help repair damaged bone or cartilage.

**27.** Tissue regeneration involves using the body's own cells or engineered tissues to regrow damaged tissue, while artificial organs are synthetic devices that replace organ function without integrating with the body's natural tissues.

**28.** Expected response: In my local clinic, there is a lack of telemedicine equipment. Without telemedicine, patients with limited mobility or those in remote areas struggle to access timely medical consultations, leading to delayed care and worsened health outcomes. Integrating telemedicine would enable virtual consultations, improving access and early intervention opportunities, which could significantly enhance patient care and reduce hospital visits for non-critical cases.

**29.** The components that could handle unclear images and low signal quality in an ultrasound machine include:

- Image detector: If this part is malfunctioning, it may not capture the sound waves effectively, leading to poor image quality.
- Image processor: If the processing algorithms (instructions) are not functioning properly, the images may not be enhanced correctly, resulting in unclear visuals.
- Power supply: Insufficient power may affect the performance of both the detector and processor, leading to weak signals.

Reasoning: Each of these components plays a critical role in the overall functionality of the ultrasound machine. If any one of them fails, it can directly affect the quality of the images produced.

**30.** An ankle brace provides extra support, stabilising the joint, which helps prevent reinjury and allows safe participation in physical activities.

**31.** A prosthetic arm can enable a person to hold objects, eat, and carry out tasks requiring grip and hand coordination, promoting independence.

**32.** They restore function and independence, which can improve self-esteem, reduce frustration, and increase social engagement.

**33.** Example: Breast Cancer Case Study: a patient is diagnosed with breast cancer after routine screening. The tumour is small and localized, so she undergoes surgery to remove it, followed by chemotherapy to destroy any remaining cancer cells. She experiences fatigue and hair loss during chemotherapy, but the treatment successfully eradicates the cancer. Her follow-up care includes regular check-ups, and she stays in remission.

**34.** Physical side effects of chemotherapy may include fatigue, nausea, hair loss, skin changes, and anaemia. Radiation therapy may cause skin irritation, fatigue, and localised pain or swelling around the treatment area.

**35.** Emotional and mental challenges like anxiety, depression, and fear of recurrence can significantly affect a patient's quality of life, leading to stress, isolation, and difficulty coping with daily tasks. These issues may require more support such as psychotherapy or support groups.

**36.** Immunotherapy boosts the body's immune system to fight cancer by using substances that help the immune system recognise and destroy cancer cells. It can be combined with other treatments like chemotherapy or radiation therapy to increase the effectiveness of treatment, as it helps target cancer cells that may not respond to traditional therapies alone.

**37.** Arguments for investment may cite the potential to cure previously untreatable conditions, reduce long-term healthcare costs by curing chronic diseases, and improve the quality of life for patients. However, opponents may argue that the field is still in initial stages, with high costs and uncertain outcomes, and that funds might be better spent on more immediate healthcare needs.

**38.** Regenerative medicine could improve access to treatments for many diseases, but there are concerns about cost and accessibility. If treatments are expensive, they may only be available to wealthier individuals, potentially widening the gap in healthcare equity unless supported by public funds or healthcare systems.

# ANSWERS TO REVIEW QUESTIONS 6.1

**MCQs: 1**. B **2.** C **3.** B **4.** D **5.** C

1. One characteristic of scientific articles is that they are typically peer-reviewed, meaning they are evaluated by experts in the field before publication to ensure accuracy and credibility. Refer to notes on scientific articles for more.
2. Ghana health service, My Joy Health news, newspapers and magazines.
3. Scientific journals are aimed at a specialised audience, such as researchers and professionals, who need detailed and technical information. In contrast, popular media sources target the public, focusing on making scientific information engaging and easily understandable.
4. Evidence plays a critical role in scientific articles by providing the data and research findings that support claims. This evidence must be credible and reproducible, allowing other researchers to verify results and build upon the work.
5. Peer review improves the quality of research published in scientific journals by subjecting the work to scrutiny from experts in the same field. This process helps find any methodological flaws, biases, or errors, ensuring that only reliable findings are published.
6. To evaluate the reliability of a health article:
    a. Author's qualifications: assess whether the author has relevant ability, such as advanced degrees or professional experience in the field.
    b. Sources cited: check if the article references credible and reputable sources, such as peer-reviewed studies or established health organisations.
    c. Date of publication: consider the timeliness of the article, as health information can change rapidly; recent articles are more reliable.
7. Researching the topic of vaccine development reveals that popular media often emphasise sensational stories, focusing on public fears or controversies, while scientific journals present detailed studies with data on efficacy and safety. For example, a popular media article may highlight adverse reactions to vaccines, drawing attention with dramatic headlines, while a scientific journal would provide comprehensive data showing overall vaccine safety and effectiveness. These differences can significantly affect public understanding, leading to misconceptions or fear of vaccines, which may affect health decisions and vaccination rates in the community.

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# GLOSSARY

| | |
|---|---|
| **Adaptive Immunity** | A specific immune response that develops over time, involving memory cells that recognize and respond more effectively to previously encountered pathogens. |
| **Addison's Disease** | A condition caused by insufficient production of adrenal hormones, leading to symptoms such as fatigue, weight loss, and darkening of the skin. |
| **Adrenal Gland** | Small triangular glands located on top of the kidneys that produce hormones like cortisol, which helps regulate metabolism, immune response, and stress adaptation. |
| **Allografts** | Tissue transplanted from one person to another. |
| **Ambulating ECG** | Refers to an electrocardiogram (ecg or ekg) that is performed while the patient is walking or moving around rather than being stationary. |
| **Amplification** | Involves making something larger, stronger, or more significant. |
| **Amygdala** | Is a small group of almond-shaped cells in the temporal lobe that plays a key role in processing emotions, particularly fear and pleasure (happiness) |
| **Anatomy** | Is the study of the parts of the body, like organs and muscles, and how they are organised |
| **Antibiotic** | A type of medication used to treat bacterial infections by killing or inhibiting bacterial growth, but ineffective against viruses. |
| **Antibiotic Resistance** | The ability of bacteria to develop mechanisms that allow them to survive and grow despite the presence of antibiotics, making infections harder to treat. |
| **Antibiotics** | Medications used to kill or inhibit the growth of bacteria by targeting specific bacterial structures or functions without harming human cells. |
| **Antibody** | A protein produced by b cells that specifically binds to an antigen to neutralise or mark it for destruction by other immune cells. |
| **Antigen** | A molecule found on the surface of pathogens that is recognized by the immune system as foreign, triggering an immune response. |
| **Antiviral Medications** | Drugs designed to target specific stages of the viral life cycle, helping to manage viral infections such as hiv, herpes, and hepatitis b and c. |
| **Aphasia** | A language disorder caused by damage to specific brain regions (such as broca's area), affecting a person's ability to speak, understand, read, or write. It is commonly associated with stroke and brain injuries. |
| **Autoimmune Disorder** | A condition in which the immune system mistakenly attacks the body's own tissues, leading to diseases such as multiple sclerosis or type 1 diabetes. |
| **Assistive devices** | Tools that help people perform tasks they might struggle with due to disabilities. |

| | |
|---|---|
| **Auditory cortex (or auditory complex)** | Is a part of the brain in the temporal lobe responsible for processing and interpreting sound, including speech, music, and environmental noises. |
| **Autografts** | Tissue transplanted from one part of a person's body to another. |
| **Bacteria** | Single-celled, living microorganisms that can exist independently or as parasites. Some bacteria are beneficial, while others cause diseases such as tuberculosis and pneumonia. |
| **Bacterial Cell Wall** | A structural layer that surrounds bacterial cells, providing protection and shape. Some antibiotics, such as penicillin, target cell wall synthesis to kill bacteria. |
| **Bacterial Infection** | An illness caused by harmful bacteria entering and multiplying in the body, often treated with antibiotics. |
| **Bias** | Favouring one side over another, which can affect fairness. |
| **Biochip** | A small device that holds many tiny biological tests for analysing genes or proteins. |
| **Biohazard** | A biological substance that can harm living things or the environment. |
| **Biohazardous waste** | Waste containing potentially infectious or harmful materials and requires special disposal methods. |
| **Bioinstrumentation** | The use of instruments to measure biological data for medical purposes. |
| **Biological agent** | Refers to a living organism or its products that can cause harm to humans, animals, or the environment. This includes bacteria, viruses, fungi, and toxins that can lead to diseases or adverse health effects. |
| **Biological sensors (or biosensors)** | Devices that detect biological changes in the body, like glucose levels. |
| **Biomedical Science** | The study of biological processes and their applications to medicine and health. |
| **Biosafety** | Protecting people, animals, and the environment from harmful biological materials. |
| **Biosafety Cabinet (BSC)** | Enclosed, ventilated lab workspace for safely handling infectious microorganisms. |
| **Biosafety Levels (BSLs)** | Safety standards (bsl-1 to bsl-4) defining containment protocols based on risk. |
| **Black light** | Is a type of lamp that emits ultraviolet (uv) light, which is not visible to the naked eye. It causes certain materials like glo germ, to glow. |
| **Brain coordination** | The ability of different brain regions to work together effectively. |
| **Brain mapping** | A technique used to visualise and understand brain structure and function. |
| **Brain mapping technology** | Tools and methods used to study and measure brain functions. |
| **Brainstem** | Connects the brain to the spinal cord and regulates vital functions such as breathing, heart rate, and blood pressure. |
| **Capsid** | The protein shell that encloses the genetic material of a virus, providing protection and aiding in infection. |

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| **Career path** | A series of jobs or roles that lead to a particular profession or career goal. |
| **Cell counters** | Devices that automatically count and analyse cells in a sample. |
| **Cellular therapy** | Involves using cells, often stem cells, to regenerate damaged tissues or replace unhealthy cells. |
| **Central sulcus** | Is a deep groove in the brain that separates the frontal lobe from the parietal lobe and helps differentiate areas involved in motor control and sensory processing. |
| **Cerebellum** | Is located at the back of the brain and is crucial for motor control, coordination, balance, and some cognitive processes |
| **Cerebral cortex (or cerebrum)** | Is the outer layer of the brain that controls thinking, senses, movement, language, and emotions, and it is divided into four main parts: frontal, parietal, temporal, and occipital lobes. |
| **Chemotherapy** | A treatment that uses drugs to kill or slow the growth of cancer cells. |
| **Chromatography machine** | A tool used to separate different substances in a mixture for analysis. |
| **Class I BSC** | Basic cabinet protecting personnel and the environment but not samples. |
| **Class II BSC** | Cabinet protecting personnel, environment, and samples, with various subclasses. |
| **Class III BSC** | Fully enclosed “glove box” providing maximum containment for high-risk agents. |
| **Clinical centrifuge** | A device that spins samples quickly to separate fluids based on density. |
| **Clinical laboratory incubator** | A machine that keeps a warm environment for growing bacteria or cells. |
| **Clinical specimens** | Samples taken from patients for the purpose of medical testing and diagnosis. |
| **Databox** | A business intelligence tool that helps users visualise and analyse data from multiple sources. |
| **Dependent variable** | The part of the experiment that is measured or observed in response to changes in the independent variable. |
| **Depression** | A mental health condition that causes persistent sadness and a loss of interest in activities. |
| **Diabetes** | A chronic condition caused by either insufficient insulin production by the pancreas or the body’s ineffective use of insulin, resulting in high blood sugar levels. |
| **Diabetes mellitus** | A chronic metabolic disorder characterised by high blood glucose levels due to the body’s inability to produce or effectively use insulin. |
| **Diagnostic Analysis** | The process of examining samples to find diseases or health issues. |
| **Dialysis** | A treatment that removes waste and excess fluid from the blood when kidneys are not working properly. |
| **Disease** | A condition that disrupts normal bodily functions or processes. |

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| **Disease Prevention** | Strategies and measures taken to reduce the risk of disease occurrence. |
| **Disorder** | A disruption in normal bodily function, often used interchangeably with disease but sometimes referring more specifically to conditions without a single known cause, such as mental health disorders or metabolic disorders. Non-infectious. |
| **Donning and Doffing** | Putting on and safely removing ppe to prevent contamination. |
| **Dwarfism** | A condition where a person is much shorter than average, often due to genetic factors or hormone issues. |
| **Effector** | Refers to an organ or tissue that responds to stimuli in the body, such as a muscle contracting or a gland secreting a hormone. |
| **Electrocardiogram (ECG)** | A test that measures the electrical activity of the heart. |
| **Electroencephalogram (EEG)** | A test that records electrical activity in the brain. |
| **Electromagnetic radiation** | Energy that travels in waves, such as x-rays and light. |
| **Electromyogram (EMG)** | A test that measures the electrical activity of muscles. |
| **Electromyography (EMG)** | A test that measures the electrical activity of muscles to help diagnose muscle and nerve problems. |
| **Electrophysiology** | The study of electrical properties of biological cells and tissues, often used to measure brain activity. |
| **Endocrine system** | A network of glands that produce hormones, regulating body functions such as metabolism, growth, and reproduction. |
| **Enhanced healthcare** | Improvements in healthcare services and outcomes through various initiatives and practices. |
| **Enveloped virus** | A type of virus that has an outer lipid membrane derived from the host cell, which helps in infecting new cells (e.G., Hiv). |
| **Evidence** | Facts or information that support a claim. |
| **Epididymitis** | Inflammation of the epididymis (a coiled tube at the back of the testicle that stores and carries sperm), often caused by bacterial infections like chlamydia and gonorrhoea. |
| **Ethical consideration** | In biomedical science, it ensures that research and healthcare practices respect patient rights, maintain honesty, and provide fair access to treatments. |
| **Exaggerating** | Making something seem larger or more important than it really is. |
| **Experiment** | Is a scientific procedure undertaken to test a hypothesis or explore a question. |
| **Findings** | The results or conclusions of an experiment. |
| **Forensic Science** | The application of scientific methods and techniques to solve crimes and legal issues. |
| **Frontal lobe** | Is located at the front of the brain and is responsible for higher cognitive functions such as thinking, planning, problem-solving, and controlling voluntary movements, as well as managing emotions and behaviour. |
| **Fully integrated devices** | Medical devices that combine multiple functions into one system. |

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| **Genetic material** | The dna or rna that carries the genetic instructions of an organism. Bacteria typically have circular dna, while viruses can have dna or rna enclosed in a protein coat. |
| **Gene therapy** | Involves altering or replacing defective genes with new healthy genes to treat or prevent diseases. |
| **Gigantism** | A rare disorder caused by excessive secretion of growth hormone by the pituitary gland during childhood, leading to abnormal height and large body proportions. |
| **Gyri** | Are the raised, rounded areas or folds on the surface of the brain that increase the surface area of the cerebral cortex or cerebrum. |
| **Haematology analyser** | A device that tests blood to measure components like red and white blood cells, haemoglobin, and platelets for diagnosis and monitoring. |
| **Haemoglobin analyser** | A device that measures the amount of haemoglobin in blood to monitor anaemia. |
| **Health education** | The profession of educating people about health and wellness to promote better health choices. |
| **Healthcare outcomes** | The measurable effects of healthcare services on patient health and quality of life. |
| **HEPA (High-Efficiency Particulate Air)** | Is a type of air filter that captures at least 99.97% Of tiny particles, like dust and allergens, to improve air quality. |
| **Hippocampus** | Is a small, curved structure in the temporal lobe that is essential for forming new memories and spatial navigation (understanding locations and movement). |
| **Hormone** | A chemical produced by glands that regulates various functions in the body, such as growth, metabolism, and mood, by traveling through the bloodstream to target organs or cells. |
| **Host cell** | A living cell that a virus invades and uses to replicate its genetic material, since viruses cannot reproduce on their own. |
| **Hyperglycaemia** | A condition in which blood glucose levels are abnormally high, often a result of inadequate insulin production or insulin resistance. |
| **Hyperthyroidism** | A condition in which the thyroid gland overproduces hormones, leading to symptoms like weight loss, rapid heartbeat, and nervousness. |
| **Image processor** | A part that analyses and enhances images captured by diagnostic devices to improve clarity and interpretability. |
| **Immune response** | The body's defence mechanism against pathogens, involving white blood cells, antibodies, and various immune processes. |
| **Immunological memory** | The ability of the immune system to remember a previously encountered pathogen and mount a quicker, more effective response upon subsequent exposures. |
| **Immunotherapy** | Treatment that helps the immune system fight cancer. |
| **Independent variable** | The part of the experiment that is changed or controlled by the researcher. |
| **Infectious** | Refers to the ability of a disease or pathogen to spread from one person, organism, or environment to another. |

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| **Inflammation** | A biological response to injury or infection, characterized by redness, swelling, heat, and pain, which helps isolate and eliminate harmful agents. |
| **Innate immunity** | The body's first line of defence against pathogens; it is a non-specific immune response present from birth, including barriers like skin and mucous membranes. |
| **Insulin** | A hormone produced by the pancreas that regulates blood glucose levels by facilitating the uptake of glucose into cells for energy production. |
| **Laboratory-Acquired Infections (LAIs)** | Infections you get from handling biological materials in a lab. |
| **Leptin** | Is a key hormone in regulating hunger, energy balance, and fat storage. It communicates the body's fat stores to the brain and helps maintain a stable body weight. |
| **Malignant tumours** | Cancerous growths that can spread to other parts of the body. |
| **Mammography machine** | A specialised x-ray machine used to examine breast tissue for signs of cancer. |
| **Mastectomy** | A surgical procedure that involves the removal of one or both breasts, typically to treat or prevent breast cancer |
| **Median** | The middle value in a data set when the numbers are arranged in ascending order. |
| **Medical Laboratory Technician** | A healthcare worker who performs diagnostic tests and analyses on clinical specimens. |
| **Metabolism** | Is the chemical processes in the body that convert food into energy, allowing growth and maintenance of vital functions. |
| **Methodology** | Refers to the methods and processes used in conducting research or an experiment. |
| **Migraine** | A severe headache typically on one side of the head, often accompanied by nausea and sensitivity to light. |
| **Mobility aid** | Devices like walkers or wheelchairs that help people move around. |
| **Mode** | The number that occurs most frequently in a data set. |
| **Motor functions** | The actions and movements produced by the muscles under brain control. |
| **Neuron** | Is a specialised cell in the nervous system that transmits information through electrical and chemical signals, functioning as the basic building block of the brain and nervous system. |
| **Neuropathy** | Nerve damage caused by prolonged high blood glucose levels, leading to symptoms such as numbness, tingling, or pain, especially in the hands and feet. |
| **Non-enveloped virus** | A virus lacking a lipid envelope, making it generally more resistant to harsh environmental conditions (e.G., Adenovirus). |
| **Null hypothesis** | A prediction that there is no effect or no difference in an experiment. It is tested to see if it can be rejected. |
| **Occipital lobe** | Is located at the back of the brain and is primarily responsible for visual processing, interpreting information from the eyes to help you understand what you see |

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| **Manuscript** | Is a written document that is not yet published. |
| **Mean** | The average value of a set of numbers, calculated by adding them together and dividing by the number of values. |
| **Measures of Central Tendency** | These are statistical tools that describe the centre or typical value of a dataset. |
| **Oncology** | The branch of medicine that specialises in the diagnosis, treatment, and management of cancer. |
| **Orthosis** | Device used to support, align, or correct a body part, often to improve mobility or prevent further injury. |
| **Paper-based device** | A simple diagnostic tool that uses paper to test for specific substances. |
| **Parameters** | Measurable factors that describe communication processes in the body. |
| **Parietal lobe** | Is situated behind the frontal lobe and processes sensory information from the body, including touch, temperature, pain, and spatial awareness, helping you understand your environment. |
| **Pathogen** | Is a microorganism, such as a bacteria, virus, fungus, or parasite, that can cause disease or illness in a host organism. |
| **Peer review** | When experts check a study before it gets published. |
| **Pelvic Inflammatory Disease (PID)** | A severe complication of bacterial infections such as chlamydia and gonorrhoea in females, leading to inflammation of the reproductive organs, which may result in infertility. |
| **Peripheral Nervous System (PNS)** | The part of the nervous system that connects the brain and spinal cord to the rest of the body, helping to control movement and gather information from the senses. |
| **Personal Protective Equipment (PPE)** | Safety gear (e.G., Gloves, masks) worn to prevent contamination. |
| **Physiology** | Is the study of how the body works, including how organs and systems function together. |
| **Placebo** | Is a substance or treatment that has no therapeutic effect (often used in clinical trials as a control to compare against the actual treatment being tested). |
| **POCT tools** | Point-of-care testing tools that provide quick results at the location of patient care. |
| **Popular media** | Refers to accessible news sources like newspapers, magazines, and online platforms that inform the public. |
| **Power BI** | Is a data visualisation tool that allows users to create interactive reports and dashboards. |
| **Preventive measures** | Actions taken to prevent disease and promote health before it occurs. |
| **Professional responsibilities** | Duties and ethical obligations associated with a particular profession. |
| **Prosthesis** | An artificial device used to replace a missing body part, such as a limb or eye, to help restore function and improve mobility. |
| **Public health** | The science of protecting and improving the health of communities through education, policymaking, and research. |

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| **P-Value (or hypothesis testing)** | A number that helps decide if the results of a study are significant or just due to chance. |
| **Radiation therapy** | A treatment that uses high doses of radiation to kill cancer cells. |
| **Radiation therapy machine** | Equipment that uses high-energy radiation to treat cancer. |
| **Reflexes** | Are quick, automatic responses to specific stimuli (triggers) that happen without thinking, helping the body react quickly to changes for protection or adjustment. |
| **Regenerative medicine** | A field of medicine focused on repairing or replacing damaged tissues and organs using techniques like stem cell therapy and tissue engineering. |
| **Rehabilitation** | Therapy aimed at helping individuals recover or improve their physical abilities. |
| **Research Scientist** | A professional who investigates and studies diseases to understand their causes and effects. |
| **Respirators** | Are protective devices worn over the nose and mouth, or the entire face, to filter out harmful substances from the air. |
| **Rigorous** | It means strict and demanding, often requiring careful attention to detail. |
| **Robotic surgery** | A type of surgery performed with the help of robotic systems for precision. |
| **Scaffold** | Is a support structure used in tissue engineering that provides a base for cells to grow and form new tissue, guiding the healing process by mimicking the body's natural environment. |
| **Scientific journal** | Is a publication that shares peer-reviewed research and findings in specific fields of science. |
| **Selective toxicity** | The ability of antibiotics to specifically target bacterial cells while minimising harm to human cells. |
| **Sensor** | A device that detects and responds to physical stimuli (such as light, heat, or sound) to provide data for diagnostics. |
| **Sensory aid** | Tools that help individuals with sensory impairments, like hearing aids. |
| **Sensory processing** | The way the brain interprets sensory information from the environment. |
| **Spectroscopy** | A method that analyses light to show substances in a sample. |
| **Standard deviation** | Measures the amount of variation or dispersion in a set of values. |
| **Statistical tool** | A method or technique used to collect, analyse, interpret, and present data. For example, mean. |
| **Stem cells** | Special cells capable of turning into several types of cells in the body, used in regenerative medicine to repair damaged tissues, such as in spinal cord injuries or heart disease. |
| **Sterilisation** | Is the process of eliminating all microorganisms, including bacteria and viruses, from surfaces or equipment to ensure they are safe for use. |
| **Sulci** | Are shallow grooves or marks that separate the gyri and help define the boundaries between different brain regions and lobes. |

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| **Synapse** | Is the tiny gap or junction between two neurons (nerve cells) that allows them to communicate. |
| **Tableau** | A data visualisation (turning numbers into charts and graphs) software that lets users create interactive (clickable and dynamic) and shareable dashboards (organised data displays). |
| **Telemedicine** | The use of digital communication technologies, like video calls or mobile apps, to provide remote clinical healthcare services and consultations. |
| **Temporal lobe** | Is found on the sides of the brain around the ears and is involved in processing auditory information, language comprehension, and memory, as well as emotional responses. |
| **Tension headaches** | Common headaches that cause a dull ache or tightness around the forehead and back of the head, usually triggered by stress. |
| **Therapeutic** | Means something that helps heal or improve a person's health, either physically or mentally. |
| **Tissue engineering** | Is a scientific field that combines biology and engineering to create artificial tissues or organs by using cells, scaffolds, and growth factors to repair or replace damaged body tissues. |
| **Ultrasound** | A technique that uses sound waves to create images of organs and tissues inside the body. |
| **Urinalysis** | A test that examines urine to check for health issues. |
| **User interface** | How an operator interacts with a diagnostic device, allowing control over its functions and display of results. |
| **Vaccination** | A preventive strategy using weakened or inactivated pathogens or their components to stimulate immunity against infectious diseases. |
| **Validity** | Refers to how accurately a study or test measures what it is intended to measure. |
| **Variability** | How much a set of data points differ from each other. |
| **Variable** | A factor or element that can change and affect the results in an experiment or study. |
| **Variance** | A statistical measurement that indicates how much individual data points differ from the average. |
| **Wearable device** | Gadget worn on the body that tracks health data, like steps or heart rate. |
| **Xenografts** | Tissue transplanted from one species to another. |

# ACKNOWLEDGMENTS







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This book is intended to be used for the Year Two Biomedical Science Senior High School (SHS) Curriculum. It contains information and activities to support teachers to deliver the curriculum in the classroom as well as additional exercises to support learners' self-study and revision. Learners can use the review questions to assess their understanding and explore concepts and additional content in their own time using the extended reading list provided.

All materials can be accessed electronically from the Ministry of Education's Curriculum Microsite.

[Scan the QR Code to visit the website]

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