SCHEME : J

Name : _____

Roll No. : _____ Year : 20___ 20___

Exam Seat No. : _____

LABORATORY MANUAL FOR

HUMAN ANATOMY & PHYSIOLOGY

(20054)

FIRST YEAR D.PHARMACY

MAHARASHTRA STATE BOARD OF TECHNICAL EDUCATION, MUMBAI
(Autonomous) (ISO 9001: 2015) (ISO/IEC 27001:2013)

VISION

To ensure that the diploma level technical education constantly matches the latest requirements of technology and industry and includes the all-round personal development of students including social concerns and to become globally competitive, technology led organization.

MISSION

To provide high quality technical and managerial manpower, information and consultancy services to the industry and community to enable the industry and community to face the challenging technological & environmental challenges.

QUALITY POLICY

We, at MSBTE are committed to offer the best-in-class academic services to the students and institutes to enhance the delight of industry and society. This will be achieved through continual improvement in management practices adopted in the process of curriculum design, development, implementation, evaluation and monitoring system along with adequate faculty development programmes.

CORE VALUES

MSBTE believes in the following:

- ✓ Skill development in line with industry requirements.
- ✓ Industry readiness and improved employability of Diploma holders.
- ✓ Synergistic relationship with industry.
- ✓ Collective and Cooperative development of all stake holders.
- ✓ Technological interventions in societal development.
- ✓ Access to uniform quality technical education.

LABORATORY MANUAL OF

HUMAN ANATOMY & PHYSIOLOGY

(20054)

First Year

Diploma in Pharmacy

Maharashtra State Board of Technical Education, Mumbai.

(Autonomous)

(ISO 9001:2015) (ISO/IEC27001:2013)

PCI ER-2020/'J' Scheme Curriculum

Maharashtra State Board of Technical Education, Mumbai

(Autonomous) (ISO 9001:2015) (ISO/IEC27001:2013)

4th floor, Government Polytechnic Building, 49, Kherwadi, Bandra (E), Mumbai- 400 051

(Printed on – July 2024)

MAHARASHTRA STATE BOARD OF TECHNICAL EDUCATION, MUMBAI

CERTIFICATE

This is to certify that Mr. /Ms. _____

Roll No. _____ of First Year Diploma in Pharmacy studying at _____

has completed the practical work satisfactorily in Human Anatomy and Physiology (20054) for the academic year 20___ - 20___ as prescribed in the PCI ER 2020 syllabus.

Date: _____ Enrollment No.: _____

Place: _____ Exam Seat No.: _____

Course Teacher **Principal**

External Examiner

Seal of the Institute

MAHARASHTRA STATE BOARD OF TECHNICAL EDUCATION MUMBAI

PROGRAM OUTCOMES

1. **Pharmacy knowledge:** Possess knowledge and comprehension of the core and basic knowledge associated with the profession of pharmacy.
2. **Modern tool usage:** Learn, select, and apply appropriate methods and procedures, resources, and modern pharmacy-related computing tools with an understanding of the limitations.
3. **Leadership skills:** Understand and consider the human reaction to change, motivation issues, leadership and team-building when planning changes required for fulfilment of practice, professional and societal responsibilities. Assume participatory roles as responsible citizens or leadership roles when appropriate to facilitate improvement in health and wellbeing.
4. **Professional identity:** Understand, analyze and communicate the value of their professional roles in society (e.g. health care professionals, promoters of health, educators, managers, employers, employees).
5. **Pharmaceutical ethics:** Honour personal values and apply ethical principles in professional and social contexts. Demonstrate behavior that recognizes cultural and personal variability in values, communication and lifestyles. Use ethical frameworks; apply ethical principles while making decisions and take responsibility for the outcomes associated with the decisions.
6. **Communication:** Communicate effectively with the pharmacy community and with society at large, such as, being able to comprehend and write effective reports, make effective presentations and documentation, and give and receive clear instructions.
7. **The Pharmacist and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety and legal issues and the consequent responsibilities relevant to the professional pharmacy practice.
8. **Environment and sustainability:** Understand the impact of the professional pharmacy solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
9. **Life-long learning:** Recognize the need for and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change. Self-assess and use feedback effectively from others to identify learning needs and to satisfy these needs on an ongoing basis

COMPETENCIES FOR THE INDIAN D. PHARM HOLDERS

Competency is defined as "A distinct composite of knowledge, skill, attitude and value that is essential to the practice of the profession in real life contexts".

The candidates who successfully complete the Diploma in Pharmacy (D. Pharm) program of Education Regulations 2020 (ER-2020), from the institutions approved by the Pharmacy Council of India are expected to attain the following professional competencies.

1. Review Prescriptions: The student should receive and handle prescriptions in a professional manner and be able to check for their completeness and correctness. Also, the prescribers should be contacted for any clarifications & corrections in the prescriptions with suggestions if any.

2. Dispense Prescription / Non-Prescription Medicines: The student should be able to dispense the various scheduled drugs / medicines as per the implications of the Drug & Cosmetic Act and Rules thereunder. Also, the non-prescription medicines (over-the-counter drugs) should be dispensed judicially to the patients as required.

3. Provide Patient Counselling / Education: The student should be able to effectively counsel / educate the patients / caretakers about the prescription / non-prescription medicines and other health related issues. Effective communication includes using both oral and written communication skills and various communication techniques.

4. Hospital and Community Pharmacy Management: The student be able to manage the drug distribution system as per the policies and guidelines of the hospital pharmacy, good community pharmacy practice and the recommendations of regulatory agencies. Also, be able to manage the procurement, inventory, and distribution of medicines in hospital / community pharmacy settings.

5. Expertise on Medications: The student should be able to provide an expert opinion on medications to health care professionals on safe and effective medication – use, relevant policies and procedures based on available evidence.

6. Proficiency on Pharmaceutical Formulations: The student should be able to describe the chemistry, characteristics, types, merits and demerits of both drugs and excipients used in pharmaceutical formulations based on her/his knowledge and scientific resources.

7. Entrepreneurship and Leadership: The student should be able to acquire the entrepreneurial skills in the dynamic professional environments. Also, be able to achieve leadership skills through teamwork and sound decision-making skills.

8. Deliver Primary and Preventive Healthcare: The student should be able to contribute to various healthcare programs of the nation including disease prevention initiatives to improve public health. Also contribute to the promotion of national health policies.

9. Professional, Ethical and Legal Practice: The student should be able to deliver professional services in accordance with legal, ethical, and professional guidelines with integrity.

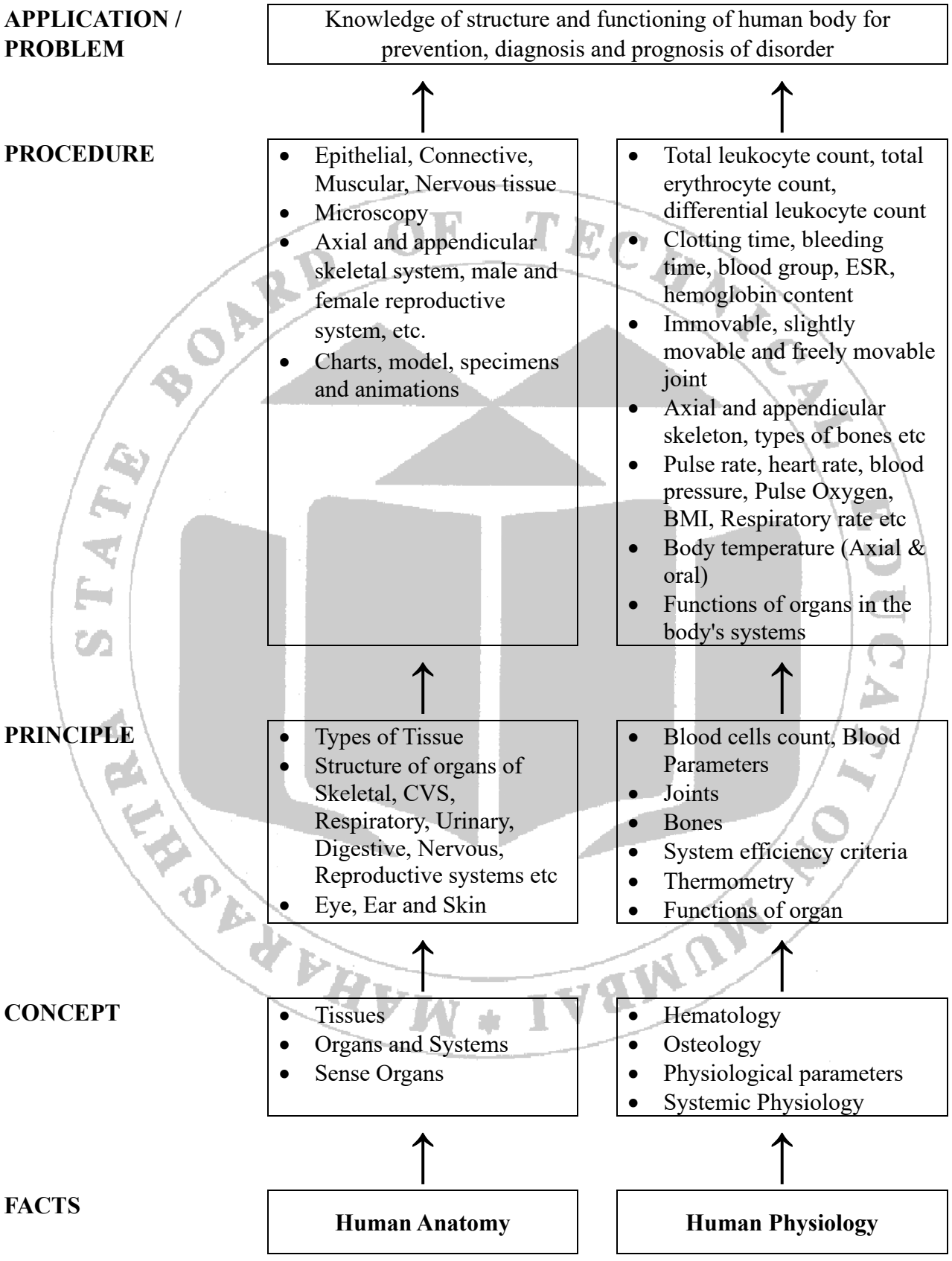
10. Continuing Professional Development: The student should be able to recognize the gaps in the knowledge and skills in the effective delivery of professional services from time to time and be self-motivated to bridge such gaps by attending continuing professional development programs.

COMPETENCY MAPPING WITH THE COURSE

Competencies	Human Anatomy & Physiology
1.Review Prescriptions	✓
2. Dispense Prescription / Non-Prescription Medicines	
3.Provide Patient Counselling / Education	✓
4.Hospital and Community Pharmacy Management	
5.Expertise on Medications	✓
6.Proficiency on Pharmaceutical Formulations	
7.Entrepreneurship and Leadership	
8.Deliver Primary and Preventive Healthcare	✓
9.Professional, Ethical and Legal Practice	
10.Continuing Professional Development	

GRAPHICAL STRUCTURE OF SUBJECT AREA

HUMAN ANATOMY AND PHYSIOLOGY (20054)



HUMAN ANATOMY AND PHYSIOLOGY – PRACTICAL

Course Code: ER20-14P/20054 **75 Hours (3 Hours/week)**

Scope:

This course is designed to train the students and instill the skills for carrying out basic physiological monitoring of various systems and functions.

Course Objectives:

This course will provide hands-on experiences to the students in

1. General blood collection techniques and carrying out various hematological assessments and interpreting the results
2. Recording and monitoring the vital physiological parameters in human subjects and the basic interpretations of the results
3. Microscopic examinations of the various tissues permanently mounted in glass slides
4. Discuss the anatomical and physiological characteristic of various organ systems of the body using models, charts and other teaching aids.

Course Outcomes:

Upon successful completion of this course, the students will be able to

1. Perform the hematological tests in human subjects and interpret the results
2. Record, monitor and document the vital physiological parameters of human subjects and interpret the results
3. Describe the anatomical features of the important human tissues under the microscopical conditions
4. Discuss the significance of various anatomical and physiological characteristics of the human body

Practicals

1. Study of compound microscope
2. General techniques for the collection of blood
3. Microscopic examination of Epithelial tissue, Cardiac muscle, Smooth muscle, Skeletal muscle, Connective tissue and Nervous tissue of ready / pre-prepared slides.
4. Study of Human Skeleton – Axial skeleton and appendicular skeleton
5. Determination of
    a. Blood group
    b. ESR
    c. Hemoglobin content of blood
    d. Bleeding time and Clotting time

6. Determination of WBC count of blood
7. Determination of RBC count of blood
8. Determination of Differential count of blood
9. Recording of Blood Pressure in various postures, different arms, before and after exertion and interpreting the results
10. Recording of Body temperature (using mercury, digital and IR thermometers at various locations), Pulse rate / Heart rate (at various locations in the body, before and after exertion), Respiratory Rate
11. Recording Pulse Oxygen (before and after exertion)
12. Recording force of air expelled using Peak Flow Meter
13. Measurement of height, weight, and BMI
14. Study of various systems and organs with the help of chart, models and specimens
    a) Cardiovascular system
    b) Respiratory system
    c) Digestive system
    d) Urinary system
    e) Endocrine system
    f) Reproductive system
    g) Nervous system
    h) Eye
    i) Ear
    j) Skin

STRATEGY FOR IMPLEMENTATION

It is suggested that 32-35% of experiments shall be completed before every sessional exam.

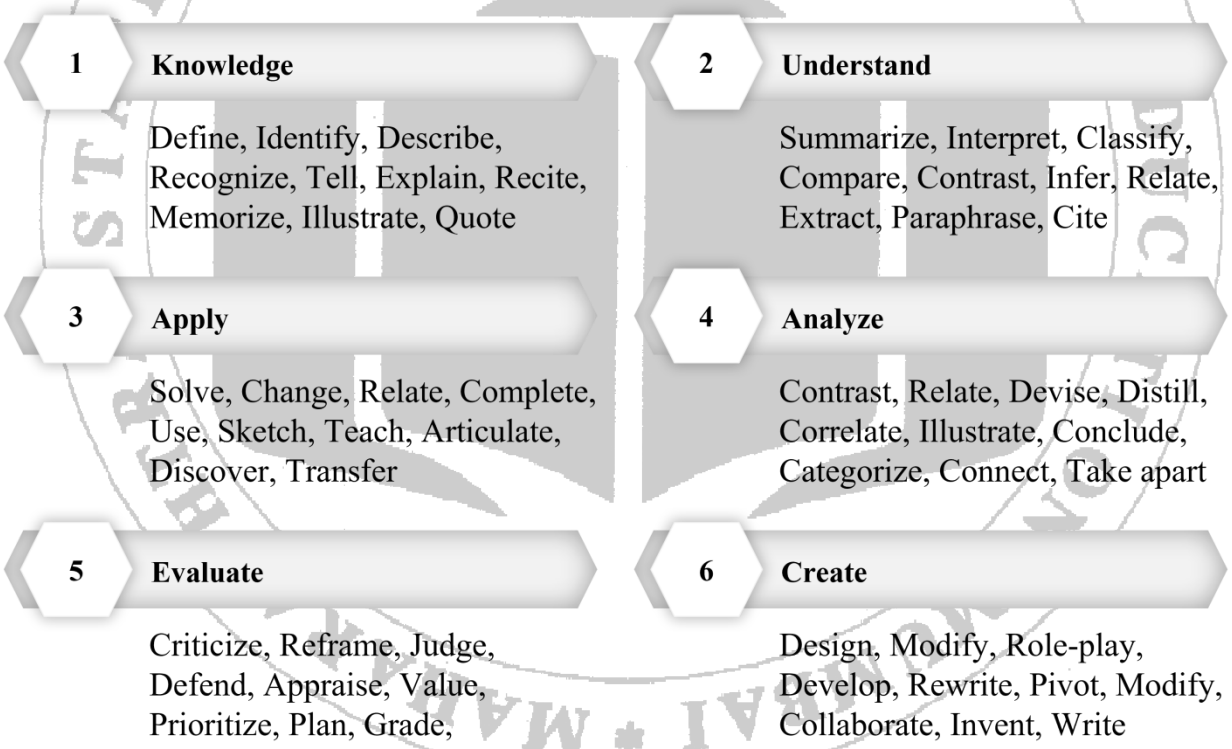
GUIDELINES FOR TEACHERS

Teacher shall explain the following points to the students before starting of the practical:

1. **Learning Objectives:** To foster better understanding of the subject and to inculcate the skills and attitude related practicals.
2. **Graphical structure:** In graphical structure topics and subtopics are organized in systematic way so that ultimate purpose of learning the subject is achieved. This is arranged in the form of fact, concept, principle, procedure, application and problem.
3. **Elementary Guide to work in Laboratory:** The methods and other finer details of the equipment including equipment specifications should be explained to avoid equipment breakages, create conducive environment for proper organizing of the practical work with the time schedule.
4. Teachers should verify and check the work conditions of the equipment and request the students to follow the standard operating procedures (SOP).
5. Before starting the practical, Teachers should explain the strategies of the experiment.
6. Teachers should ensure the active participation of students while performing the experiment.
7. Observations should be checked individually, and each student should be given a chance to perform the experiment.
8. Teachers should ask the students to complete the questions which are given at the end of the experiment accordingly.
9. Assessment of manuals should be done according to the assessment norms. Proper marks should be distributed according to the performance of the individuals.
10. Teachers should explain the competencies that student should achieve, in detail with their importance to students after completion of their course.
11. Apart from the syllabus, teachers should provide and cover extra topics which are beneficial for the students.
12. Explanation about various equipment with some interesting videos, reagents, chemicals, glassware's should be given to students prior to commencing of the practical.
13. Teachers should observe the students when students are performing practicals in groups, proper contributions of the individual student should be there, and record of observation should be noted by all of them.
14. Teachers should also organize a visit to the pharmaceutical industries where students get a brief idea about the manufacturing processes of common dosage forms such as tablets, capsules, liquid orals, injectables, etc.
15. Teachers should also ask them to gather information about each type of dosage forms, their generic name, branded names and label contents.

16. Teachers may suggest the students to refer to sources of information such as literature, research papers, books, attending conferences, seminars for the updation of knowledge.
17. According to the professional competencies given by PCI, teachers should develop the professional skills of the students.
18. Teacher should conduct different types of sessions for students such as quiz, group discussions projects on different topics, etc.
19. Teachers should ensure that revised CIAAN – 2017 norms or the latest norms given by MSBTE are followed simultaneously and implemented.
20. Teachers should follow the guidelines given by PCI & MSBTE from time to time.

BLOOMS TAXONOMY LEVELS



INSTRUCTIONS FOR STUDENTS

Students should follow the instructions given below for better understanding of the subject from a theoretical and practical concept of view.

1. As per the instructions, the students should wear an apron, cap, mask, gloves and slippers before entering the lab.
2. The students should keep their important things in the locker which is provided by the college.
3. While entering the laboratory, the students should carry manual, rough book and practical requirements as instructed.
4. Students should attend the practical regularly throughout the year, so as to understand the subject properly, and to develop the skills for performing the experiments and attaining the competencies.
5. The students should carry out the experiment individually and perform the experiment at the allotted specific work area.
6. The practical applications of every experiment should be noted by the students.
7. Students should answer the questions asked in the practical's and should ask the teacher about their difficulties without any hesitation.
8. After completion of practical's students should write the answers of the question given at the end of the experiment.
9. Students should develop different types of competencies to become competent Pharmacists.
10. Students should actively participate in group discussions, activities and strive to achieve the knowledge, skills, and attitude.
11. Student should submit the manual for assessing regularly on the scheduled date.
12. After completing the practical, the student should clean the platform and glassware used in the practical.

LABORATORY MANUAL OF HUMAN ANATOMY AND PHYSIOLOGY

MAPPING OF COURSE OUTCOMES

Expt No.	Title of Experiment	CO1	CO2	CO3	CO4
01	Study of Compound Microscope	✓		✓	
02	Study the Microscopic Structure of Human Tissues: Epithelial, Connective, Muscular, & Nervous tissue			✓	
03	Study of Human Skeleton: Axial & Appendicular Skeleton			✓	✓
04	Study the General Techniques for collection of blood	✓			
05	Determination of Bleeding time	✓			
06	Determination of Clotting time	✓			
07	Determination of Blood group	✓			
08	Determination of Hemoglobin content & Oxygen carrying capacity of own blood	✓			
09	Determination of WBC count of blood	✓			
10	Determination of RBC count of blood	✓			
11	Determination of Differential Leukocyte Count of blood	✓			
12	Determination of Erythrocyte Sedimentation Rate	✓			
13	Study of Cardiovascular System				✓
14	Recording of Pulse rate and Heart rate		✓		
15	Recording of Blood pressure		✓		
16	Study of Respiratory System				✓
17	Recording of Respiratory rate, Pulse oxygen and Force of Air Expelled using Peak Flow meter		✓		
18	Study of Sense Organs- Eye, Ear & Skin				✓
19	Recording of Body Temperature		✓		
20	Measurement of Height, Weight & Body Mass Index		✓		
21	Study of Nervous System				✓
22	Study of Digestive System				✓
23	Study of Urinary System				✓
24	Study of Endocrine System				✓
25	Study Reproductive System				✓

LIST OF EXPERIMENTS AND RECORD OF PROGRESSIVE ASSESSMENT

Expt No.	Title of Experiment	Page No	Date of Performance	Date of Submission	Assessment Marks	Sign of Teacher
01	Study of Compound Microscope	1				
02	Study the Microscopic Structure of Human Tissues: Epithelial, Connective, Muscular, & Nervous tissue	7				
03	Study of Human Skeleton: Axial & Appendicular Skeleton	15				
04	Study the General Techniques for collection of blood	28				
05	Determination of Bleeding time	34				
06	Determination of Clotting time	38				
07	Determination of Blood group	42				
08	Determination of Hemoglobin content & Oxygen carrying capacity of own blood	47				
09	Determination of WBC count of blood	53				
10	Determination of RBC count of blood	60				
11	Determination of Differential Leukocyte Count of blood	67				
12	Determination of Erythrocyte Sedimentation Rate	72				
13	Study of Cardiovascular System	76				
14	Recording of Pulse rate and Heart rate	84				
15	Recording of Blood pressure	88				
16	Study of Respiratory System	93				

Expt No.	Title of Experiment	Page No	Date of Performance	Date of Submission	Assessment Marks	Sign of Teacher
17	Recording of Respiratory rate, Pulse oxygen and Force of Air Expelled using Peak Flow meter	99				
18	Study of Sense Organs- Eye, Ear & Skin	105				
19	Recording of Body Temperature	111				
20	Measurement of Height, Weight & Body Mass Index	117				
21	Study of Nervous System	121				
22	Study of Digestive System	129				
23	Study of Urinary System	136				
24	Study of Endocrine System	143				
25	Study Reproductive System	150				

I) PRACTICAL RECORD MARKS*:

Sessional Exam	Experiment No.		Total no. of experiments conducted	Average marks obtained for the experiments conducted. (out of 10)	Teacher's Signature
	From	To			
First Sessional					
Second Sessional					
Third Sessional					

*Sessional wise marks should be considered for internal assessment of practical sessional examinations (out of 10M)

II) PRACTICAL SESSIONAL MARKS*:

First Sessional (Out of 20)	Second Sessional (Out of 20)	Third Sessional (Out of 20)	Average (Best of Two)	Teacher's Signature

Experiment No. 01
Study of Compound Microscope

1. Aim
To study the Compound Microscope.

2. Practical Significance
Compound microscopes is the scientific tool that allow us to see tiny objects in detail, such as animal or plant cells, bacteria, algae, and protozoa. They use multiple lenses to magnify those specimens which are not visible to the naked eye. This magnification is essential for various applications, including academic research, forensic analysis, medical diagnosis and the study of microorganisms. This experiment will allow the students to handle the microscope and to focus the tissues and cells.

3. Practical Outcomes (PrOs)
After completion of this practical, the students will be able to:

PrO	Practical Outcomes	Mapped CO	BTL
1	Identify the different parts of microscope.	CO 1 & 3	2
2	Handle the microscope with precaution.	CO 1 & 3	3
3	Focus the histological slides by using adjustment knobs.	CO 1 & 3	3
4	State the use of compound microscope.	CO 1 & 3	1
5	Collaborate and communicate with fellow students.	CO 1 & 3	5

4. Relevant Theoretical Background

Terminology
The term microscope can be split into two separate words, ‘micro’ and ‘scope’, where the term ‘micro’ means small or tiny, and ‘scope’ means to view or to observe. Therefore, it is defined as, an optical instrument used to magnify and observe the small objects which cannot be seen by naked eyes. It is used to study Cell Morphology, Histology, Histopathology and Microbiology.

Magnification: Increase the size of micro-objects.

Resolution: Differentiation of neighbouring objects as separate entities.

Types of Microscopes
a. **Simple Microscope**: Single Lens Magnification.
b. **Compound Microscope**: Multiple Lenses System.
c. **Electron Microscope**: Uses Electron Beam.
d. **Fluorescence Microscope**: Uses fluorescence or phosphorescence.
e. **Digital Microscope**: Displays image digitally.
f. **Dark Field Microscope**: Uses scattered light.
g. **Dissecting Microscope (Stereo Microscope)**: Views 3D objects.

Compound Microscope
The compound microscope is majorly used microscope in the laboratory. If it has a single eyepiece, then is called Monocular compound microscope while the microscope with two eyepieces called Binocular compound microscope.

Parts of Compound Microscope

The parts of compound microscope are divided into:

A. Mechanical Parts.

B. Optical Parts.

A. Mechanical Parts of Compound Microscope

a. **Base:** It is a heavy metallic, 'horseshoe' or 'U' shaped structure, holds and supports the microscope on platform and provides maximum stability.

b. **Arm:** It is strong 'C' shaped handle used to hold the microscope while moving in the laboratory and also functions to connect the tube with the base of microscope. It is fitted with fine and coarse adjustment knob.

c. **Inclination Joint:** This facilitates to tilt the microscope back for more comfortable viewing. It is a joint, wherein the arm is attached to the pillar.

d. **Body Tube:** It is 16-17 cm long cylindrical tube through which the light passes to eye piece, visualizing the image. The body tube can be shifted down and up using adjustment knob.

e. **Nose Piece:** It is also known as the revolving turret, a circular rotating metal part which has three to five holes to attach the objective lenses. It is attached to the body tube's lower end.

f. **Stage:** It is a platform where sample specimen's slides are placed for observation. This comes in a variety of shapes including rectangular, square or circular design with an aperture in its centre. The stage can be either the fixed stage or the mechanical stage. The fixed stage has two clips that hold the slide in position. The mechanical stage has a calibrated metal frame fitted on right side of stage. It has a spring mounted clip to hold the slide and two screw heads to move the slide from side to side, forward and backward. The Vernier scale is also attached to indicate degree of movement.

g. **Coarse Adjustment Knob:** It is a large knob, used to move the body tube up and down for proper focusing of slide. It brings the object to be examined under exact focus.

h. **Fine Adjustment Knob:** It is a smaller knob, used for sharp and fine focusing of the object. It is employed for accurate focusing.

B. **Optical Parts of Compound Microscope**

a. **Eyepiece, lens or Ocular:** Eyepiece is the removable lens placed at the top of the body tube. They can be 5X, 6X, 8X, 10X or 15X. Each eyepiece has two lenses; the eye lens at the top and field lens at the bottom. The field lens collects divergent rays, passes through eye lens to further magnify the image.

b. **Objectives:** There are three objectives fitted into a revolving nosepiece. Different types of the objective lenses are Low power objective of 10X, High power objective of 45X, and Oil immersion objectives of 100X.

c. **Low power objective 10X** = 10 x 10 = 100 times magnifies the image.

d. **High power objective 45X** = 45 x 10 = 450 times magnifies the image, used for viewing blood cells, blood smear and histological studies.

e. **Oil immersion objective (100X)** = 100 x 10 = 1000 times magnifies the image, as the name indicates it requires oil (Cedar Wood Oil) to focus the image.

Condenser: Condenser is an arrangement of lenses which collects the light coming from the light source and focus it onto the specimen. A condenser knob is used to move the condenser up or down. It is mounted below the stage.

f. **Iris diaphragm:** Inside the condenser, there is a knob used to open or close the opening which controls the amount of light that enters the condenser.

g. **Mirror:** A double-sided mirror with one flat side and other concave is located below condenser and can be rotated in all directions. The flat side used for oil-immersion and the concave side used for low and high-power objectives.

h. **Light Source:** It may be external (natural day light, electric lamp or tube light) or internal (electric inbuilt light source).

5. Diagram

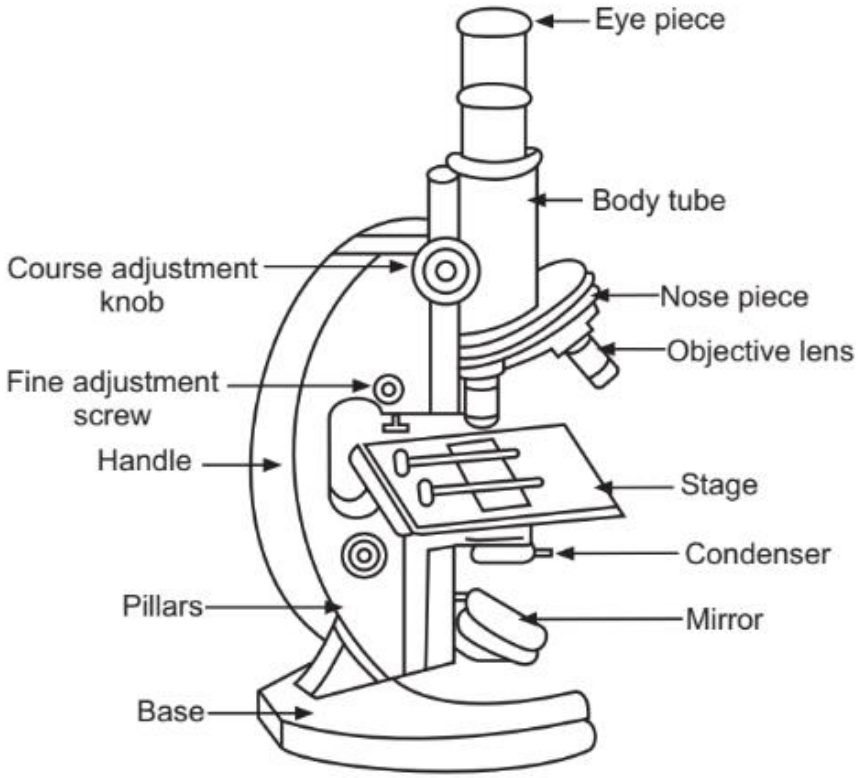


Fig 1.1: Compound Microscope

6. Requirements

Apparatus: Compound Microscope, and various permanent slides.

7. Procedure

a. Examine the permanent slide/blood film/specimen first with naked eye.
b. Place the microscope on working table in an upright position and raise the body tube approximately 7-8 cm above the stage.
c. Clean all glass surfaces such as eyepiece, objectives, substage, mirror and stage window using silk cloth and cleaning liquid.
d. Put the slide on the stage and using the mechanical stage, bring the specimen over the central aperture.
e. Select the low magnification objective (10X).
f. Select and adjust the mirror (plane or concave) so that the light shines on the specimen.

g. Adjust the condenser well down, and partly close the diaphragm to cut down excess light.
h. Looking from the side, and using the coarse adjustment, bring the body tube down so that the low power lens is about 1 cm above the slide. Look into eyepiece and gently raise the tube till the slide comes into focus.
i. Then choose the area of interest for viewing it under higher magnifications.
j. For focusing under high magnification, simply rotate the nosepiece so that the high magnification objective (45X) 'clicks' into position. Raise the condenser to mid position and open the diaphragm to admit enough light. Use fine adjustment as required.
k. For focusing under oil immersion objective (100X), raise the body tube 8-10 cm above the slide.
l. Place a drop of cedar wood oil, paraffin or glycerine on the slide. Looking from the side bring down the objective till it just enters the oil drop. Use other adjustment as required.

8. Precautions to be taken

a. Keep the microscope always clean and dust free before and after using.
b. Never put your fingers near the glass portion of the lenses. If you want to clean your lenses, only use special lens paper.
c. Height of the observer should be in a position that allows him to handle the microscope comfortably.
d. Use both hands while handling the microscope.
e. After keeping the slide under objective on stage do not bring down the objective by coarse adjustment while looking in the microscope. Should look from the side of the microscope.
f. Remove the slide from the stage and rotate the lowest power objective lens into place before putting the microscope away.

9. Observation

Sr. No.	Name of the Observed Slide	Objective Used

10. Result

_____

_____

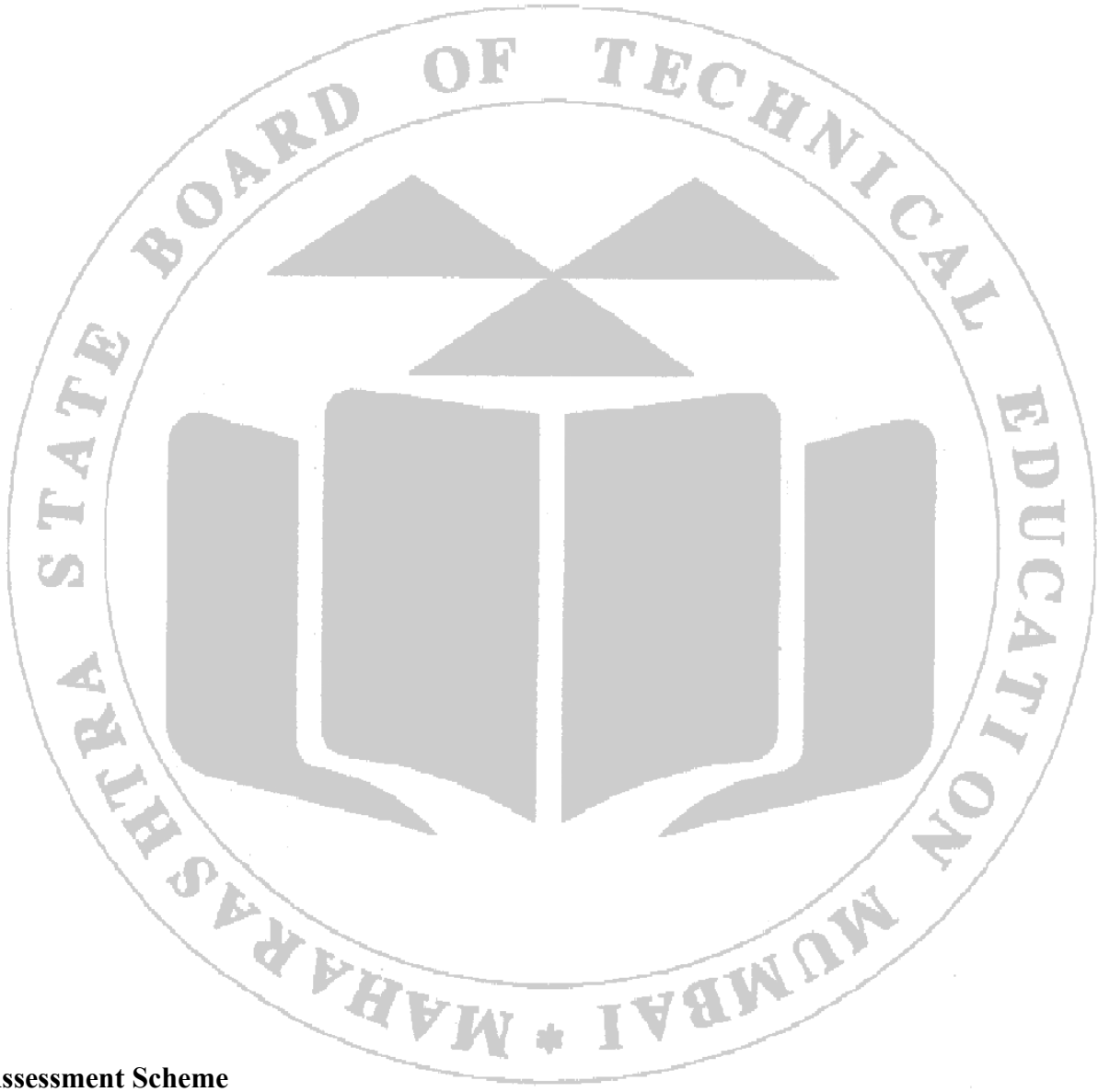
11. References

a. Compound Microscope: Principle, Parts, Uses, Diagram (microbenotes.com).
b. L Prakasam Reddy, Practical Physiology, Paras Publishing, 2nd Edition, 2009.

12. Practical Related Questions

a. What is compound microscope?
b. Define Magnification and Resolution.
c. What is objective lens? Mention the magnifying power of different objectives.
d. How to adjust the light in compound microscope?
e. Write any two precautions taken while using compound microscope.

(Space for writing answers)



13. Assessment Scheme

Particular	Understanding the basic concept (Intellectual skill)	Activities (Intellectual and motor skills)	Cleanliness & Handling (Affective domain)	Viva-voce / Answers Written	Total	Signature of teacher
Marks Obtained						
Max Marks	**02**	**05**	**01**	**02**	**10**	

Experiment No. 02
Study of Human Tissues

1. Aim

To study the microscopic structure of human tissues: Epithelial Tissue; Connective Tissue; Muscular Tissue; Nervous Tissue.

2. Practical Significance

The microscopic structure of human tissues is crucial for diagnosing diseases, tailoring treatments, and advancing research in medicine, pathology, and biomedical fields. It aids in histopathology, biopsy analysis, drug development, and forensic investigations, and is fundamental in medical education, professional training, and public health. Through microscopic examination, the structure of these tissues is revealed, enabling students to identify and differentiate the types, Practical Related parts, and functions.

3. Practical Outcomes (PrOs)

After completion of this practical, the students will be able to:

PrO	Practical Outcomes	Mapped CO	BTL
1	Identify different types of tissues.	CO3	2
2	Classify various types of tissues.	CO3	2
3	Draw the microscopic structure of the tissues.	CO3	3
4	Collaborate and communicate with fellow students.	CO3	5

4. Relevant Theoretical Background

A tissue is a group of two or more types of cells and their intercellular substance that perform a particular function. The word “tissue” was given by a French anatomist and physiologist Bichat. The study of tissues is called “histology”. Histology is also called microscopic anatomy.

Human tissues are classified into four main types:

A. Epithelial tissue
B. Connective tissue
C. Muscular Tissue
D. Nervous Tissue

A. Epithelial tissue

It is composed of tightly packed cells with minimal extracellular matrix, forming a continuous layer that covers surfaces and lines cavities throughout the body.

Types of Epithelial Tissue

SN	Types of Epithelial tissue	Description
1	Simple squamous epithelium	A single layer of flat cells; is found in areas where rapid diffusion is necessary, such as the lungs' alveoli and the lining of blood vessels.
2	Simple cuboidal epithelium	A single layer of cube-shaped cells; is commonly found in glands and their ducts and kidney tubules.
3	Simple columnar epithelium	A single layer of tall cells; that lines the stomach, intestines, and some ducts, often involved in absorption and secretion.

4	Stratified squamous epithelium	Multiple layers of cells with the outermost layer being flat; are found in areas subject to abrasions, such as the skin, mouth, and esophagus.
5	Stratified cuboidal epithelium	Multiple layers of cube-shaped cells; relatively rare, are found in some glands.
6	Stratified columnar epithelium	Multiple layers with the outermost layer being columnar; also rare, are found in parts of the pharynx and male urethra.
7	Pseudostratified columnar epithelium	Appears to be stratified but is a single layer of irregularly shaped and differently sized columnar cells; found in the respiratory tract.
8	Transitional epithelium	Multiple layers of cells that can change shape; are found in the urinary bladder.

Functions of Epithelial tissue

a. Protection: Acts as a barrier to protect underlying tissues from mechanical injury, harmful chemicals, pathogens, and water loss.
b. Absorption: Specialized to absorb substances, such as nutrients from the intestines.
c. Secretion: Produces and releases substances like enzymes, hormones, and mucus.
d. Excretion: Helps in the excretion of waste products.
e. Filtration: Facilitates the filtration of substances, especially in the kidneys.
f. Sensation: Contains sensory receptors that respond to environmental stimuli.

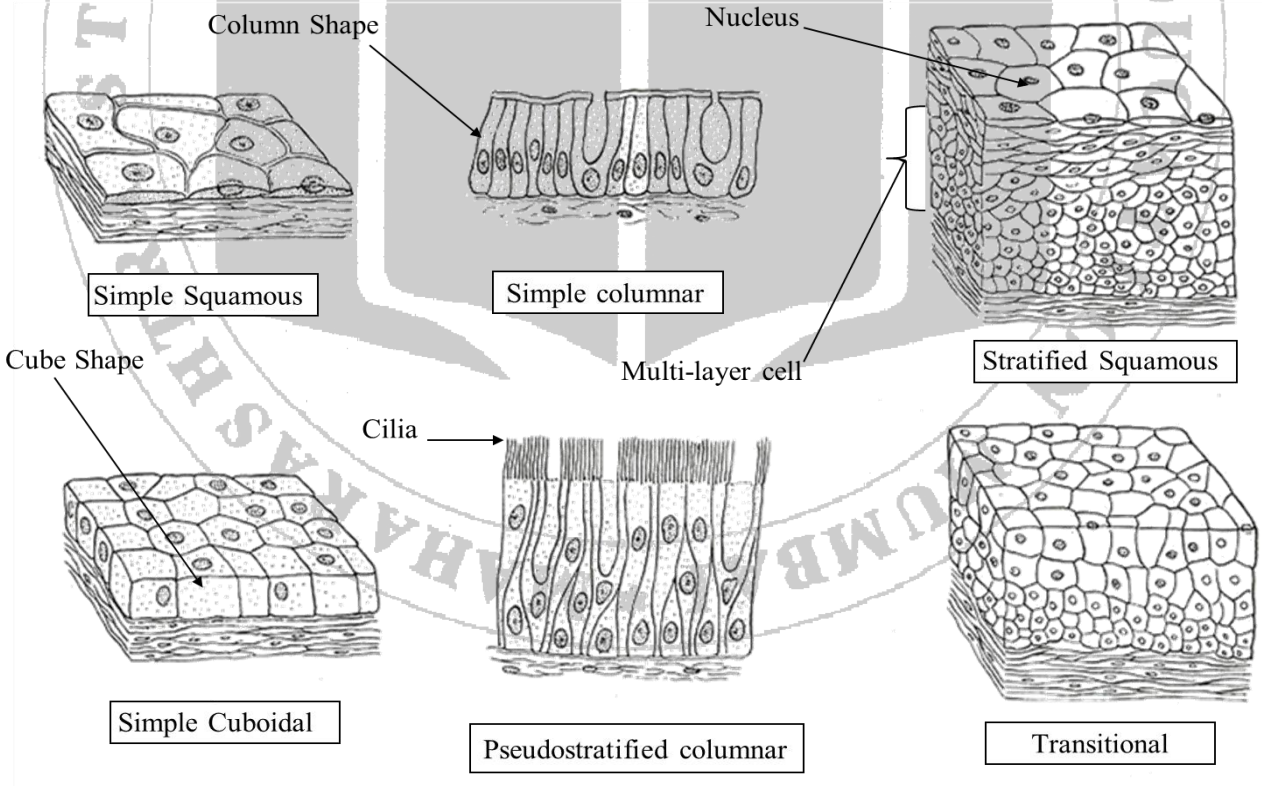


Fig No. 2.1 Types of Epithelial Tissue

B. Connective tissue

Connective tissue is a diverse group of tissues that support, bind together, and protect organs. It is characterized by an abundance of extracellular matrix with relatively few cells.

Types of Connective Tissue

SN.	Tissue type	Description
1	Areolar Tissue	A loose arrangement of fibres and cells with abundant ground substance; it provides support and flexibility and is found under epithelial layers.
2	Adipose Tissue	Composed mainly of adipocytes; stores fat, insulates the body, and provides cushioning.
3	Reticular Tissue	It contains reticular fibres; and forms a supportive framework for lymphoid organs like lymph nodes and spleen.
4	Elastic Connective Tissue	It Contains a high proportion of elastic fibres; and allows tissues to recoil after stretching, found in large blood vessel walls and certain ligaments.
5	Cartilage	Hyaline cartilage: The most common type; provides support with some flexibility, found in the nose, trachea, and ends of long bones.
		Elastic cartilage: Contains many elastic fibres; and provides flexibility, found in the external ear and epiglottis.
		Fibrocartilage: Contains thick collagen fibres; provides tensile strength and absorbs shock, as found in intervertebral discs and menisci of the knee.
6	Bone	Compact bone: Dense and solid; forms the outer layer of bones, providing strength and support.
		Spongy bone: Less dense with a porous, trabecular structure; found at the ends of long bones and inside other bones, containing marrow.
7	Blood	A fluid connective tissue composed of blood cells suspended in plasma, it transports nutrients, gases, waste products, and immune cells throughout the body.
8	Lymph	A fluid connective tissue like blood plasma; it transports immune cells and removes interstitial fluid from tissues.

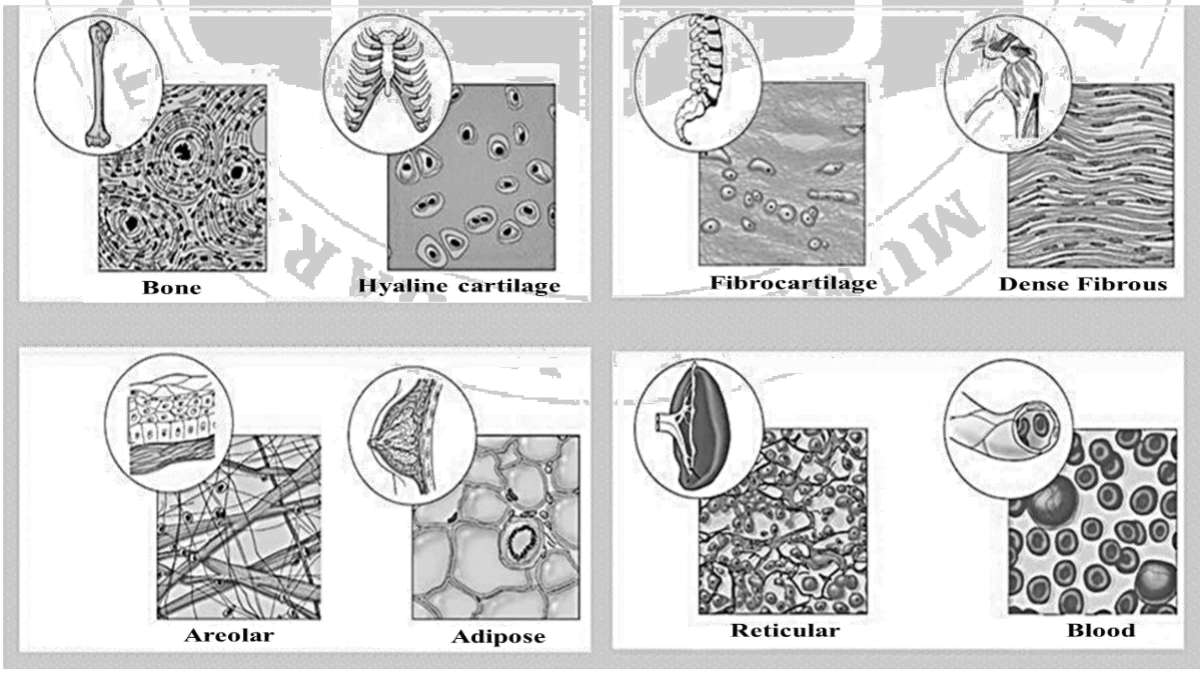


Fig 2.2: Types of connective tissues

Functions of Connective Tissue

a. Support and structural Framework: Provides support and shape to organs and the entire body (e.g., bones and cartilage).
b. Protection: Bones protects organs and tissues from damage.
c. Insulation and energy storage: Adipose tissue stores energy and insulates the body.
d. Transportation: Blood transports nutrients, gases, and waste products throughout the body.
e. Repair: Plays a role in wound healing and tissue repair through the activity of fibroblasts and other cells.

C. Muscular tissue

It is specialized for contraction, which facilitates movement and various bodily functions. Muscular tissue is composed of cells called muscle fibers that contain contractile proteins.

Types of Muscular tissue

SN.	Tissue type	Description
1	Skeletal muscles or Voluntary muscles	Long, cylindrical fibres with multiple nuclei located at the periphery, displaying a striated appearance due to the arrangement of contractile proteins (actin and myosin). Responsible for voluntary movement, stabilization, and heat production. These fibres are attached to bones via tendons.
2	Cardiac muscles	Branched fibres with one or two centrally located nuclei, striated like skeletal muscle but with unique intercalated discs that connect adjacent cells. Responsible for involuntary movement to pump blood. Found exclusively in the walls of the heart (myocardium).
3	Smooth muscles or Involuntary muscles	Spindle-shaped fibres with a single centrally located nucleus, having a non-striated appearance. Responsible for involuntary movement, regulation, and peristalsis. Found in the walls of hollow organs such as the intestines, stomach, bladder, and blood vessels, as well as in the respiratory, urinary, and reproductive tracts.

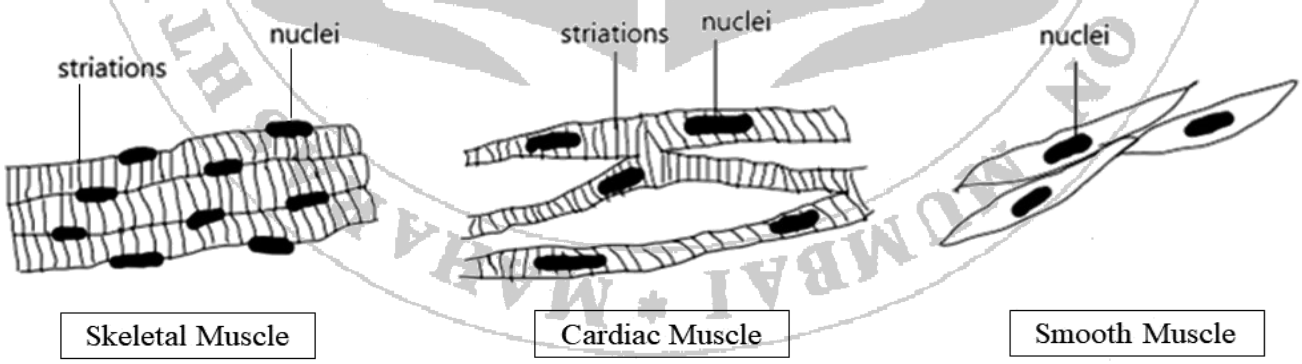


Fig 2.3: Types of Muscular Tissues

D. Nervous Tissue

Nervous tissue is composed of neurons and supporting cells called neuroglia (or glial cells).

Components of nervous tissue

a. Neurons

i. Cell Body (Soma): Contains the nucleus and organelles; integrates incoming signals and generates outgoing signals to the axon.

ii. Dendrites: Short, branched extensions from the cell body that receive signals from other neurons and conduct them toward the cell body.
iii. Axon: A long, singular extension that transmits signals from the cell body to other neurons, muscles, or glands.
iv. Axon Terminals: The ends of the axon form synapse with other cells, releasing neurotransmitters to communicate with the next cell.

b. **Neuroglia (Glial Cells):** Neuroglia, or glial cells, are non-neuronal cells in the nervous system that provide support and protection for neurons. They are essential for maintaining homeostasis, forming myelin, and providing support and protection for neurons in both the central and peripheral nervous systems.

Functions of nervous tissue

a. **Sensory input:** Detects changes in the internal and external environment through sensory receptors.
b. **Integration:** Processes and interprets sensory input, deciding on appropriate responses.
c. **Motor output:** Sends signals to muscles and glands to elicit responses, such as muscle contraction or glandular secretion.

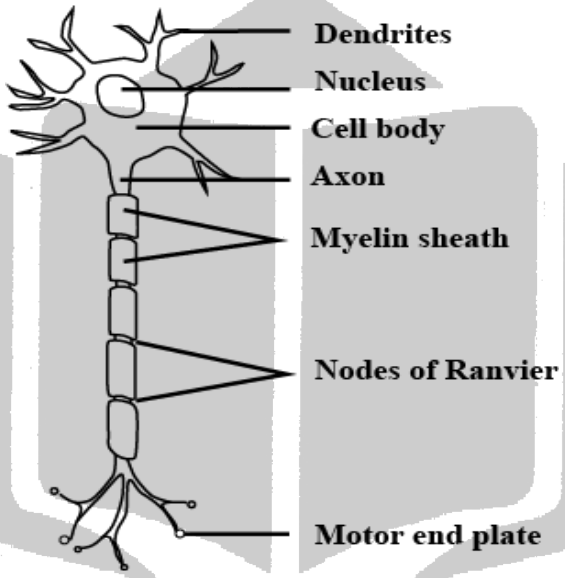


Fig 2.4: Structure of a neuron

5. Requirement

Compound microscope and permanent slides of various human tissues.

6. Procedure

a. Clean the microscope with xylol. Use a muslin cloth to clean and dry it.
b. Set the microscope to 10x magnification.
c. Adjust the light source to clearly visualize the structure of the tissue.
d. Place the tissue slide on the stage of the microscope and adjust to obtain a clear microscopic image of the structure.
e. Observe and identify different types of tissue, noting their characteristics, staining, etc.

7. Precautions to be taken

a. Always keep the microscope covered to maintain it clean and dust-free.
b. Ensure the observer's height and seating position allow comfortable handling of the microscope.
c. Handle permanent tissue slides carefully, as they are delicate and made of glass.

d. Handle the slides with clean hands and ensure they are dust-free before placing them under the microscope.

8. Observations

Observe the different tissues under a microscope. Identify the slides and draw well well-labelled diagram.

9. Result

_____

_____

10. References

a. Tortora, G. J., Derrickson, B. (2014). Principles of Anatomy and Physiology (14th ed.). Hoboken, N.J.: John Wiley.

a) Waugh, A., Grant, A. (2023). Ross & Wilson Anatomy and Physiology in Health and Illness (14th ed.).

11. Practical Related Questions

a. Give functions of skeletal, smooth, and cardiac muscles.
b. Explain the structure, function, and location of tissues.
c. State the functions of the epithelial tissues.
d. Mention types of fundamental tissues of body.
e. Draw the structure of simple epithelial tissues.
f. Enumerate the functions of connective tissues.
g. Classify various types of connective tissues and give their location.
h. Give the structure, function, and location of nervous tissues.
i. Differentiate between myelinated and non-myelinated neurons.

(Space for writing answers)

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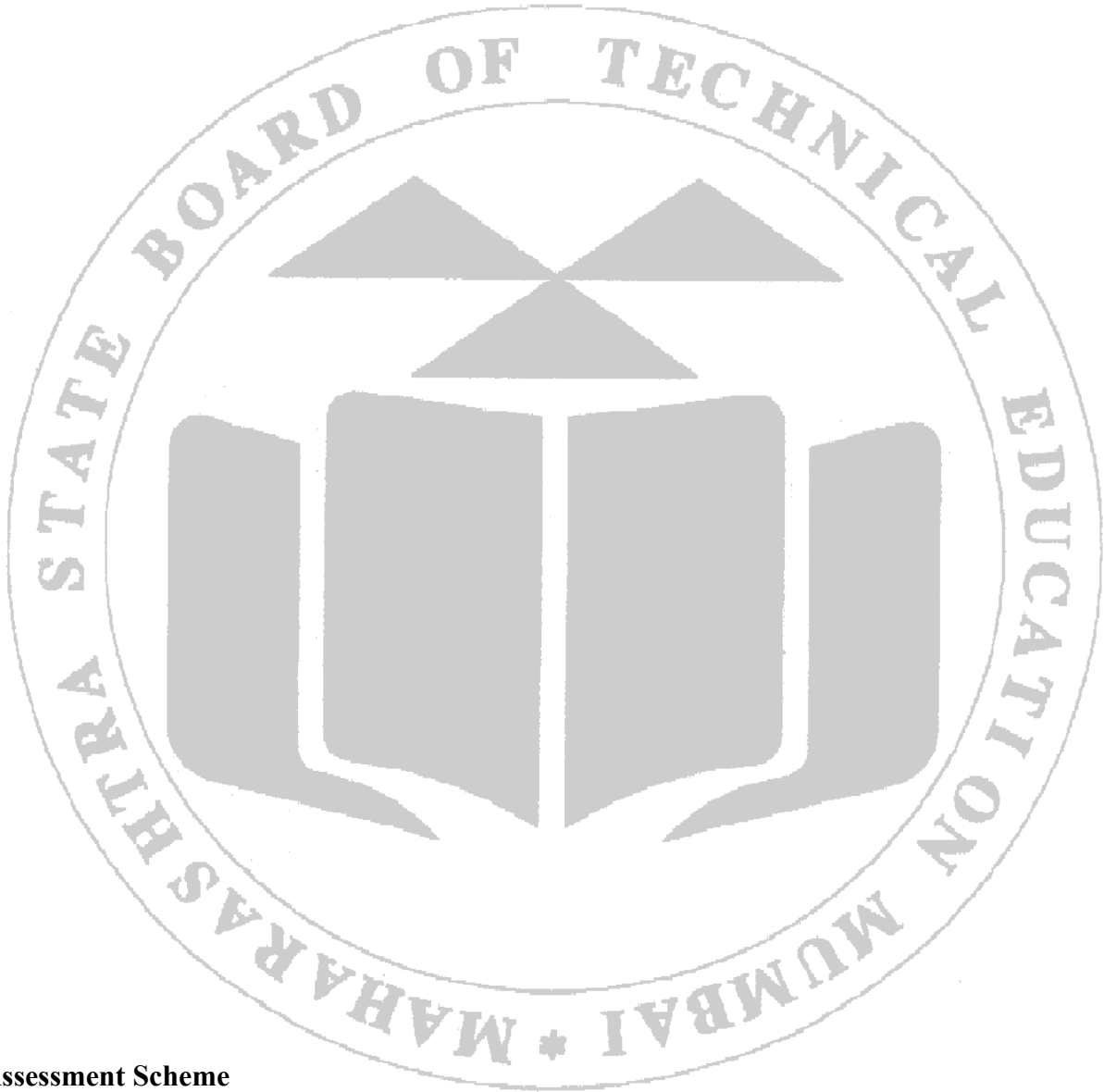


12. Assessment Scheme

Particular	Understanding the basic concept (Intellectual skill)	Activities (Intellectual and motor skills)	Cleanliness & Handling (Affective domain)	Viva-voce / Answers Written	Total	Signature of teacher
Marks Obtained						
Max Marks	**02**	**05**	**01**	**02**	**10**	

Experiment No. 3
Study of Human Skeleton

1. Aim

To study the Human Skeleton- Axial and Appendicular skeleton.

2. Practical Significance

Osteology is the scientific study of bones and understanding of human skeleton constituting an important part of human being. The skeleton is a bony and cartilaginous framework of the body. There are different types of bones; some are joined by specialized joints giving movement, locomotion, shape, support, and strength to the human body. The study of axial and appendicular skeleton will help the students to identify the number, shapes, and structure of bones present.

3. Practical Outcomes (PrOs)

After completion of this practical, the students will be able to:

PrO	Practical Outcomes	Mapped CO	BTL
1	Identify different types of tissues.	CO3	2
2	Classify various types of tissues.	CO3	2
3	Draw the microscopic structure of the tissues.	CO3	3
4	Collaborate and communicate with fellow students.	CO3	5

4. Relevant Theoretical Background

Terminology

Skeleton is defined as the framework of body consists of bones and other connective tissue that protect and supports the internal delicate organs.

Parts of skeletal system: Bones, Ligaments (Bone to Bone), Cartilage (Cushion between joint), Tendons (Muscle to Bones) and Joints.

Bones

Bone is a mineralized connective tissue made up of different bone cells like osteoblast, osteocytes, bone lining cells & osteoclasts which are involved in the formation & mineralization of bone. Bone possesses several ridges & elevations on its surface for the attachment of muscles & tendons. All the bones are externally covered with tough layer of tissue called Periosteum.

Types of bones

a. **Compact Bone** also called Cortical bone. Heavy, tough, and compact in nature.
b. **Spongy Bone** also called Cancellous bone. Light, spongy and soft in nature and have open spaces.

Classification of Bones (Based on shape and size)

Long bone, short bone, flat bone, irregular bone, and sesamoid bone.

Functions of Skeleton

a. Support and protection of internal delicate organs.
b. Movement due to attached skeletal muscles.
c. Storage of minerals and fats.
d. Blood cell formation.

Human Skeleton: The adult human skeleton is made up of 206 bones.

Classification of Skeleton

Axial Skeleton (80 Bones): It consists of skull bones, vertebral column & rib cage.

Appendicular Skeleton (126 Bones): It consists of bones of upper and lower limb, as well as shoulder girdle and pelvic girdle.

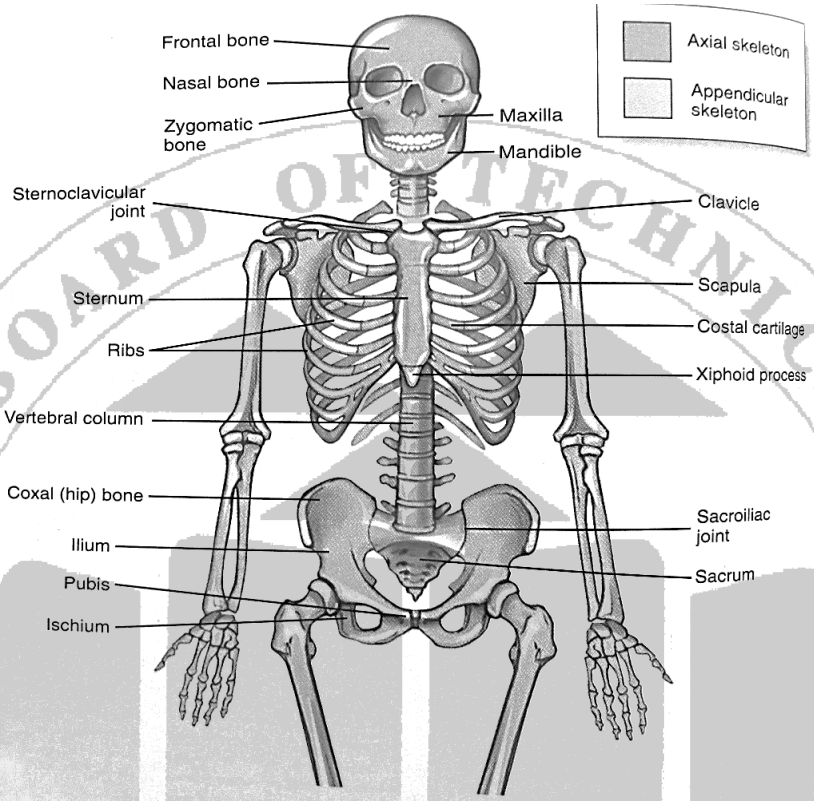


Fig 3.1: Axial Skeleton

Skull bones (29 Bones)

Cranium bones (08 Bones):

Made up of eight, flat irregular shaped bones and forms the cranium cavity which protects the brain. The cranium bones are:

a) Frontal (01)- It is a large flat bone which forms forehead and also the upper part of orbital cavities.
b) Parietal (02)- These are two flat bones which forms the middle part of skull cap and sides of the cranium.
c) Occipital (01)- A single bone that forms posterior and base part of the skull.
d) Temporal (02)- These are two bones presents on either side of the cranium.
e) Sphenoid (01)- It is the single irregular and bat like shape bone which occupies the middle lower portion of cranium.
f) Ethmoid (01)- It is the single bone located in the anterior region at the base of cranium. It forms the part of orbital cavity.

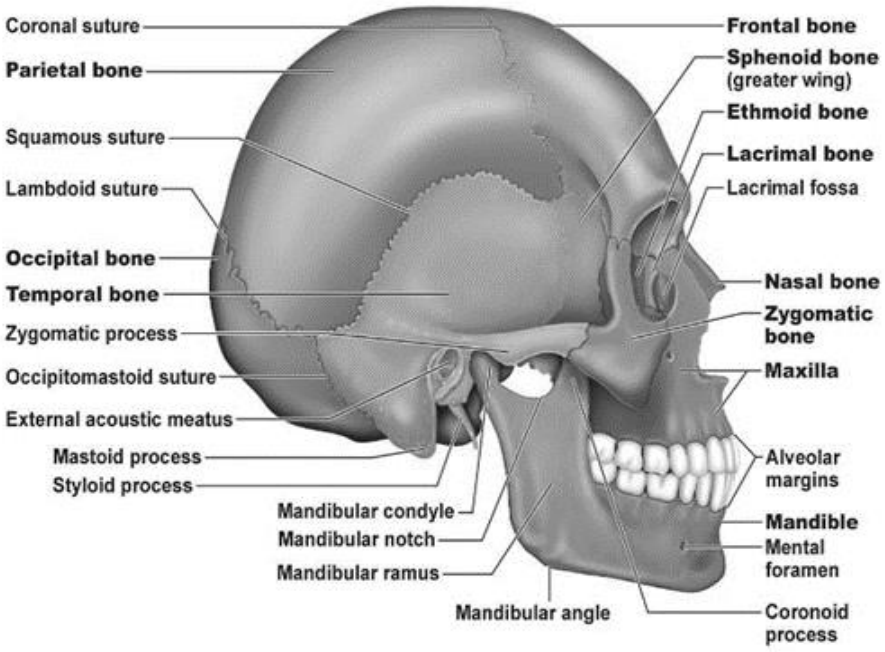


Fig 3.2: Skull Bones

Facial bones (14 Bones)

a. Maxilla (02)- It forms the upper jawbone and supports the upper row of teeth.
b. Mandible (01)- Also called as Lower Jawbone. It is the largest & strongest Facial bone, &
c. the only moving skull bone. It supports the lower jaw teeth.
d. Zygomatic bones (02)- Also called as cheek bones, present in the cheek region.
e. Nasal bones (02)- Form the lateral part of Nose.
f. Lacrimal bones (02)- It forms the inner wall of the orbit. Also contains lacrimal sac & nasal duct.
g. Vomer (01)- It forms the lower part of nasal septum.
h. Palantine bones (02)- These are L-shaped & form the back of the hard palate & extend up to the outer wall of the orbit.
i. Inferior nasal conchae (02)- It form the lateral wall of Nasal cavity.

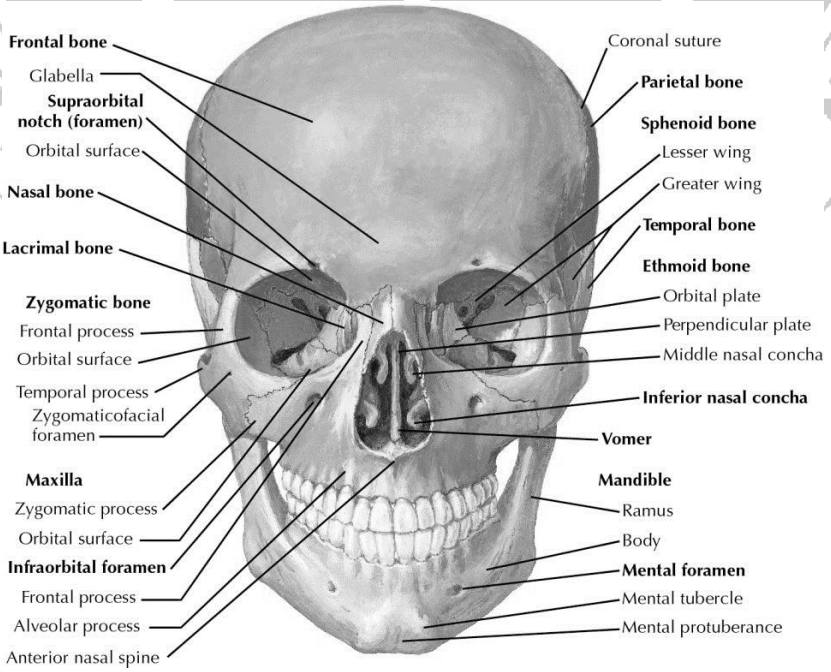
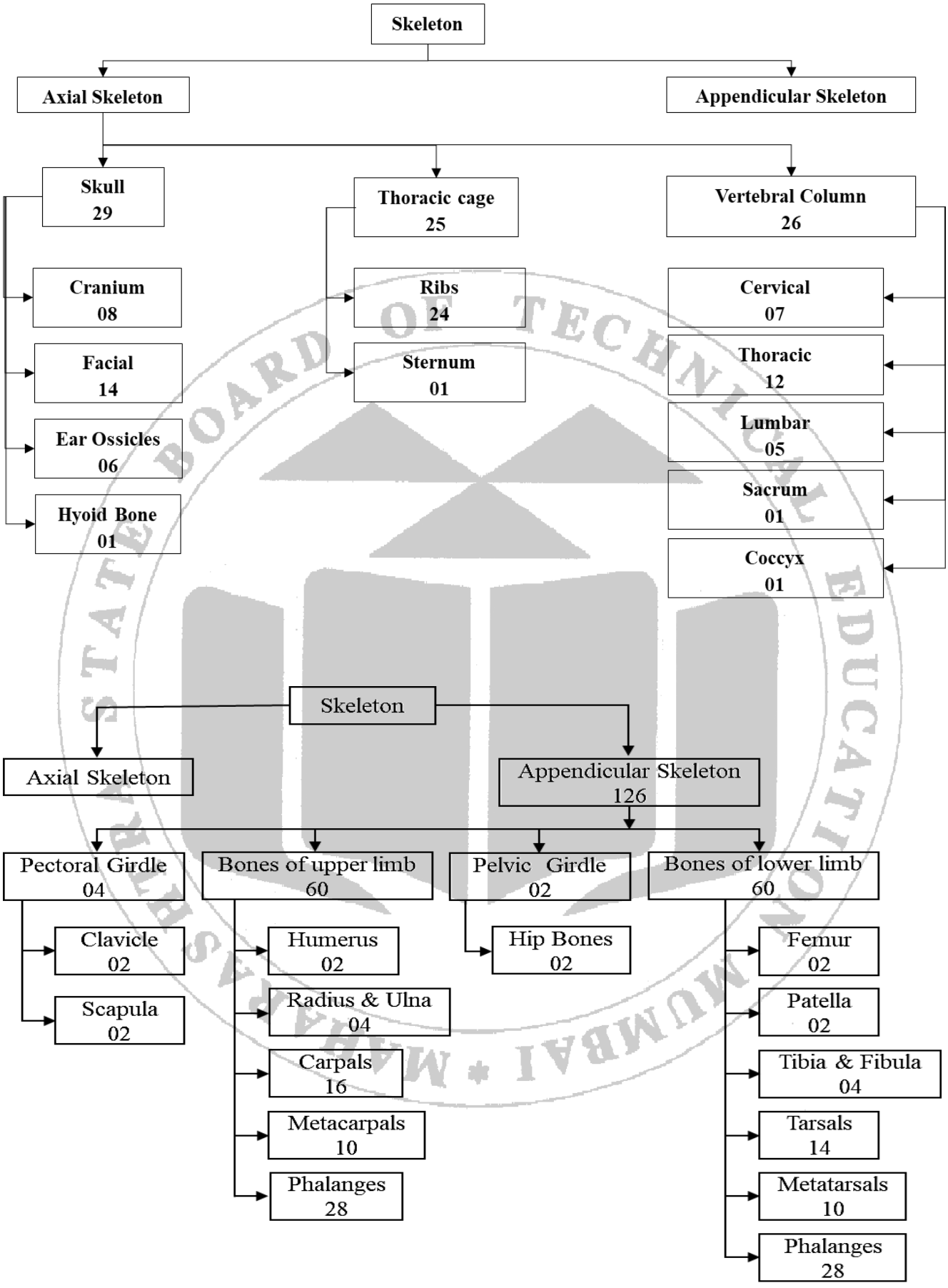


Fig 3.3: Facial bones


Skeleton
Axial Skeleton
Appendicular Skeleton
Skull
29
Thoracic cage
25
Vertebral Column
26
Cranium
08
Facial
14
Ear Ossicles
06
Hyoid Bone
01
Ribs
24
Sternum
01
Cervical
07
Thoracic
12
Lumbar
05
Sacrum
01
Coccyx
01
Skeleton
Axial Skeleton
Appendicular Skeleton
126
Pectoral Girdle
04
Bones of upper limb
60
Pelvic Girdle
02
Bones of lower limb
60
Clavicle
02
Scapula
02
Humerus
02
Radius & Ulna
04
Carpals
16
Metacarpals
10
Phalanges
28
Hip Bones
02
Femur
02
Patella
02
Tibia & Fibula
04
Tarsals
14
Metatarsals
10
Phalanges
28

Ear Ossicles (06 Bones):

These are three bones present in each of middle ear.
These are, Malleus- 02, Incus- 02 and Stapes- 02.

Hyoid bone (01):

It is a Horse-shoe shaped bone that supports to the tongue muscles. Present below mandible, & above thyroid cartilage.

Vertebral Column (26):

It is the major axis of human body, located dorsally. Vertebral column is made up of 26 bones of which 24 bones are free vertebrae followed by two fused: sacrum and coccyx.

a. Cervical- 07
b. Thoracic- 12
c. Lumber- 05
d. Sacrum- 01
e. Coccyx- 01

Vertebrae are articulated by cartilaginous joints and hence it shows some movement. The intervertebral disc of cartilage present between the vertebrae to prevent the friction and acts as a shock absorber.

Typical Vertebrae:

Vertebrae in the different region of the vertebral column have different shape, size, and structure but all of them have a basic structure. It consists of two parts: a body (centrum) present anteriorly, whose size varies according to the position, being smaller in the cervical region and becoming larger towards the lumbar end. The neural arch encloses a large foramen called the vertebral foramen, through which the spinal cord passes. The neural arch possesses following parts:

a. 2 Pedicles connects the neural arch to the centrum.
b. 2 Laminae, the bony ridges at the base of spinous process.
c. 2 Transverse process, where the pedicle and lamina attached.
d. 4 Articular processes for the articulation with the vertebrae.
e. Spinous Process, the elongated spine like structure that projects the backward for muscle attachment.

Cervical Vertebrae:

There are 7 cervical vertebrae in the neck region i.e., C_1-C_7. Bodies are smaller than thoracic vertebrae. They run down the neck forming a slightly forward curve called Lordotic curve.

Thoracic Vertebrae:

These are larger & stronger than cervical vertebrae. Total vertebrae are 12 (T_1 to T_{12}). Articulates with the ribs, at surfaces called Facets. The curve of upper and mid back is called Kyphotic curve.

Lumbar Vertebrae:

The lumbar vertebrae are the largest vertebrae in the vertebral column. There are a total of five vertebrae, named L1 to L5. The bodies of these vertebrae are kidney shaped. The spinous processes are short, flat-sided, and project straight back to provide attachment points for the large back muscles. The curve in the lower back is called the lordotic curve.

Sacral Vertebrae (Sacrum): The 5 sacral vertebrae fused together to form one bone known as Sacrum. Triangular structure & forming a backward curve. Articulates above with the fifth lumber vertebrae forming the lumbo-sacral angle.

Coccyx: It is also called as Tail Bones. Triangular shape and consists of 4 vertebrae fused together to form coccyx. Articulates with the tip of the sacrum. Movements are very limited.

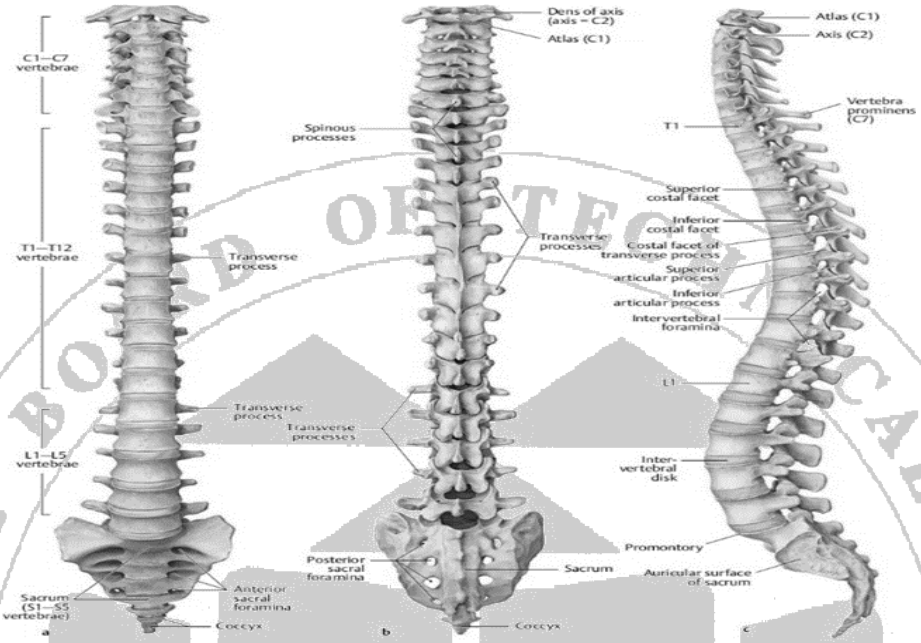


Fig 3.4: Vertebral column

Thoracic Cage / The bones of the Thorax: The thorax is formed by the thoracic vertebrae (12), sternum (1), costal cartilage and ribs (12 pairs) in front.

Sternum: It is also known as Breast Bones. A flat bone in the middle of the chest. The costal cartilage of the ribs is attached to the sternum. It is divided into three parts: The Manubrium, The Body, The Xiphoid Process.

Ribs: These helps in the forming of thoracic cage which protect the lungs and heart. There 12 pairs of ribs and divided into: True Ribs & False Ribs.

a. **True Ribs**: The upper seven pairs of ribs articulate with sternum through costal cartilage.

b. **False Ribs**: Remaining 8^{th}, 9^{th}, & 10^{th} are false ribs as they do not join the sternum directly. Last 11^{th} & 12^{th} ribs are floating ribs. Each rib is a long bone & is divided into Head, Neck & Shaft.

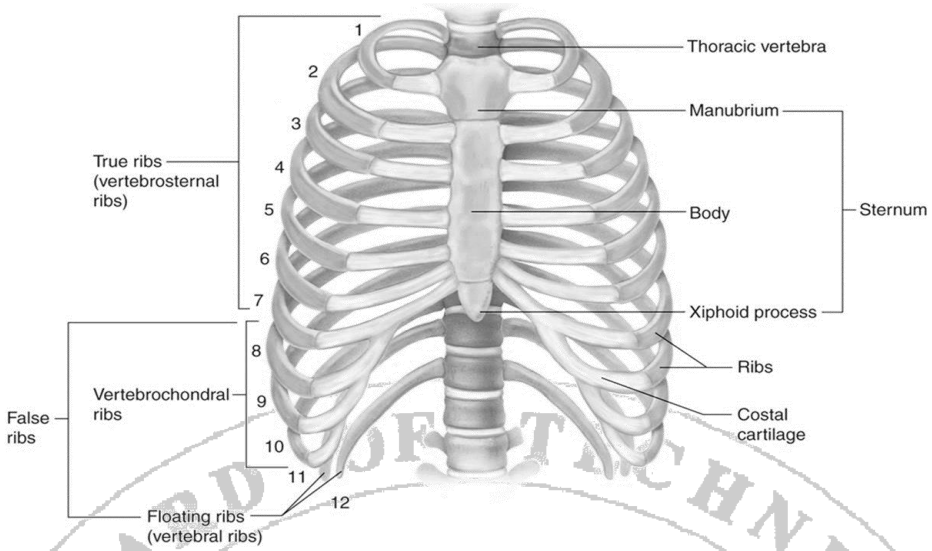


Fig 3.5: Rib cage

Appendicular Skeleton

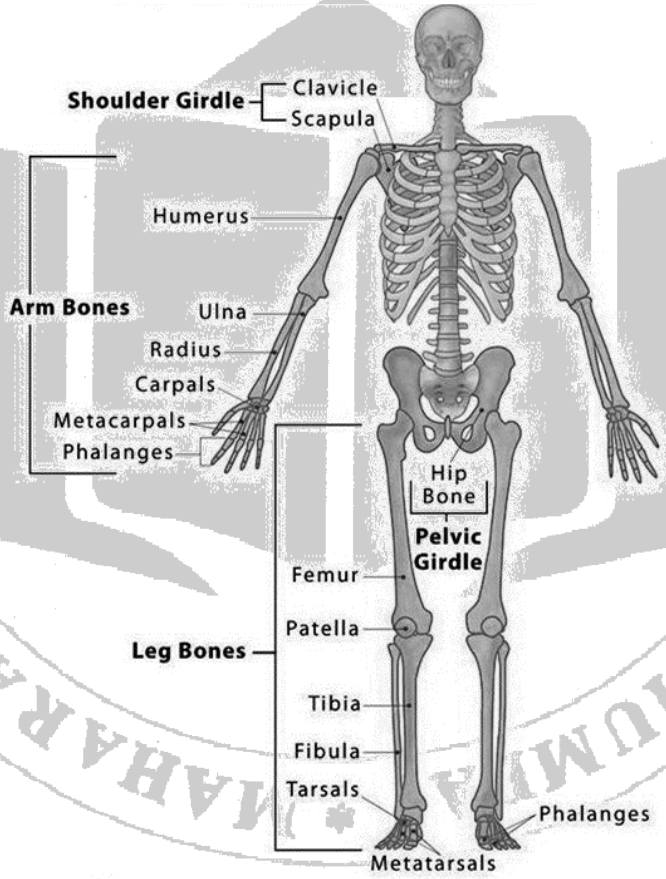


Fig 3.6: Appendicular Skeleton

It consists of shoulder (Pectoral) girdle with upper limbs (Arm bones) and pelvic girdle with lower limbs (Leg bones).

Pectoral Girdle: Clavicle (2) and Scapula (2).

Upper Limbs bones: Humerus (2), Radius (2), Ulna (2), Carpals (16), Metacarpals (10), and Phalanges (28).

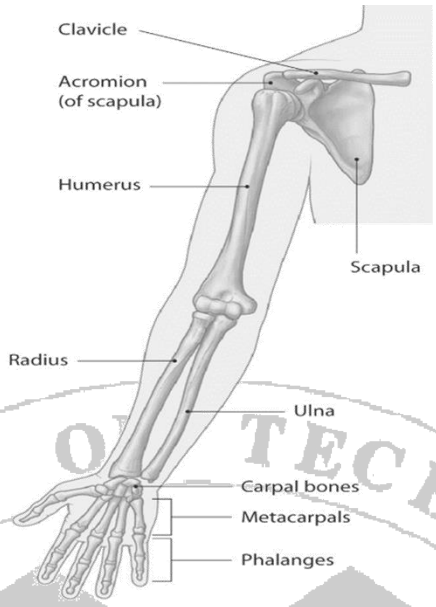


Fig 3.7: Bones of upper limb

Clavicle (Collar bone / Beauty bone): A S-shaped long bone, its one end is articulating with the manubrium of the sternum. The other end forms the joint with Acromion process of scapula. It keeps the scapula in position.

Scapula or Shoulder blade: A flat triangular bone present at posterior of the chest wall. It is held in place by muscles which attach it to the ribs and the vertebral column.

Forelimb bones (Upper limb): Each forelimb consists of 30 bones and are as:

Humerus: A largest bone in the upper limb & also known as Arm Bone. Extend from shoulder to the elbows. It consists of head, neck, shaft, and distal end. The posterior surface of the scapula is divided by a spine. The head of humerus fits into glenoid cavity of scapula. Distal end articulates with ulna.

Radius: Long bone of the forearm lying on the thumb side. Consists of head, neck, tuberosity, shaft & distal extremity. The head is disc shaped and flat on the top and articulates with the distal end of humerus. At the upper end of the shaft, there is a radial tuberosity which gives attachment to muscles. The distal end articulates with the carpal bones to form a wrist joint and with the ulna to form a radioulnar joint. Also carries styloid process which felt at the bottom of thumb which gives attachment to ligament and muscles.

Ulna: Long bone consists of proximal end, shaft and distal end or head. Located on the inner side of forearm. Slightly bigger than radius. Extending from the elbow to wrist. The upper end consists of C-shaped cavity known as Trochlear Notch which articulates with humerus. Styloid process presents at the lower end.

Bones of the wrist and hand: Wrist also known as Carpus consists of 8 bones arranged in two rows i.e., Proximal row & Distal row. These bones are called as carpals and are irregular bones. These carpals articulated with each other and are held in position by ligaments. The upper row forms the wrist joint articulating with the radius and the lower row articulates with the metacarpus.

Metacarpal bones (10) are forming a structure of palm of a hand. Head articulates with proximal phalanges and base articulates with distal carpals.

Phalanges (28) also called Finger bones. Each finger except thumb has three phalanges i.e., the proximal, middle & the distal. The proximal phalanges are longest. The thumb has only two phalanges. The phalanges are articulating with each other by interphalangeal joints and the base of proximal phalanges articulates with distal end of metacarpal bones.

Pelvic Girdle (02): The basin like structure formed by two hip bones, the sacrum and the coccyx is called Pelvis. Pelvic girdle consists of two hip bones on either side. These bones are also called as Innominate bones or Coxal bones. Pelvic girdle provides a strong support to the vertebral column.

Hip bones: These Large, irregular, flat bone. Made up of three parts separated by cartilage in childhood but fused in adulthood. Upper expanded flat part of hip bone called Ilium, frontal portion of hip bones called Pubis and the lower back part of solid broad portion of hip bone called Ischium. These bones articulate with sacrum posteriorly and anteriorly with each other by pubis symphysis.

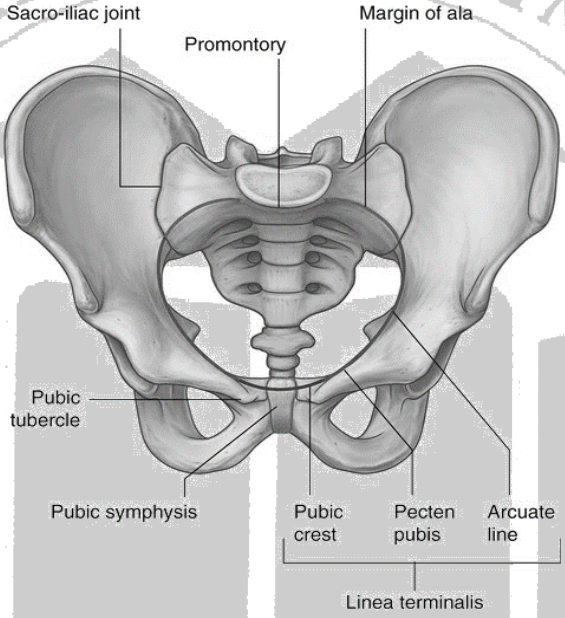


Fig 3.8: Hip bones

Ilium is the expanded bone located dorsally. Its lateral border line called iliac crest. The lower border is fused with ischium and pubis bones at acetabulum cavity. Thus, it forms the part of acetabulum. Acetabulum is the socket for articulation of head of femur bone. The inner margin articulates with sacrum by sacro-iliac joint.

Ischium is fused with ilium superiorly and forms a part of acetabulum. At lower region it fuses with pubis bone.

Pubis is also the part of acetabulum. The spinal nerves and the blood vessels pass through the obturator foramen which is a large ring like opening present between ischium and pubis.

Bones of lower limb

Femur: It also called as Thigh Bone and is the longest and strongest bone of the body. It consists of head, neck, greater and lesser trochanters. Head is spherical shaped fits into acetabulum of the hip bone forming the ball and socket joint of the hip. The shaft is cylindrical on the upper part whereas the lower one third part is slightly flat & broader. Lateral & Medial Condyle present at lower end of the shaft forming knee joint.

Patella: Also, known as Knee Cap. It is a sesamoid bone, roughly triangular and flat. It attached to the tibia and femur by ligaments. Anterior surface is rough while posterior surface is smooth. It is covered by articular cartilage. It protects the knee and maintains the position of tendons and ligaments during movement.

Tibia: A long **s**hin bone consists of shaft and upper and lower extremities. It is located on the inner side of a leg. The median and lateral condyle present on the proximal end for articulation with distal end of femur. On the front side, there is a tuberosity of tibia which gives the attachment to muscles. Lower extremity is slightly expanded and forms ankle joint with the talus.

Fibula: It is located lateral to tibia. The head articulate with tibia whereas the distal articulate with the talus bone of the ankle.

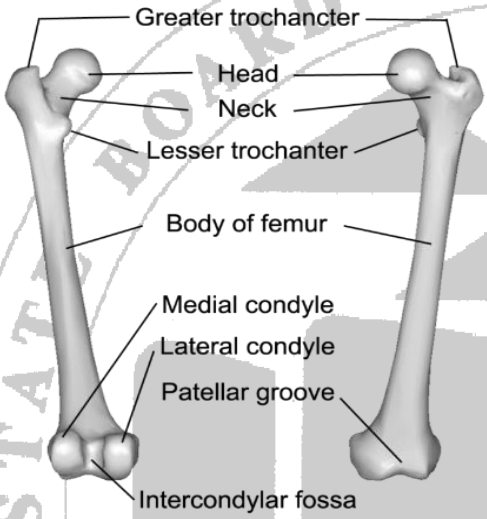


Fig 3.9: Femur

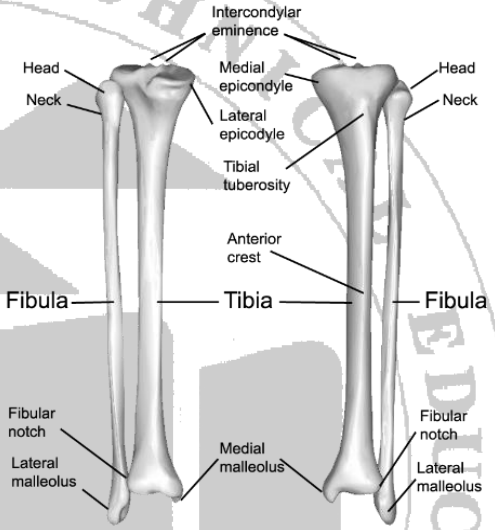


Fig 3.10: Tibia and Fibula

Tarsals: These are also called ankle bones, 7 in numbers and form the posterior part of the foot.

Bones: 1 Talus, 1 Navicular, 3 Cuneiform, 1 Calcaneus, and 1 Cuboid bones. Talus articulates with tibia and fibula at the ankle joint. Calcaneus or heel bone is roughened for the attachment of muscles. Navicular situated on the medial side of the foot. The medial, intermediate, and lateral cuneiform and cuboid form a row of bones.

Metatarsals: Intermediate portion of the foot made up of the metatarsus consists of five metatarsal bones. It consists of proximal base, intermediate shaft, and a distal head. Base articulates with tarsal bones and the distal ends with phalanges.

Phalanges: There are 14 phalanges in each foot. Articulates with metatarsals. It consists of proximal phalanges, middle phalanges & distal phalanges.

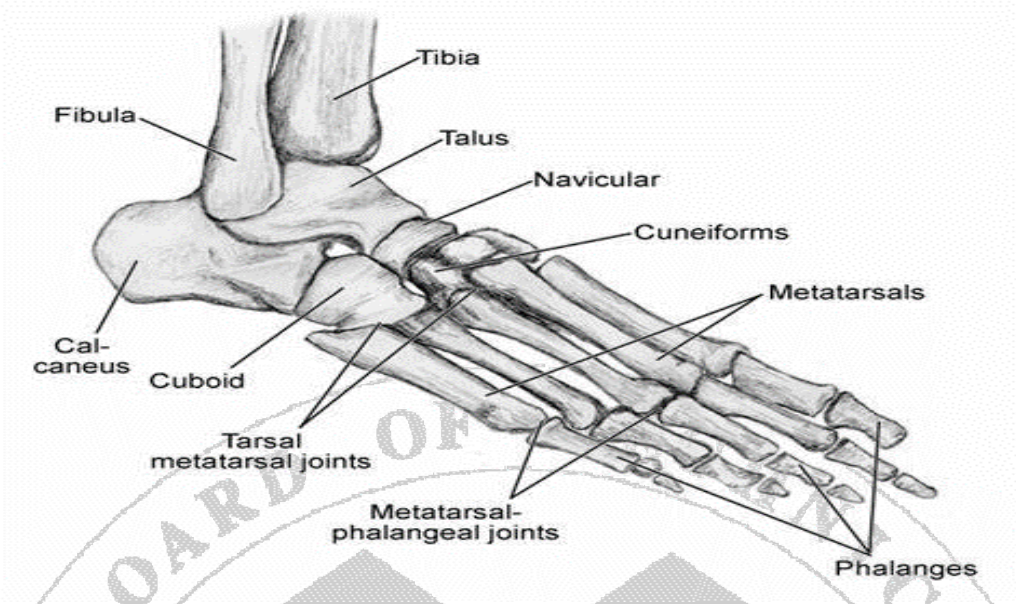


Fig 3.11: Bones of foot

5. Requirements:

Articulated human skeleton, disarticulated human bones, and chart of human skeleton.

6. Procedure

a. Read the theory part and observe the specimens of the bones one by one.
b. Observe the joints of bones formed when they articulate with other bones.
c. Correlate the disarticulated specimens with the articulated specimen of the human skeleton.

7. Precautions to be taken

a. Do not touch the specimens or models with bare hands. Always wear gloves to prevent contamination and maintain hygiene.
b. Handle models or specimens with care and gentleness to avoid damage or breakage. Use both hands when necessary to support and stabilize items.
c. After completing the experiment or study session, clean the specimens following appropriate protocols and guidelines

8. Result

_____

_____

9. References

a. Tortora, G. J., Derrickson, B. (2014). Principles of Anatomy and Physiology (14th ed.). Hoboken, N.J.: John Wiley.
b. Waugh, A., Grant, A. (2023). Ross & Wilson Anatomy and Physiology in Health and Illness (14th ed.).
c. https://www.healthline.com/human-body-maps/skeletal-system

10. Practical Related Questions

a. Define and classify Skeleton.
b. Give the four functions of bone.
c. Name the sutures present in cranium.

d. What are true ribs and false ribs?
e. Draw the structure of atlas and axis vertebra.
f. Name the parts of typical vertebra.
g. Name the bones present in tarsal region.
h. State any four differences between male and female pelvis.

(Space for writing answers)

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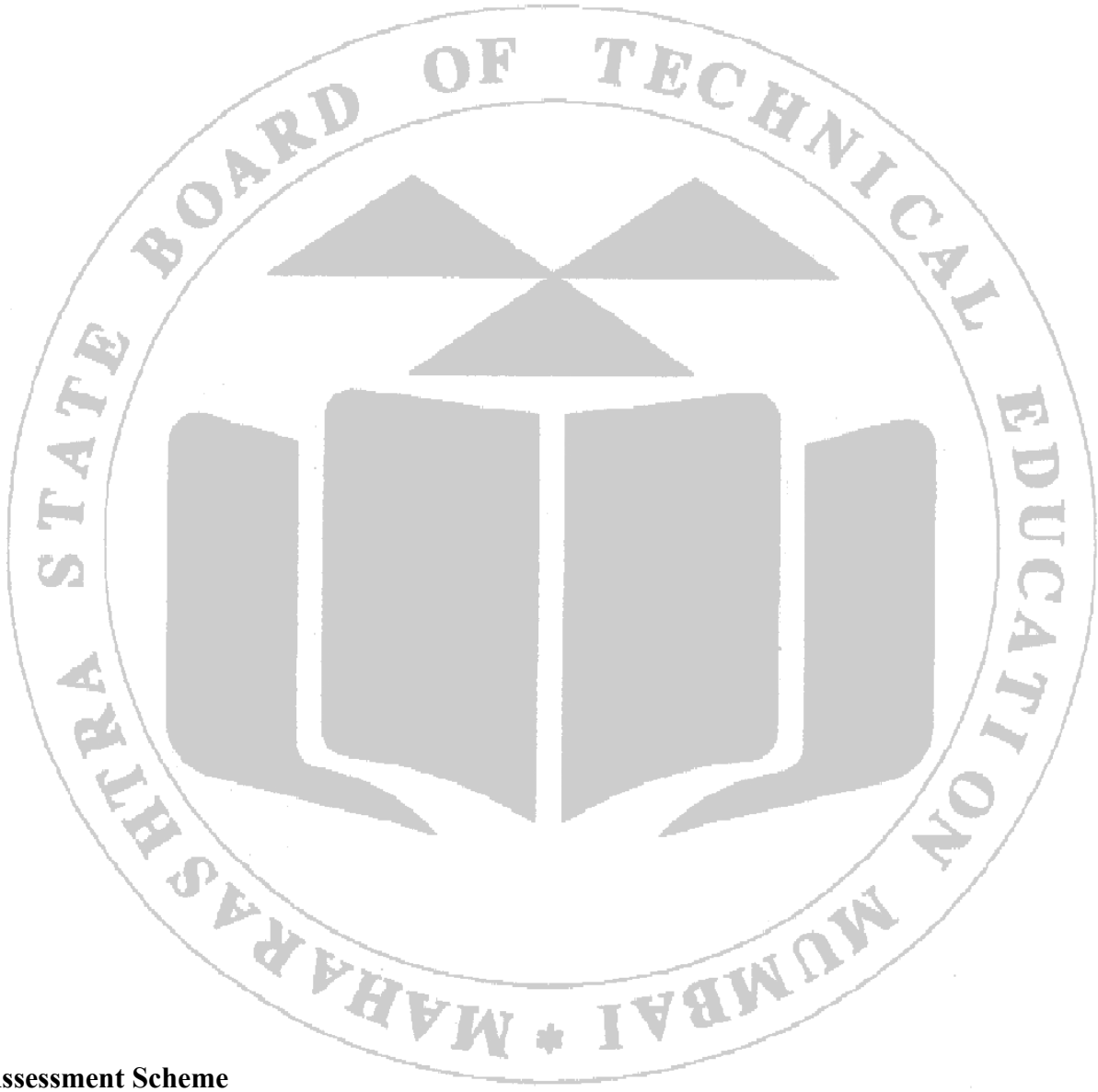


11. Assessment Scheme

Particular	Understanding the basic concept (Intellectual skill)	Activities (Intellectual and motor skills)	Cleanliness & Handling (Affective domain)	Viva-voce / Answers Written	Total	Signature of teacher
Marks Obtained						
Max Marks	**02**	**05**	**01**	**02**	**10**	

Experiment No. 4
General Techniques for Blood Collection

1. Aim
To study the general techniques for blood collection.

2. Practical Significance
Collecting blood samples is a common method used to diagnose and monitor diseases. By analyzing the different components of blood, both normal and abnormal, healthcare providers can identify patients' health conditions. Understanding various blood collection techniques is essential for healthcare providers to obtain samples efficiently and safely for testing. This knowledge ensures that the right amount of blood is collected using appropriate methods, minimizing discomfort, and maximizing diagnostic accuracy.

3. Practical Outcomes (PrOs)
After completion of this practical, the students will be able to:

PrO	Practical Outcomes	Mapped CO	BTL
1	Choose suitable technique of blood collection.	CO1	3
2	Collect blood samples from capillary or vein of other subjects.	CO1	3
3	Perform disinfection and pricking accurately.	CO1	3
4	Collaborate and communicate with fellow students.	CO1	5

4. Relevant Theoretical Background
Blood is a fluid connective tissue that circulates within a closed system of blood vessels. Blood constitutes approximately 8% of body weight. Collecting blood samples is crucial for understanding, preventing, and treating diseases. Human blood is used to determine various parameters including complete blood count, erythrocyte sedimentation rate (ESR), hemoglobin levels, blood sugar levels, serum electrolytes, and blood group classification, among others.

Methods of Blood collection

A. Capillary puncture method:

Capillary puncture is a technique used to obtain small amounts of blood from capillaries close to the skin's surface. Blood is collected by pricking the skin of the fingertip (fingerstick) or heel (heel stick) to access capillary blood. In adults capillary blood sample can be obtained from the lateral side of tip of the 3rd or 4th finger while in infants the sample can be obtained by a deep puncture of the plantar surface of the heel or great toe. This method is commonly employed for diagnostic testing when only a small volume of blood is needed.

Finger - The tip of the ring finger and middle finger are indeed commonly preferred for blood sampling in adults and children. These fingers have good blood flow and sufficient tissue for successful capillary puncture. The thumb is typically avoided for blood sampling due to its strong pulse and potential for excessive bleeding. Capillary blood flow in the thumb can be more variable and the risk of discomfort or complications is higher. The index finger can be sensitive, and the little finger does not have enough tissue to prevent hitting the bone with the lancet.

Heel - The heel is commonly used for blood sampling in infants less than one year old, especially when their fingers are too small for sampling.

Great toe - The big toe can be used as an alternative site, if necessary, in infants who are not yet walking. Only the great toe has sufficient tissue to protect the bone from injury during blood sampling.

Ear lobe - Although the ear lobe has been used for capillary blood sampling in the past, it is no longer recommended. The blood flow in the ear lobe is lower compared to the fingertip or heel. However, the ear lobe may still be used if no other suitable site is available.

B. Venipuncture method:

This process involves puncturing a vein, usually in the arm, to collect blood using a needle and syringe or vacuum tube system. Collection takes place from a superficial vein in the upper limb, generally the median cubital vein in the arm. This vein is close to the skin and is not surrounded by many large nerves, which reduces pain and discomfort for the patient. Venipuncture is a commonly utilized technique for collecting larger volumes of blood.

C. Arterial puncture method: Blood is obtained from an artery, typically at the wrist (radial artery) or groin (femoral artery), to perform arterial blood gas measurements or assess oxygen levels.

Types of samples collected for hematological investigations

a. **Whole blood:** This is used for performing complete blood counts including reticulocyte count and for making peripheral blood films.

b. **Serum:** Serum is the liquid portion of blood that remains after the blood has clotted and the clotting factors (fibrinogen and other proteins involved in blood clotting) have been removed. When blood is allowed to clot without anticoagulant, the solid components such as red blood cells, white blood cells, and platelets form a clot, leaving behind the clear, straw-colored fluid is called serum.

Serum = Blood – (Blood cells + clotting factors)

c. **Plasma:** Plasma is the pale cream-colored fluid obtained by centrifuging blood collected with anticoagulant. Plasma contains clotting factors and is separated from blood cells during centrifugation.

Plasma = Blood – Blood cells

Anticoagulants used in collection of blood samples:

Anticoagulants are chemical substances that prevent blood clot formation either in vitro (outside the body) or in vivo (inside the body). Various types of anticoagulants are used in clinical laboratories:

a. **Double Oxalate Mixture:** Potassium oxalate and ammonium oxalate are combined in a 2:3 ratio to form a double oxalate mixture, which serves as an anticoagulant.

b. **Ethylene Diamine Tetra acetic Acid (EDTA):** EDTA prevents blood clotting by chelating with calcium ions present in the blood.

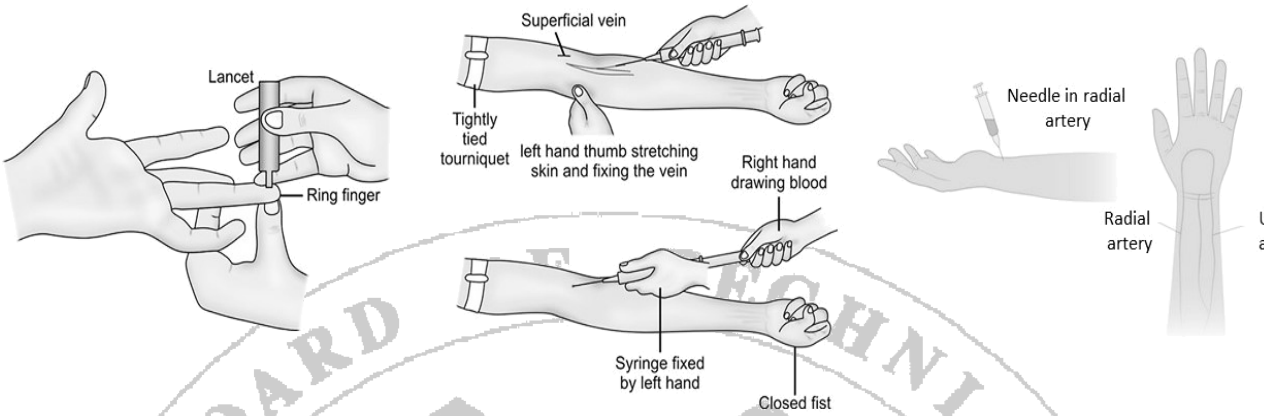
c. **Trisodium Citrate:** This anticoagulant is often used in combination with other agents for blood storage in blood banks.

d. **Sodium Fluoride:** Sodium fluoride acts as both an anticoagulant and a preservative.

e. **Acid Citrate Dextrose (ACD) and Citrate Phosphate Dextrose (CPD):** ACD and CPD are anticoagulants used specifically for preserving blood in blood banks.

f. **Heparin:** Heparin is a natural anticoagulant found in human circulation. It works by enhancing the activity of antithrombin III, thereby preventing blood clotting.

5. Diagram



Capillary puncture Venipuncture Arterial puncture

Fig 4.1: Methods of blood collection

6. Requirements

Apparatus: Disposable sterile syringe and needle/lancet.

Materials: Methylated spirit or 70% v/v ethyl alcohol, sterile gauze, collection vial/bottle, tourniquet, cotton swab, and hand glows.

7. Procedure

A. Capillary puncture method

a. Clean the area (as applicable) to be punctured with soap and water, then dry it with a clean cloth.
b. Sterilize the area with spirit (such as alcohol) and allow it to air dry naturally.
c. Use a sterile disposable needle or lancet to puncture the skin to a depth of 2-3 mm.
d. Wipe away the first drop of blood and gently squeeze the area to encourage a free flow of blood.
e. Collect the blood sample using a clean, dry micropipette, capillary tube, or onto a slide as needed.
f. After collection, apply gentle pressure with a fresh cotton swab to the puncture site until bleeding stops.

B. Venipuncture method

a. Clean hands thoroughly with soap and water.
b. Assemble the needle with the syringe, keeping the needle capped until ready for use. Ensure that the syringe operates smoothly.
c. Apply the tourniquet above the site where you plan to insert the needle, typically around the upper arm if drawing blood from the vein in the forearm.
d. Sterilize the site where the needle will be inserted, usually the selected vein in the forearm.
e. Insert the needle into the vein with the bevel up and parallel to the skin surface. Blood in the needle hub confirms successful entry into the vein. Release the tourniquet once blood flows into the syringe.
f. Withdraw the syringe piston slowly to avoid frothing of blood.

g. After collecting the required amount of blood, place a sterile gauze pad over the needle insertion site. Withdraw the needle smoothly while applying pressure to the site.
h. Carefully transfer the collected blood into the designated receiver (e.g., blood collection tube) and cap it securely to prevent leakage.
i. Maintain gentle pressure on the gauze pad over the venipuncture site until bleeding stops. Cover the site with a small adhesive dressing.
j. Immediately dispose of the needle in a designated needle destroyer device. Do not break, bend, or recap needles after use.
k. Place used swabs, syringes, and other contaminated materials into a puncture-resistant container for safe disposal.

8. Precautions to be taken

A. Capillary puncture method

a. Select the appropriate site for puncture (e.g., fingertip or heel) based on patient age and condition.
b. Ensure the area is clean and dry before puncturing the skin.
c. Use a sterile lancet or needle for each puncture to prevent infection.
d. Avoid squeezing the puncture site too vigorously, as this can distort blood sample results.
e. Wipe away the first drop of blood to minimize tissue fluid contamination.
f. Collect the blood sample using a capillary tube or micropipette without touching the puncture site to prevent contamination.
g. Apply gentle pressure with a clean cotton swab to stop bleeding and prevent hematoma formation.

B. Venipuncture method

a. Cleanse the venipuncture site thoroughly with an antiseptic solution to reduce the risk of infection.
b. Use appropriate vein selection techniques, considering patient comfort and accessibility.
c. Ensure the needle is sterile and securely attached to the syringe or collection tube holder.
d. Insert the needle smoothly and at the correct angle to minimize pain and tissue trauma.
e. Release the tourniquet promptly once blood flow is established to prevent hemoconcentration.
f. Mix blood tubes gently to prevent clot formation or hemolysis.
g. Apply pressure to the venipuncture site after needle removal to facilitate hemostasis.
h. Dispose of used needles and other sharps in designated puncture-proof containers to prevent accidental needlestick injuries.

9. Observations

Observe the actual working methods during demonstration. Note relevant precautions taken.

10. Result

_____

_____

11. References

a. Goyal, R. K., Patel, N. M., (2010). Practical Anatomy and Physiology. B. S. Shah Prakashan, 14th edition.
b. Reddy, L. P., (2009). Practical Physiology, Paras Publishing, 2nd Edition.

c. Pal, G. K., Pal, P., (2001). Textbook of Practical Physiology, Orient Longman Ltd.
d. https://uomustansiriyah.edu.iq/media/lectures/6/6_2022_11_26!01_15_26_AM.pdf.
e. https://www.neoteryx.com/microsampling-blog/the-best-way-to-collect-a-blood-sample-3-methods-examined

12. Practical Related Questions

a. Give a reason, why is the pricking site cleaned with a spirited cotton swab?
b. List methods of blood collection.
c. State the purposes of blood sample collection.
d. Name the anticoagulant used in the blood bank.
e. Name the sites from which blood samples are collected in infants.

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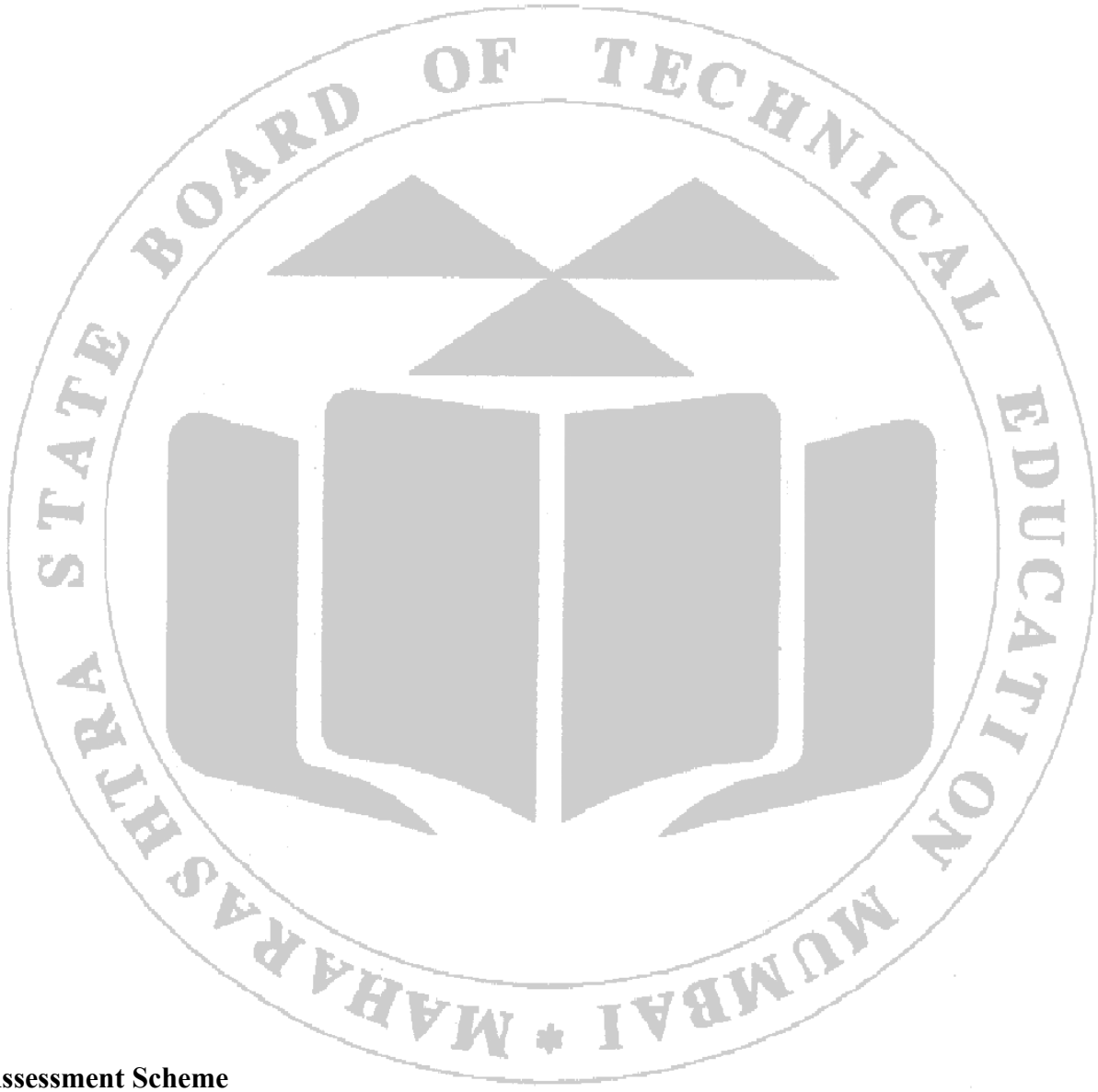

13. Assessment Scheme

Particular	Understanding the basic concept (Intellectual skill)	Activities (Intellectual and motor skills)	Cleanliness & Handling (Affective domain)	Viva-voce / Answers Written	Total	Signature of teacher
Marks Obtained						
Max Marks	**02**	**05**	**01**	**02**	**10**	

Experiment No. 5
Study of Bleeding time

1. Aim

To determine the bleeding time of own blood.

2. Practical Significance

Bleeding time evaluates how quickly tiny blood vessels in the skin stop bleeding. An increase in bleeding shows certain pathological conditions. In this practical, students will learn to determine the bleeding time and identify the pathological condition based on the result.

3. Practical Outcomes (PrOs)

After completion of this practical, the students will be able to:

PrO	Practical Outcomes	Mapped CO	BTL
1	Use Duke's method for determination of bleeding time.	CO1	4
2	Determine the factors responsible for increase or decrease in bleeding time.	CO1	4
3	Identify the pathological condition based on result.	CO1	3
4	Collaborate and communicate with fellow students.	CO3	5

4. Relevant Theoretical Background

Terminology

Bleeding Time

It is the time interval between skin puncture (Blood coming out from vessel) and complete cessation of blood flow. The cessation of blood flow depends exclusively on blood vessel constriction and platelet aggregation.

Method

It is determined by Duke's method and Ivy's method.

Duke's method is more commonly used in laboratories as it requires minimal equipment and less skills.

Normal Value: 02 to 06 minutes.

Significance in diagnosis: Increase in bleeding time indicates, thrombocytopenia, scurvy due to Vit. C deficiency, purpura etc.

5. Diagram

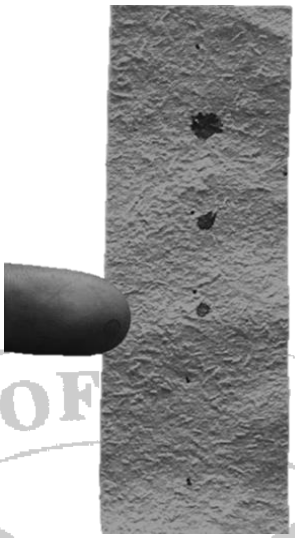

Fig No. 5.1 Blotting of blood drop

6. Requirements

Sterile lancet, filter paper, stopwatch, cotton swab and spirit.

7. Procedure

a. Keep the stopwatch and filter paper ready. Write name, age, sex, date, name of test and method on the corner of the filter paper.
b. Wash the hands properly and allow them to dry.
c. Sterilize the fingertip to be pricked with spirit and allow to dry.
d. Prick the fingertip with sterilized lancet deep enough about 3-5 mm depth and start the stopwatch immediately.
e. Blot the first blood drop on the filter paper after 10 seconds.
f. Repeat the blotting after every 10 seconds in a row till stoppage of bleeding. Do not touch the skin to the filter paper.
g. Stop the stopwatch as soon as the bleeding stops.

8. Precautions to be taken

a. Always use sterilized needle.
b. Before pricking, fingertip should be dry completely.
c. Pricking should be deep enough.
d. Do not touch the tip to the filter paper.

9. Observation

Bleeding Time = (Number of blots + 1) × duration between blots (10 sec)

= _____

= _____minutes_____seconds.

10. Result

_____

_____

11. Conclusion

The bleeding time of my own blood was_____ (Normal/Prolonged/Reduced).

12. References

a. Reddy, L. P., (2009). Practical Physiology, Paras Publishing, 2nd Edition.
b. Nade, V., Godse, S., (2014). Practicals of Human Anatomy & Physiology, Career Publications, 1st Edition.

13. Practical Related Questions

a. State meaning of bleeding time and give its normal value.
b. How bleeding time change in hemophilia?
c. What care should be taken while using pricking needle or lancet?
d. What is the effect of purpura on bleeding time?
e. Why bleeding time is less than clotting time? Give the reason.

(Space for writing answers)

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14. Assessment Scheme

Particular	Understanding the basic concept (Intellectual skill)	Activities (Intellectual and motor skills)	Cleanliness & Handling (Affective domain)	Viva-voce / Answers Written	Total	Signature of teacher
Marks Obtained						
Max Marks	**02**	**05**	**01**	**02**	**10**	

Experiment No. 6
Study of Clotting time

1. Aim

To determine the clotting time of own blood.

2. Practical Significance

Clotting time helps to determine the time taken by the blood to form a clot. An increase in clotting time shows certain pathological conditions. In this practical, students will learn to determine the clotting time and identify the pathological condition based on the result.

3. Practical Outcomes (PrOs)

After completion of this practical, the students will be able to:

PrO	Practical Outcomes	Mapped CO	BTL
1	Use capillary tube method for determination of clotting time.	CO1	4
2	Explain the mechanism of blood coagulation.	CO1	2
3	Determine the factors responsible for increase in clotting time.	CO1	4
4	Identify the pathological condition based on result.	CO1	3
5	Collaborate and communicate with fellow students.	CO3	5

4. Relevant Theoretical Background

Terminology

Clotting Time

It is the time interval between onset of bleeding and formation of blood clot. When the blood vessel ruptures, in a few minutes blood loses its fluidity and converts into a semisolid mass called clot. It consists of a network of insoluble protein fibres, called Fibrin. This process of clot formation is called blood coagulation. Clotting involves several substances known as clotting factors.

Method

It is determined by capillary tube method and Lee-white method.

Capillary tube method is the most commonly used in laboratories.

Normal Value: 02 to 08 minutes.

Significance in diagnosis: Increase in clotting time indicates, hemophilia, Vit. K deficiency, thrombocythemia etc.

5. Diagram

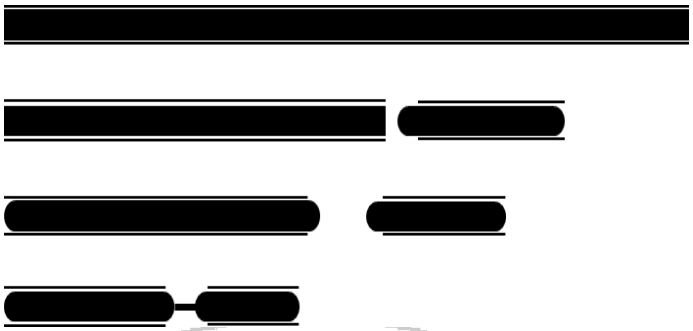

Fig 6.1: Determination of clotting time

6. Requirements

Sterile lancet, capillary tube (1 mm diameter and min. 10 cm long), stopwatch, cotton swab, and spirit.

7. Procedure

a. Wash the hands properly and allow them to dry.
b. Sterilize the fingertip to be pricked with spirit and allow to dry.
c. Prick the fingertip with sterilized lancet with precaution and start the stopwatch immediately.
d. Deep one end of the capillary into blood drop gently without pressure. Allow the blood to flow into the capillary freely by lowering the other end of capillary (Do not suck the blood).
e. Hold the filled capillary in palm to maintain the temperature of 37^0C.
f. Start the stopwatch and after every 30 seconds break a small piece of capillary and observe the appearance of fibrin thread.
g. Repeat the procedure after every 30 seconds till a fibrin thread appears between broken ends of capillary.
h. Stop the stopwatch once the thread appears and record the clotting time.

8. Precautions to be taken

a. Always use sterilized needle.
b. Before pricking, fingertip should be dry completely.
c. Pricking should be deep enough.
d. Allow the blood to move freely into capillary and entrapment of air bubble should be avoided.

9. Observation

Clotting Time = Number of breaks × duration between breaks (30 sec)

= _____

= _____minutes_____seconds.

10. Result

_____

_____

11. Conclusion

The clotting time of my own blood was_____ (Normal/Prolonged/Reduced).

12. References

a. Reddy, L. P., (2009). Practical Physiology, Paras Publishing, 2nd Edition.
b. Nade, V., Godse, S., (2014). Practicals of Human Anatomy & Physiology, Career Publications, 1st Edition.

13. Practical Related Questions

a. Define clotting time and give its normal value.
b. What is the effect of purpura on clotting time?
c. Give the significance of clotting time.
d. State two pathological conditions when clotting time is prolonged.
e. What is hemophilia?

(Space for writing answers)

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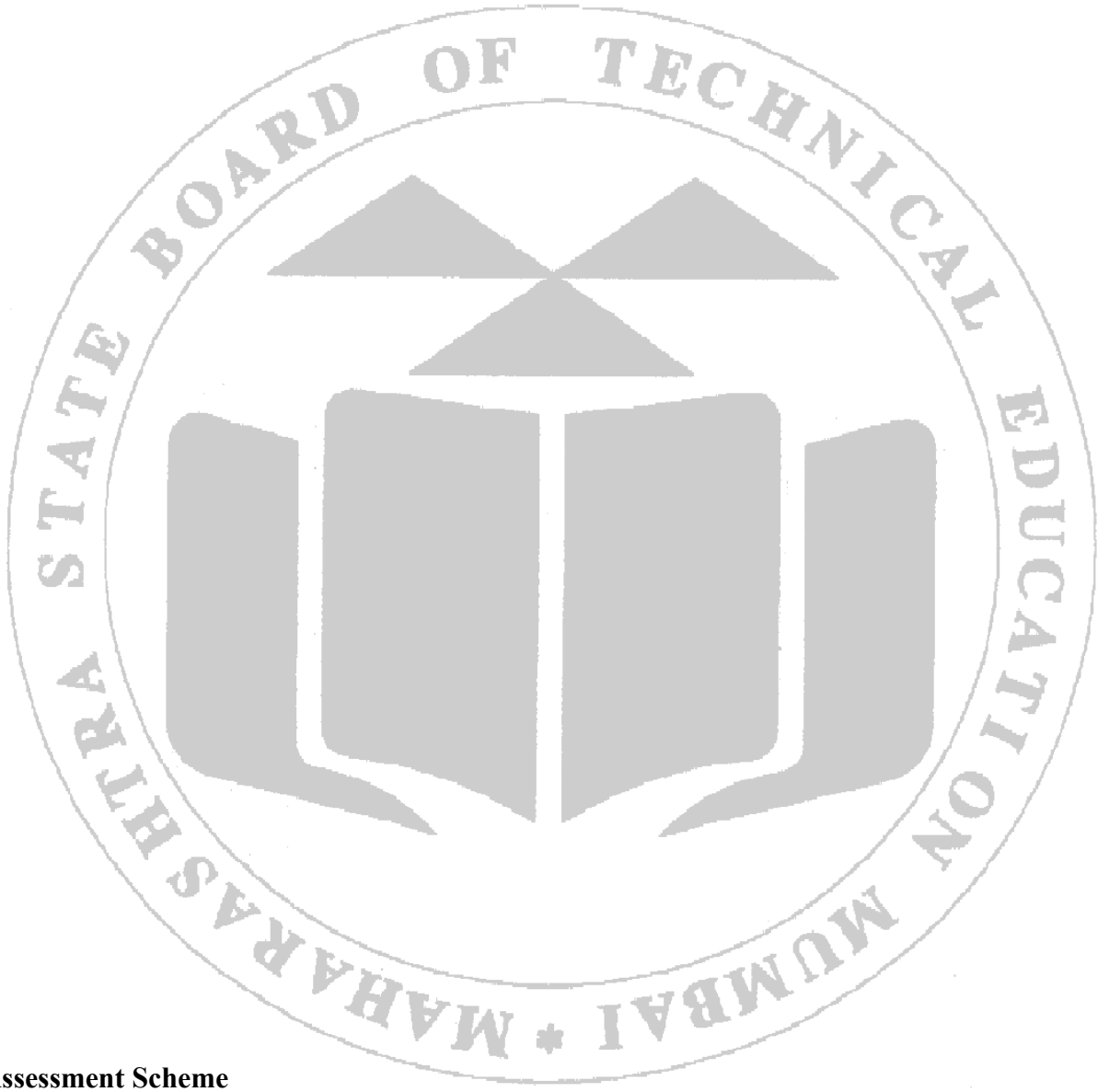


14. Assessment Scheme

Particular	Understanding the basic concept (Intellectual skill)	Activities (Intellectual and motor skills)	Cleanliness & Handling (Affective domain)	Viva-voce / Answers Written	Total	Signature of teacher
Marks Obtained						
Max Marks	**02**	**05**	**01**	**02**	**10**	

Experiment No. 7
Determination of the Blood Group

1. Aim
To determine the blood group of own blood by ABO system.

2. Practical Significance
According to the ABO system of blood grouping, there are four types of blood groups: A, B, AB, and O. This classification is based on the presence or absence of specific antigens on the surface of red blood cells (RBCs) and corresponding antibodies in the plasma. Knowing the correct blood group plays a crucial role in various medical and health- related contexts, including blood transfusions, organ transplantation, pregnancy and newborn care, medical diagnostics, forensic science, and genetic research.

In addition to the ABO system, the Rh system is another key blood group classification. It is based on the presence (Rh-positive) or absence (Rh-negative) of the Rh factor (D antigen) on RBCs. The Rh status is especially important in pregnancy; a Rh-negative mother with a Rh-positive fetus can develop antibodies that may harm the fetus, leading to hemolytic disease of the newborn. Both ABO and Rh systems are vital for safe blood transfusions and managing Rh incompatibility during pregnancy.

3. Practical Outcomes (PrOs)
After completion of this practical, the students will be able to:

PrO	Practical Outcomes	Mapped CO	BTL
1	Find out own blood group by ABO system.	CO1	3
2	Justify which type of blood group is suitable for a particular subject.	CO1	3
3	Assist the society by donating the blood.	CO1	5
4	Collaborate and communicate with fellow students.	CO1	5

4. Relevant Theoretical Background
The surfaces of erythrocytes contain a genetically determined assortment of antigens. These antigens (agglutinogens) occur in characteristic combinations, while the corresponding antibodies (agglutinins) are present in plasma.

Principle: The principle of blood group detection is based on identifying specific antigens on erythrocytes and the corresponding antibodies present in the blood. Agglutination is a key reaction that allows for the identification of blood types and ensures compatibility in blood transfusions. When a blood sample is mixed with a reagent containing specific antibodies, these antibodies will bind to the corresponding antigens on the RBCs if they are present. This binding causes the RBCs to clump together or agglutinate. The presence or absence of agglutination helps determine the blood type.

Landsteiner's Law: Karl Landsteiner, an Austrian biologist and physician, discovered the ABO blood group system in 1901. According to his law, if a specific type of antigen (agglutinogen) is present on the RBC membrane, the corresponding antibody (agglutinin) must be absent in the plasma. Conversely, if a particular type of antigen is absent on the RBC membrane, then the corresponding antibody must be present in the plasma.

ABO blood group system: The ABO blood group is based on two glycolipid antigens called A and B. This system categorizes blood into four groups: A, B, AB, and O, based on the presence of antigens A, B, both (A and B), or neither on the red blood cells. Following table summarizes ABO blood group system.

Blood group	Antigens (agglutinogen) on RBC	Antibodies (agglutinins) in Serum	Can be a donor to	Can be a recipient for
A	A	Anti-B	A and AB	A and O
B	B	Anti-A	B and AB	B and O
AB	A and B	None	AB only	All groups
O	None	Anti-A and Anti-B	All groups	O only

Donor: A person who donates blood is a donor. Blood group 'O' is known as the universal donor because it does not contain any antigens (agglutinogens) and hence can be donated to individuals of any blood group.

Recipient: A person who receives blood is a recipient. Blood group 'AB' is known as the universal recipient because it does not contain any antibodies (agglutinins) and hence can receive blood from individuals of any blood group.

Rh Blood Group System: Besides agglutinogens A and B, another agglutinogen called the Rh factor (Rhesus factor) or Rh antigen was discovered in human blood, named after its discovery in Rhesus monkeys in 1940. The most significant Rh antigen is the D antigen. Blood with this antigen is Rh positive (Rh+), while blood without it is Rh negative (Rh-). Nearly 90% of the world's population is Rh+.

Agglutinins against the Rh antigen is not naturally present but develop after the first exposure. Thus, if Rh+ blood is given to an Rh- patient for the first time, anti-Rh antibodies will form without causing incompatibility. However, a second transfusion to the same patient may cause agglutination.

5. Diagram

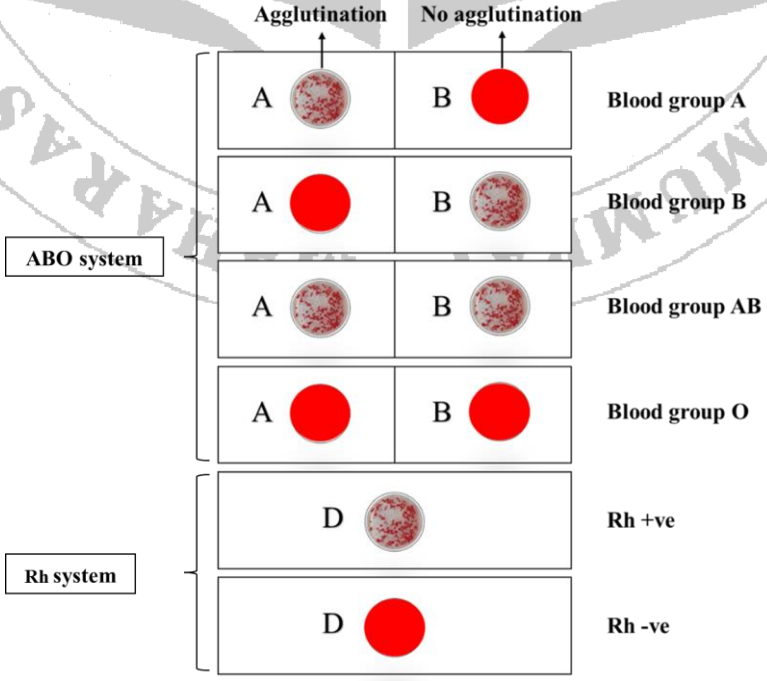


Fig 7.1: Blood group determination

6. Requirements

Apparatus: Glass slides, glass marker, dropper, pricking needle/lancet, and watch glass.

Chemicals: Normal saline, 1% sodium citrate prepared in normal saline, 70% alcohol or spirit, blood group reagents (Anti-A, Anti-B, and Anti-D sera).

7. Procedure

a. Take two clean glass slides and label one with A and B, and the other with C and D, spaced evenly apart.
b. Place 4-5 drops of sodium citrate in a watch glass. Using proper aseptic techniques, prick the finger with a needle or lancet. Collect 3-4 drops of blood into the watch glass containing sodium citrate.
c. After thorough mixing, dispense one drop of the mixture onto the opposite side of the labeled areas on each glass slide, at positions A, B, C, and D.
d. Immediately add 2 drops of corresponding antisera onto the respective labeled areas and 2 drops of
e. saline solution onto the C label (serving as a control). The C label will be used for comparison to observe agglutination.
f. Thoroughly mix the blood solution with antisera using a separate edge of another slide for each antisera.
g. Allow the mixture to react for 5 minutes.
h. After 5 minutes, observe for agglutination by comparing each slide to the control (C). If agglutination is observed in the control, repeat the entire procedure.
i. Use following table for determination of blood group.

Blood group	Blood + Antisera A	Blood + Antisera B	Blood + Antisera D	Rh status
A^+	+	-	+	Rh +
B^+	-	+	+	Rh +
AB^+	+	+	+	Rh +
O^+	-	-	+	Rh +
A^-	+	-	-	Rh -
B^-	-	+	-	Rh -
AB^-	+	+	-	Rh -
O^-	-	-	-	Rh -

8. Precautions to be taken

a. Always use sterile equipment, including needles, lancets, and slides, to avoid contamination and infection.
b. Clearly label all slides to ensure accurate identification of samples.
c. Use the correct antisera (anti-A, anti-B, and anti-Rh) for each corresponding test. Ensure reagents are within their expiration date and properly stored.
d. Mix the blood sample and reagents thoroughly to ensure a proper reaction. Use separate mixing tools for each reagent to avoid cross-contamination.

e. Always include a control sample (saline solution) to compare and validate the results. Ensure no agglutination occurs in the control.
f. Allow sufficient time (usually 5 minutes) for the reaction to occur. Do not interpret results too early or too late.
g. Dispose of all used materials, including needles, lancets, and contaminated gloves, in appropriate
h. biohazard containers.

9. Observations

S. N.	Slide marking	Antisera/Saline solution	Agglutination (Yes/No)
1	A	Antisera A	
2	B	Antisera B	
3	C	Saline solution	
4	D	Antisera D	

10. Result

_____

_____

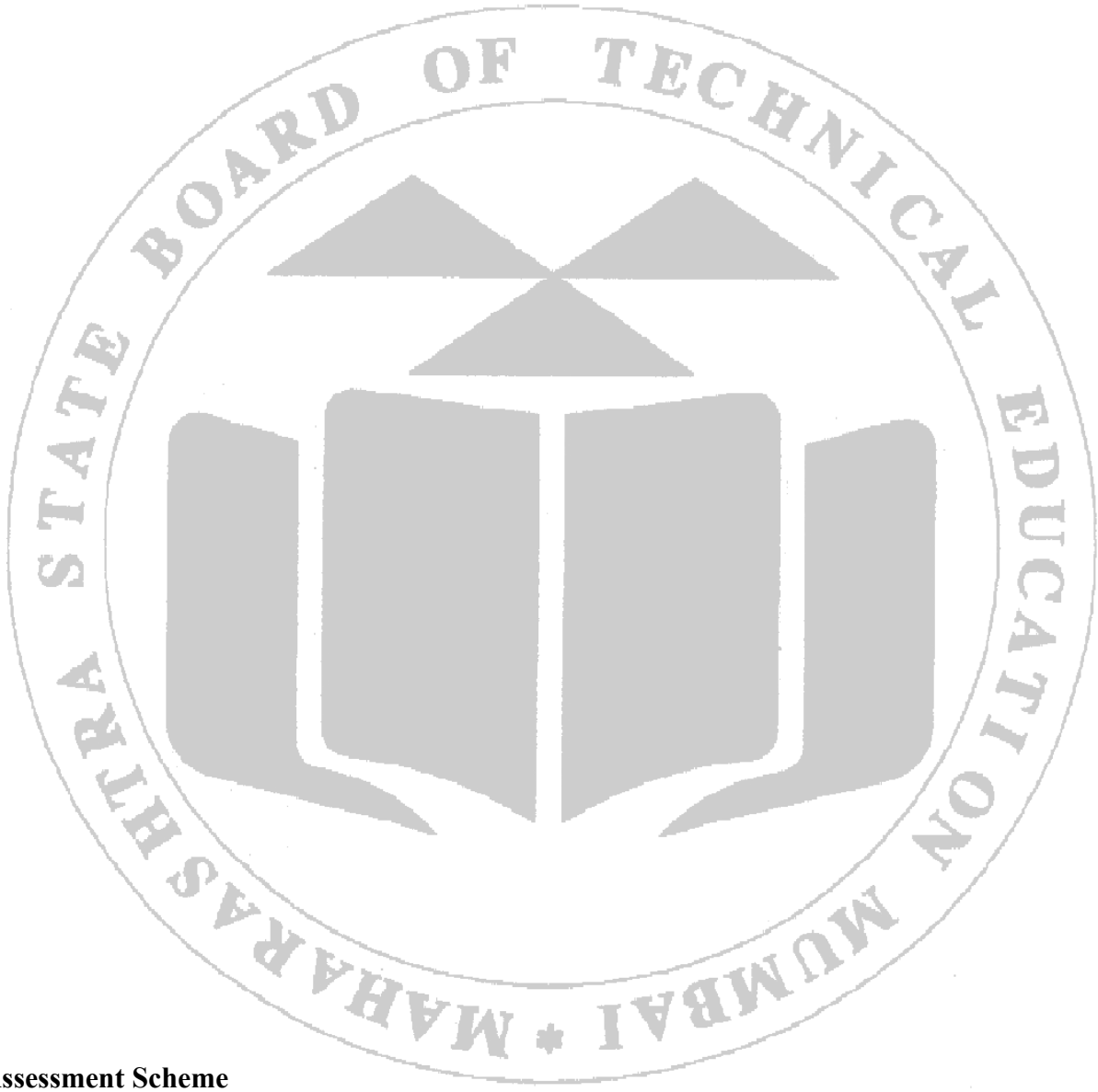
11. References

a. Goyal, R. K., Patel, N. M., (2010). Practical Anatomy and Physiology. B. S. Shah Prakashan, 14th edition.
b. Tortora, G. J., & Derrickson, B. (2014). Principles of Anatomy and Physiology (14th ed.). Hoboken, N.J.: John Wiley.
c. Waugh, A., Grant, A. (2023). Ross & Wilson Anatomy and Physiology in health and illness (14th ed.).

12. Practical Related Questions

a. What is the basis for the ABO system and Rh system?
b. Explain the concept of universal donor and recipient.
c. What are the objectives of determining blood groups?
d. Describe the process of agglutination.
e. Specify the anticoagulants commonly used in blood grouping.

(Space for writing answers)



13. Assessment Scheme

Particular	Understanding the basic concept (Intellectual skill)	Activities (Intellectual and motor skills)	Cleanliness & Handling (Affective domain)	Viva-voce / Answers Written	Total	Signature of teacher
Marks Obtained						
Max Marks	**02**	**05**	**01**	**02**	**10**	

Experiment No. 8
Determination of the Hemoglobin content of blood

1. Aim
To determine the hemoglobin content & oxygen carrying capacity of own blood by Sahli Hellige method.

2. Practical Significance
Hemoglobin (Hb) is a colouring matter and respiratory pigment of blood found in RBCs. The chief role of Hb is the transport of oxygen. In addition, hemoglobin also plays a role in the regulation of blood flow and blood pressure. Changes in hemoglobin levels indicate various health conditions. High hemoglobin can signal lung or heart disease, while low levels suggest anemia. Measuring hemoglobin helps diagnose the severity of these conditions. This practical exercise will teach students how to measure hemoglobin levels and identify related health issues.

3. Practical Outcomes (PrOs)
After completion of this practical, the students will be able to:

PrO	Practical Outcomes	Mapped CO	BTL
1	Explain the principle of hemoglobin estimation.	CO1	2
2	Calculate oxygen carrying capacity of blood.	CO1	3
3	Use Sahli's hemoglobinometer for estimation of hemoglobin.	CO1	3
4	Collaborate and communicate with fellow students.	CO1	5

4. Relevant Theoretical Background
Hemoglobin (Hb) is a conjugated protein synthesized in immature erythrocytes in the red bone marrow. It consists of a protein portion (globin) and an iron-containing non-protein portion (heme), with each Hb molecule having one globin unit and four heme units.
Hemoglobin's primary function is to carry oxygen and carbon dioxide, and its secondary function is to help maintain blood pH.

Principle of Sahli's (Acid hematin) method
The method is based on development of color.

a. When blood is mixed with 0.1N HCl, RBCs are hemolyzed and Hb is liberated.
b. This Hb is converted into acid hematin which is reddish brown in colour.
c. The solution is diluted with distilled water till it exactly matches with the standard glass (comparison) tubes.
d. The Hb levels can directly be read from the graduated tube in g/dL and % Hb.

Normal levels of Hb
Adult males: 14 to 18 grams per deciliter (g/dL)
Adult females: 12 to 16 g/dL
Children: 11 to 16 g/dL (varies with age)
Newborns: 14 to 24 g/dL

Factors affecting hemoglobin content

a. Physiological factors: Age, Sex, Body weight, Blood volume, Diet, Altitude, Hereditary and disease conditions.

b. Low hemoglobin in females is often due to factors such as the menstrual cycle, pregnancy, and lactation. In males, testosterone secretion stimulates the formation of red blood cells, resulting in higher hemoglobin levels compared to females.

Deficiency of hemoglobin

Deficiency of hemoglobin leads to the decreased oxygen-carrying capacity of blood, condition called anemia. This condition may be also due to reduction in RBC count.

Types of Anemia

a) Iron-deficiency anemia
b) Vitamin B_{12} deficiency anemia (Pernicious anemia)
c) Folate deficiency anemia
d) Aplastic anemia
e) Hemolytic anemia
f) Blood loss anemia
g) Sickle cell anemia
h) Thalassemia
i) Megaloblastic anemia
j) Microcytic anemia
k) Macrocytic anemia
l) Normocytic anemia

Methods of hemoglobin estimation

A. Traditional Methods:

a. Tallquist Method: Color comparison with a standard scale.
b. Sahli's (Acid Hematin) Method: Conversion of hemoglobin to acid hematin, followed by color comparison.
c. Halden's Method: Color comparison with oxyhemoglobin.
d. Alkaline Hematin Method: Conversion of hemoglobin to hematin in an alkaline solution, followed by spectrophotometric measurement.
e. Comparator Method: Visual comparison of blood sample color to a standard color scale.

B. Advanced Methods:

a. Cyanmethemoglobin Method: Conversion of hemoglobin to cyanmethemoglobin, followed by spectrophotometric measurement.
b. Hemoglobinometer (Hemocue Method): Color change with a reagent in a microcuvette, measured by a portable device.
c. Automated Hematology Analyzers: Spectrophotometric or optical methods used in automated instruments.
d. Sodium Lauryl Sulfate (SLS) Method: Conversion of hemoglobin to a stable SLS complex, followed by spectrophotometric measurement.
e. Oxygen-Binding Capacity Method: Measurement of hemoglobin's oxygen-binding capacity using specialized equipment.
f. Gasometric Method (Van Slyke Method): Measurement of oxygen consumed by hemoglobin in a known volume of blood, usually via gas burette.

5. Diagram

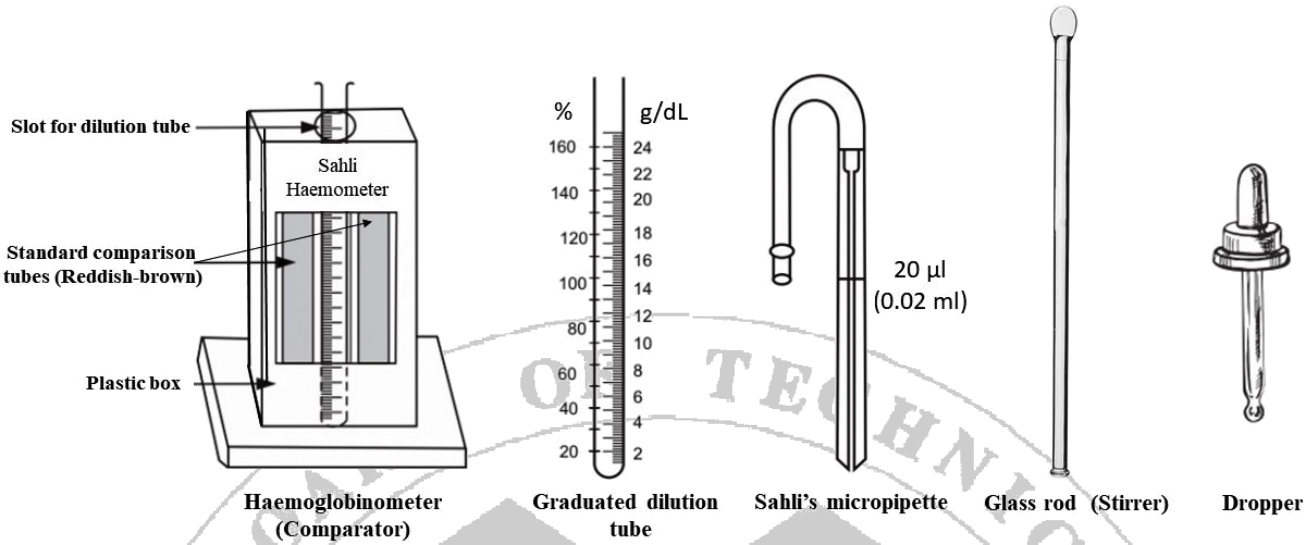


Fig 8.1: Sahli's hemoglobinometer

6. Requirements

Apparatus: Pricking needle/lancet and Sahli Hellige's hemoglobinometer.

Chemicals: 70% alcohol or spirit, 0.1 N HCl, and distilled water.

7. Procedure

a. Clean and dry the graduated dilution glass tube. Add 0.1N HCl up to the lowest mark of the tube using a dropper.
b. Wash the micropipette, rinse it with distilled water to ensure it is not blocked, and allow it to dry.
c. Massage the finger to increase blood flow, sterilize the fingertip with the alcohol swab, and then perform a bold prick with the lancet to allow free blood flow.
d. Touch the tip of the micropipette to the blood drop and collect the blood up to the 20 µL (0.02 ml)
e. mark. Ensure no air is entrapped and that the blood column is continuous. If excess blood is drawn, remove the excess by gently blowing it out.
f. Immediately transfer the collected blood from the micropipette to the graduated dilution tube containing 0.1N HCl, ensuring all blood is transferred (if necessary, rinse it with the acid in test tube).
g. Mix the blood with the 0.1N HCl using a glass stirrer to avoid clotting at the bottom of the test tube. Wait 8-10 minutes for the formation of acid hematin.
h. After 10 minutes, dilute the acid hematin solution by adding distilled water drop by drop while stirring continuously. Compare the colour of the test solution with the standard comparison tubes. If the test solution is darker, continue diluting with distilled water until it matches the standard colour.
i. After the exact match, note the reading on the graduated tube in g/dL and as a percentage (% Hb).

8. Precautions to be taken

a. Obtain a clean and adequate blood sample without clotting.
b. Take blood and reagents accurately to avoid errors.
c. Prevent air bubbles from entering the blood sample.

d. Mix the blood and reagents promptly to prevent clotting.
e. Dilute the acid hematin solution promptly after the waiting period.
f. Allow enough time for hemoglobin to convert to acid hematin.
g. Frequently compare with reference standards during dilution to prevent over-dilution.

9. Observations

a. The hemoglobin content in gram /100 mL of blood is _____ g/dL.

b. The hemoglobin content in % Hb from the graduated tube scale is _____% Hb.

10. Calculation

A. % Hb

14.5 g/dL of hemoglobin = 100% of Hb, hence,

% Hb content = (Observed g/dL of Hb x 100)/ 14.5

= (_____x 100)/ 14.5

= _____% Hb content.

B. Oxygen carrying capacity

100 % hemoglobin = 18.5 cm^3 of oxygen carrying capacity, hence

Oxygen carrying capacity = (% Hb x 18.5)/100

= (_____x 18.5)/ 100

= _____ cm^3.

11. Result

From observation and calculation, the hemoglobin content of my own blood was found to be _____ g/dL which has oxygen carrying capacity is _____cm^3.

12. Conclusion

S. N.	Level of Hemoglobin	Severity	According to the result, mark the level
1	More than 12 g/dL	Non- anemic	
2	8-12 g/dL	Mild anemic	
3	5-8 g/dL	Moderate anemic	
4	<5 g/dL	Severe anemic	

13. References

a. Goyal, R. K., Patel, N. M., (2010). Practical Anatomy and Physiology. B. S. Shah Prakashan, 14th edition.
b. Tortora, G. J., & Derrickson, B. (2014). Principles of Anatomy and Physiology (14th ed.). Hoboken, N.J.: John Wiley.
c. Waugh, A., Grant, A. (2023). Ross & Wilson Anatomy and Physiology in health and illness (14th ed.).

14. Practical Related Questions

a. Outline the principle underlying hemoglobin estimation using the Sahli Hellige's method.
b. List the various techniques for estimating hemoglobin levels.
c. Define anemia and enlist types.
d. Provide the standard hemoglobin values based on age and gender.
e. Highlight the significance of hemoglobin estimation.

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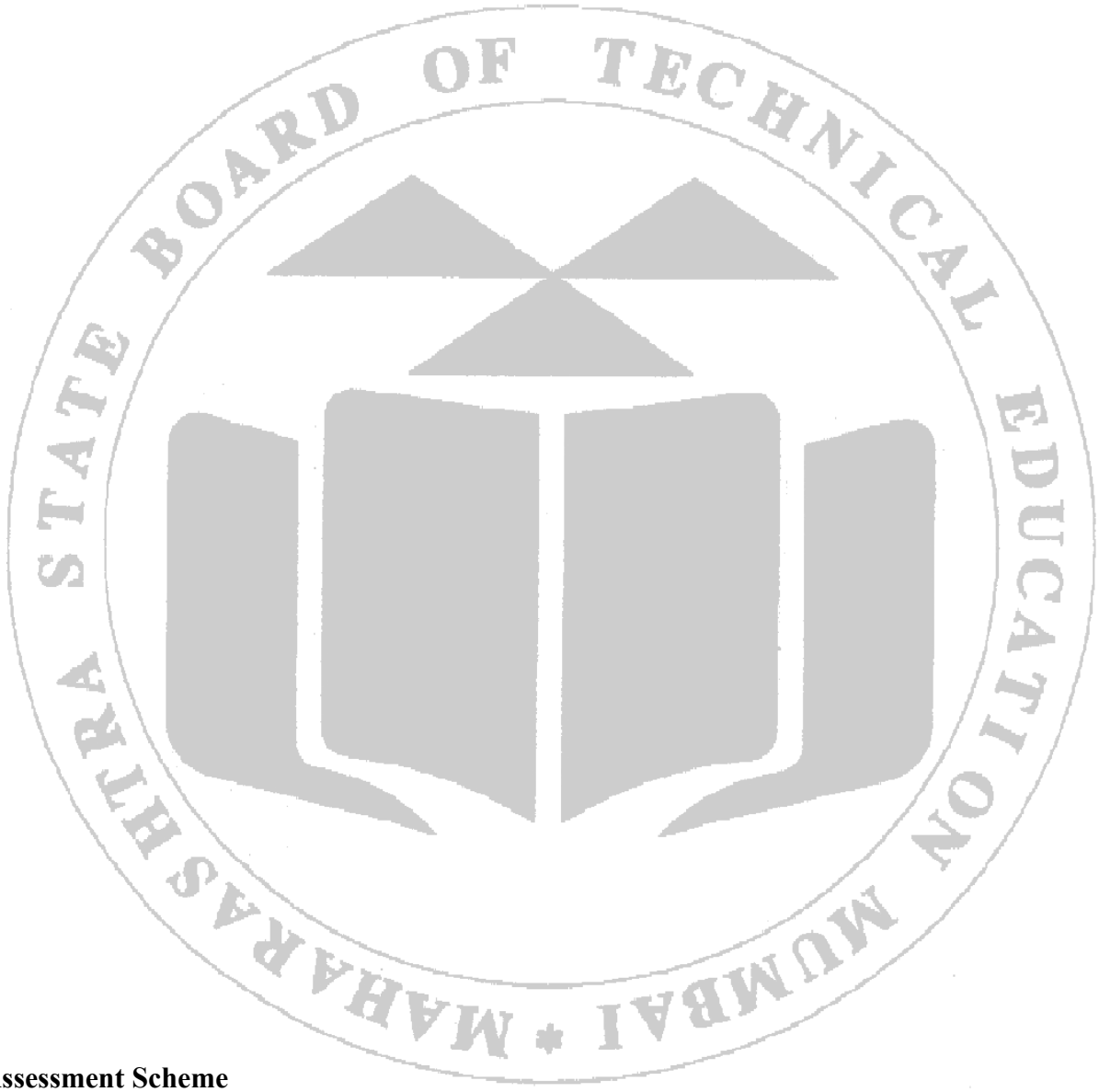


15. Assessment Scheme

Particular	Understanding the basic concept (Intellectual skill)	Activities (Intellectual and motor skills)	Cleanliness & Handling (Affective domain)	Viva-voce / Answers Written	Total	Signature of teacher
Marks Obtained						
Max Marks	**02**	**05**	**01**	**02**	**10**	

Experiment No. 9
Determination of Total WBC Count of Blood.

1. Aim
To determine total white blood cell (WBC) count of own blood by using Hemocytometer.

2. Practical Significance
The estimation of total WBCs count is essential in hematological testing. It is used to evaluate the severity of infection, spread of disease and body's defence capability. In this practical, students will learn to determine the WBC count and identify the pathological condition based on the results.

3. Practical Outcomes (PrOs)
After completion of this practical, the students will be able to:

PrO	Practical Outcomes	Mapped CO	BTL
1	State the composition and functions of WBC diluting fluid.	CO1	1
2	Identify the Neubauer's chamber and WBC diluting pipette.	CO1	2
3	Focus on the Neubauer's slide under the compound microscope.	CO1	3
4	Estimate the total WBC count of own blood.	CO1	4

4. Relevant Theoretical Background

Terminology

WBCs are the nucleated, non-hemoglobin containing cells derived from hemopoietic stem cells in red bone marrow. They are the largest blood cells and account for about 1 % of the blood volume. These cells contain nuclei and some of them have granules in their cytoplasm.

Formation of white blood cells called leukopoiesis. The increase in total white blood cells count above the normal is known as leucocytosis whereas decrease in count below the normal is called leukopenia.

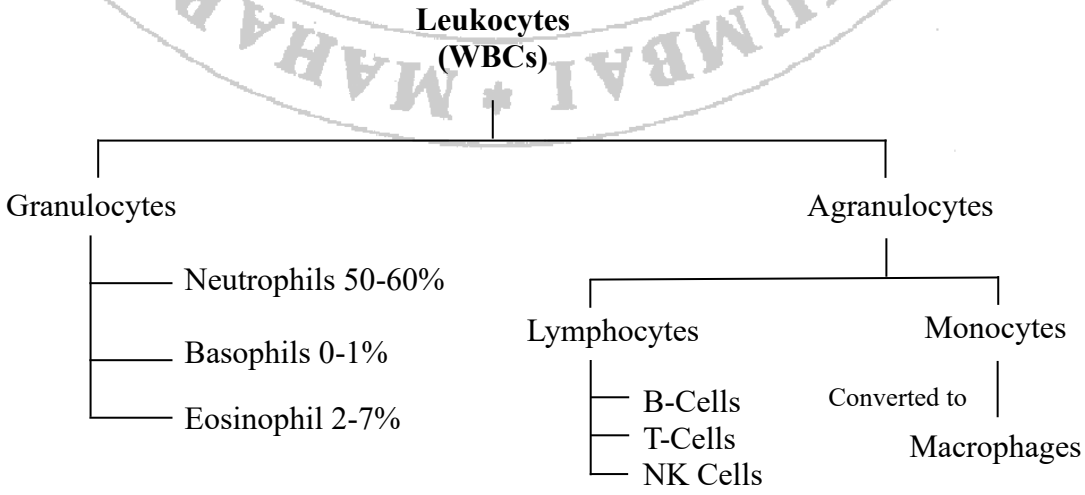
Normal Values

Newborn: 15000 to 20000/mm^3

Adults: 4000 to 11000/mm^3

Children: 5000 to 15000/mm^3

Types of WBCs



Composition of WBC diluting fluid (Turk's fluid)

S. N.	Ingredients	Quantity	Function
1.	Glacial Acetic Acid	1.5 ml	To destroy RBCs & swell the nucleus of WBC.
2.	Gentian Violet	1.0 ml	To stain the nuclei of WBCs
3.	Distilled Water	Upto 100 ml	As Vehicle

5. Diagram

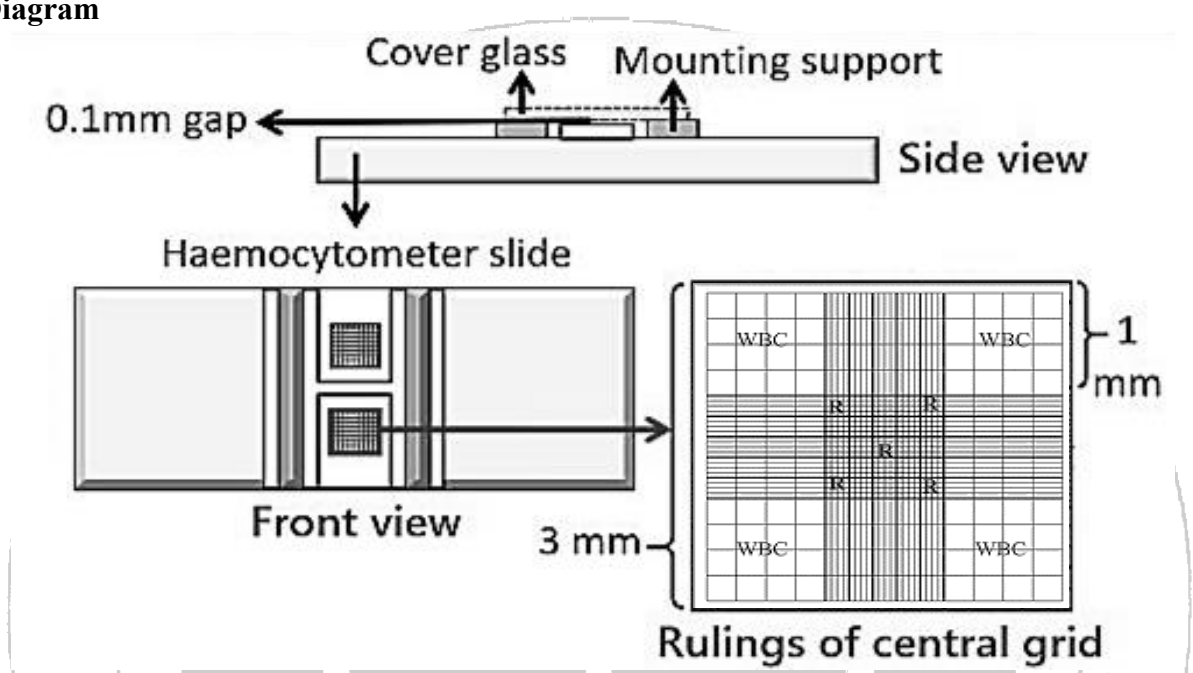


Fig 9.1: Neubauer's Chamber

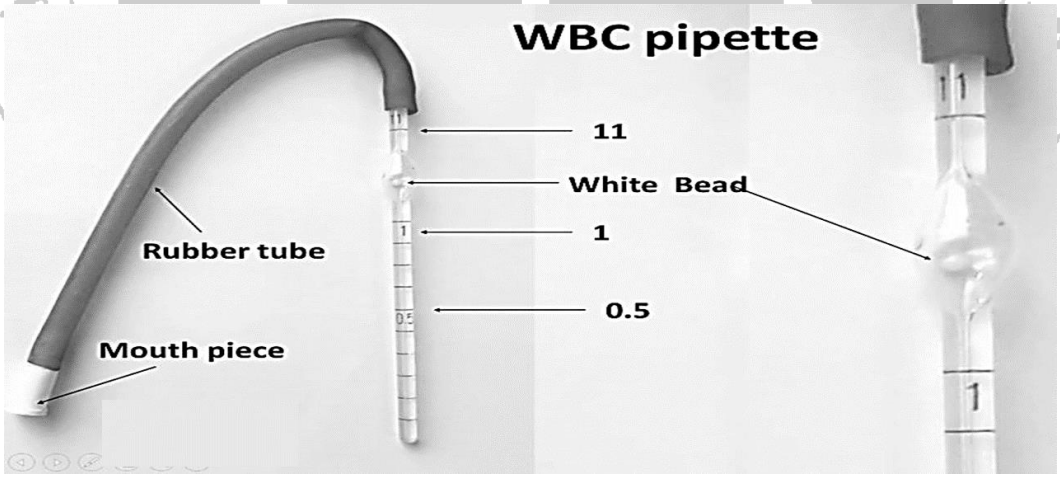


Fig 9.2: WBC diluting pipette

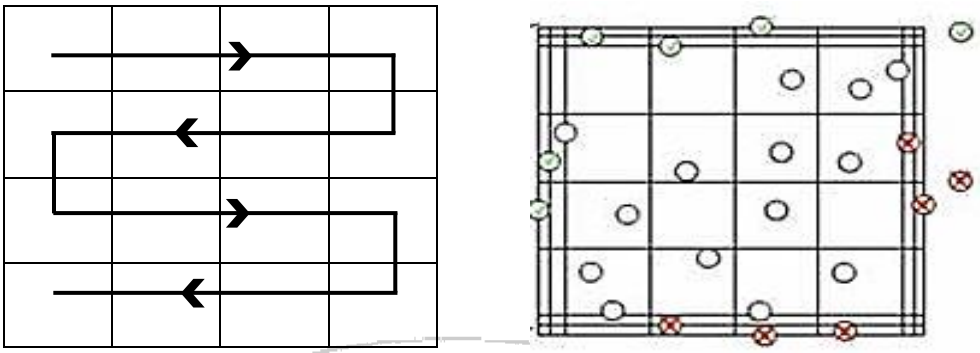


Fig 9.3: Counting of WBCs

6. Requirements

Apparatus: Neubauer's counting chamber slide, WBCs diluting pipette, coverslip, watch glass, sterile disposable pricking needle or lancet, and compound microscope.

Materials: 70% alcohol or spirit, WBC diluting fluid (Glacial acetic acid 1% v/v + Gentian violet 1% w/v + water), tissue paper, and cotton swab.

7. Procedure

A. Keeping apparatus ready

a. Ensure all apparatus are clean and readily available.
b. Examine the counting chamber under the microscope to confirm it is clean and the ruled lines are clearly visible.
c. Check the WBC diluting pipette for blockage by blowing through the mouthpiece.
d. Pour about 2 ml of WBC diluting fluid in the watch glass. Hold the WBC pipette mouthpiece between the infolded lips and allow the pipette to hang down.

B. Filling Capillary pipette and diluting sample of blood

a. Blood is obtained by aseptic finger prick.
b. Fill the pipette with blood accurately without the entry of air bubble up to the mark 0.5.
c. If any air bubble enters in the pipette discard it and repeat with fresh clean and dry pipette. It any excess is there remove it by tapping on a dry absorbent cotton plug.
d. Dip the tip of pipette in the WBC diluting fluid in the watch glass and suck accurately up to the mark 11.
e. Bring the pipette to a horizontal position, place a finger over the tip, tie a simple knot to the rubber tubing, and roll the pipette between the palms to thoroughly mix the blood with the WBC diluting fluid.

C. Charging of Counting Chamber

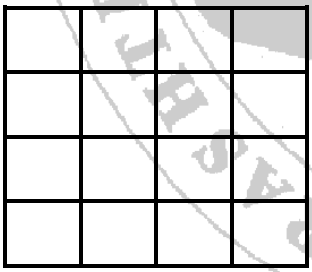
a. Clean the counting chamber and Thomas cover slip.
b. Place the counting chamber on a plane horizontal surface or on the microscope stage.
c. Place the cover slip resting over the flanges on either side of the depressed platform.
d. Roll the pipette to ensure thorough mixing of the cells in the fluid just before charging.
e. Discard 2-3 drops of fluid, as the pipette stem contains no blood.
f. Hold the pipette at a 45° angle to the surface of the counting chamber and position the tip to the narrow slit between the counting chamber and the coverslip. A drop is allowed to come out from the pipette. The fluid will run into the capillary space automatically due to the capillary action.

g. The fluid run down in a moat or if any air bubble is left on the slide, remove cover slip. Clean the slide. Replace it and charge it again.
h. After charging the counting chamber correctly, allow the fluid to settle for a period of 2 to 3 minutes on the stage of microscope before actual counting starts. Counting cannot be done while cells are in motion.

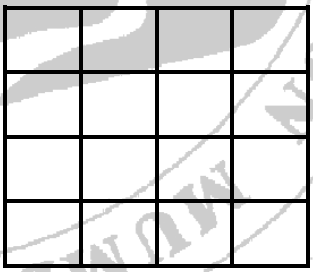
D. Counting the cells

a. Fix the slide on the stage of the compound microscope with the clips.
b. Allow to settle the cells for 2 minutes.
c. Focus the large corner square under the low power (10x) objective.
d. While looking in the eye piece, make the adjustment of light with the help of mirror and diaphragm and turn coarse adjustment back and front until you get the cells in good focus.
e. Move the slide to bring the 16 smallest squares into view and confirm cells are settled and not moving.
f. Start counting the cells in right upper corner large square, right lower large corner square, left upper corner square and left lower large corner square. And in this way count cells from 64 smallest squares.
g. While counting the cells lying across the upper horizontal and left vertical border line should be counted in the square under consideration. While those lying across the lower horizontal and right vertical border line should be counted in the adjutant square.
h. First count the cells in the upper four horizontal squares from left to right Then drop down and count the cells in the second row towards the left. Now drop down and count the cells in the third row towards the right and so on till you count the cells in all sixteen smallest squares and note down reading of each smallest square.
i. Move the slide to the upper right block of 16 squares (W2) and count cells, then repeat for the lower right (W3), and lower left (W4) block.
j. Do not count if the preparation has dried.

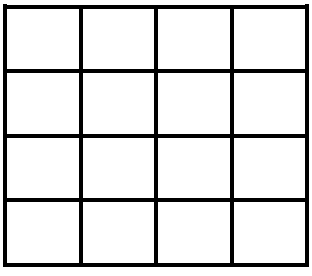
8. Observation



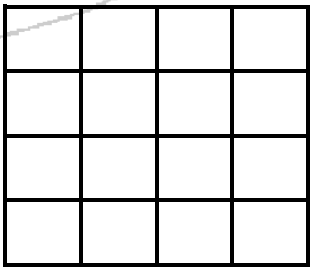
W1 =



W2 =



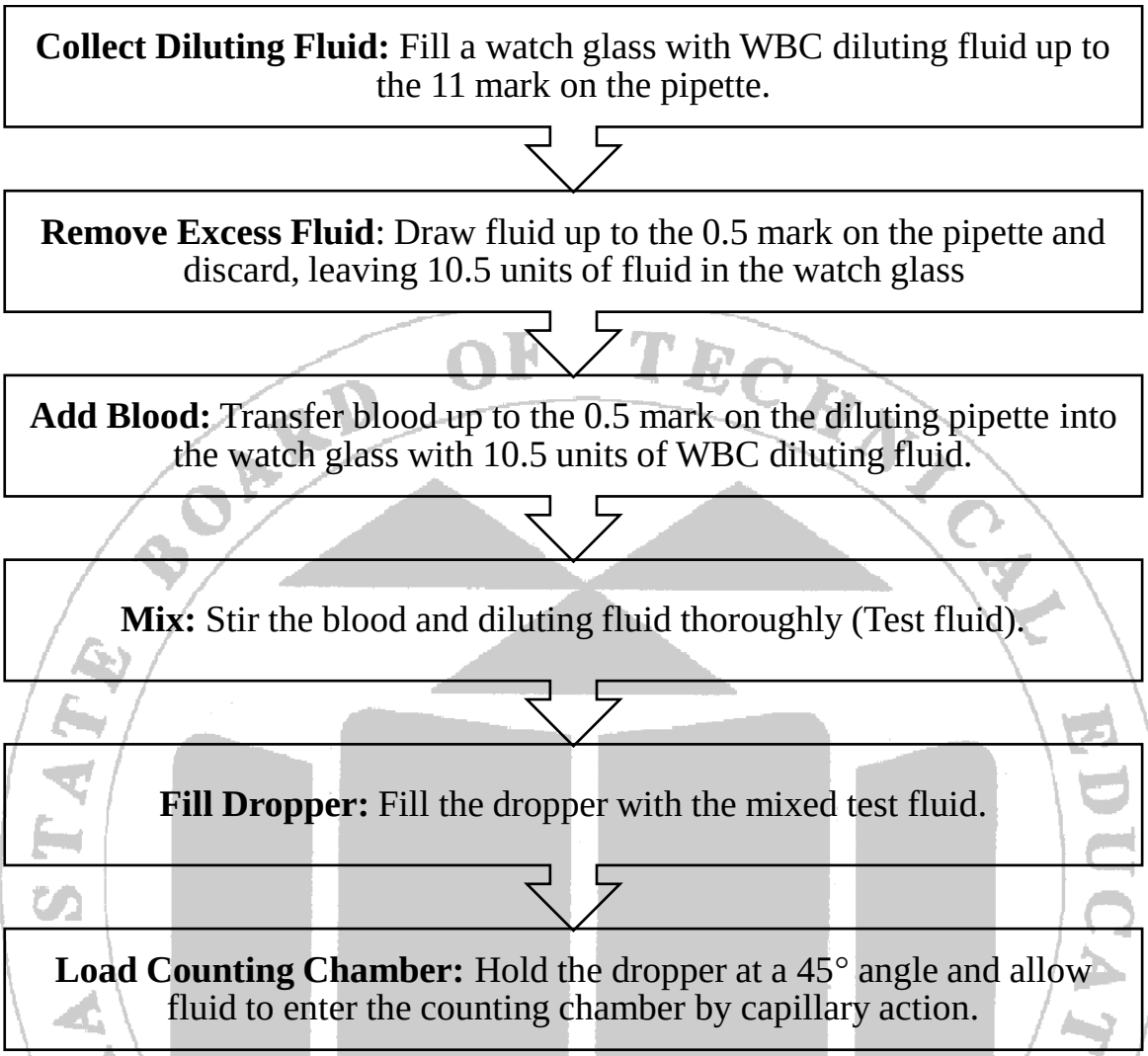
W3 =



W4 =

Blocks	W1	W2	W3	W4	Total No. of WBCS (W)
No. of WBCs					= _____

Alternative procedure to prevent blocking of pipette



9. Precautions to be taken

a. To avoid counting errors, fill the pipette precisely to the 0.5 mark.
b. The diluting fluid should be of analytical grade.
c. Dilute the blood in the pipette promptly to prevent clotting.
d. Before charging the chamber, ensure the diluting fluid and blood are thoroughly mixed in the bulb.

10. Calculations

A. Dilution Factor

a. Blood taken up to 0.5 mark.
b. Blood + Diluting fluid taken up to mark of 11.
c. Means: 0.5 Blood + 10.5 diluting fluid.
d. The l part of diluting fluid present in stem of pipette means only 9.5 parts of diluting fluid mixed with 0.5 part of blood in the bulb giving 10 parts of solution.
e. Hence dilution factor is, 10 parts/0.5 = 20.

B. Total WBC count

a. Length each smallest square = 1/4 mm and the breadth of each smallest square is = 1/4 mm.

b. Height between cover slip and counting chamber = 1/10 mm.
c. Total area of each smallest square = 1/4 × 1/4 = 1/16 mm.
d. The W.B.C.s counted from 64 smallest squares denoted "W".
e. The volume of fluid mixture from which WBCs counted as = 1/16 × 1/10 × 64 = 0.4 cu.mm.
f. 1 cubic mm of diluted blood contains WBCs = (W/0.4).
g. As the dilution of blood 1: 20, one cubic mm of undiluted blood contains

WBCs = W/0.4 × 20

= _____ × 50 per cubic mm

= _____ WBCs per cubic mm.

11. Result

From observation and calculation, the total WBC count of my own blood was found to be_____ WBCs per cubic mm.

12. Conclusion

Total leukocytes count of the sample is _____ (Normal/Abnormal). If abnormal, it is _____ (increased/decreased), indicating _____(leucocytosis/leukocytopenia).

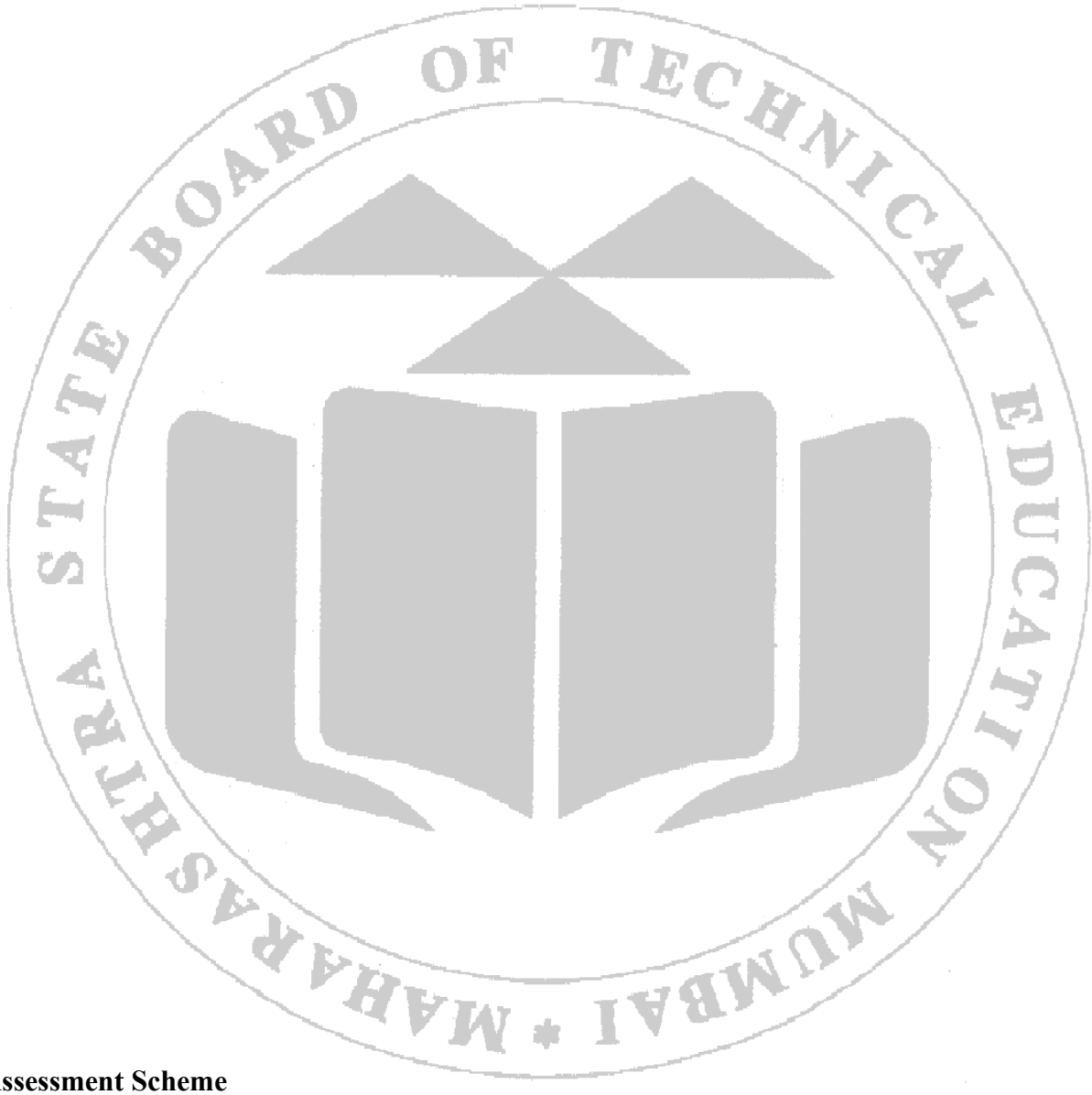
13. References

a. Goyal, R. K., Patel, N. M., (2010). Practical Anatomy and Physiology. B. S. Shah Prakashan, 14th edition.
b. Tortora, G. J., & Derrickson, B. (2014). Principles of Anatomy and Physiology (14th ed.). Hoboken, N.J.: John Wiley.
c. Waugh, A., Grant, A. (2023). Ross & Wilson Anatomy and Physiology in health and illness (14th ed.).

14. Practical Related Questions

a. Define and classify Blood.
b. Give the composition of WBC diluting fluid.
c. Give reason, why first few drops of blood fluid mixture are discarded before charging squares?
d. Define the term leukaemia and leucocytosis.
e. What is dilution factor?
f. Give reason, why RBCs are not seen while counting WBCs?

(Space for writing answers)



15. Assessment Scheme

Particular	Understanding the basic concept (Intellectual skill)	Activities (Intellectual and motor skills)	Cleanliness & Handling (Affective domain)	Viva-voce / Answers Written	Total	Signature of teacher
Marks Obtained						
Max Marks	**02**	**05**	**01**	**02**	**10**	

Experiment No. 10
Determination of Total RBC Count of Blood

1. Aim
To determine the total Red Blood Cell (RBC) count of own blood by using Hemocytometer.

2. Practical Significance
Estimating the total RBC count is essential in hematological testing because it helps diagnose and monitor conditions like anemia and polycythemia, and it assesses overall health and bone marrow function. In this practical, students will learn to determine the RBC count and identify the pathological condition based on the results.

3. Practical Outcomes (PrOs)
After completion of this practical, the students will be able to:

PrO	Practical Outcomes	Mapped CO	BTL
1	Identify the Neubauer's chamber and RBC diluting pipette.	CO1	2
2	Focus on the Neubauer's slide under the compound microscope.	CO1	3
3	State the composition and functions of RBC diluting fluid	CO1	1
4	Estimate the total RBC count of own blood.	CO1	4
5	Collaborate and communicate with fellow students	CO1	5

4. Relevant Theoretical Background
Red blood cells (RBCs), or erythrocytes, are non-nucleated, biconcave discs containing hemoglobin. Their primary function is to transport oxygen from the lungs to body tissues and carry carbon dioxide back to the lungs for exhalation. Each RBC has a mean diameter of 7.2 μm, a thickness of 2.5 μm at its thickest point, and a surface area of 140 μm^2. RBCs have a lifespan of approximately 120 days before being recycled by the spleen.

Normal values

Newborn: 6.0 to 8.0 million per mm^3 of blood.

Adult male: 4.5 to 6.0 million per mm^3 of blood.

Adult female: 4.0 to 5.5 million per mm^3 of blood.

Children: 3.8-5.5 million per mm^3 of blood.

Principle: The high number and small size of red blood cells make direct counting difficult, even under high power. This is overcome by diluting the blood with a suitable fluid. The diluted blood is placed in a capillary space between the counting chamber and coverslip. Cells in this known volume are counted under the microscope, and the total count is calculated by multiplying by the dilution factor.

5. Diagram

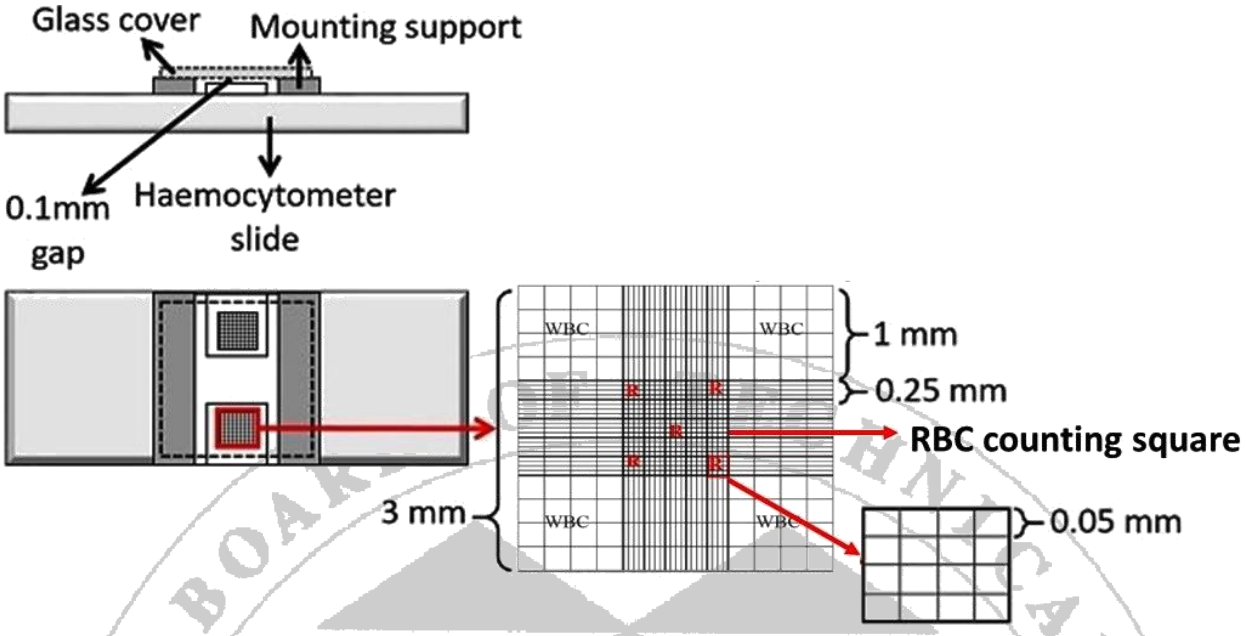


Fig 10.1: Neubauer's RBC counting chamber

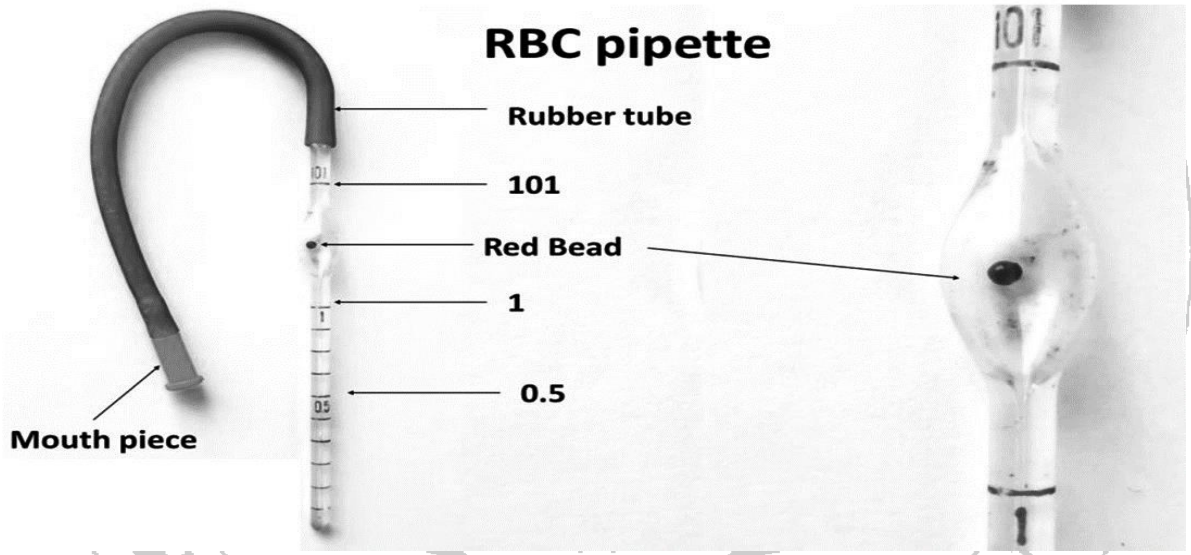


Fig 10.2: RBC diluting pipette

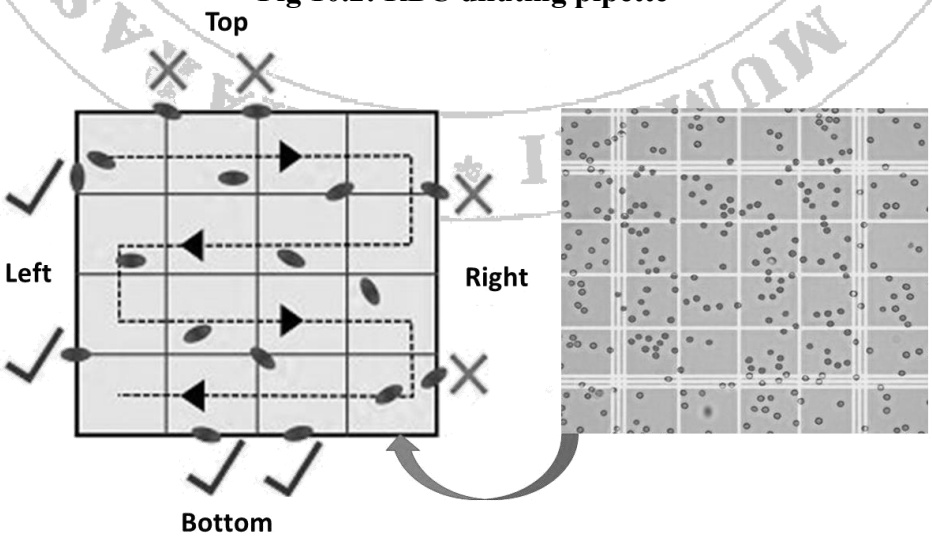


Fig 10.3: Counting of RBCs

6. Requirements

Apparatus: Neubauer's counting chamber slide, RBCs diluting pipette, coverslip, watch glass, sterile disposable pricking needle or lancet, and compound microscope.

Material: 70% alcohol or spirit, RBC diluting fluid (Hayem's fluid), tissue paper, and cotton swab.

Composition of RBC diluting fluid (Hayem's fluid)

S.N.	Ingredients	Quantity	Function
1	Sodium chloride (NaCl)	0.5 g	To maintain isotonicity and prevents hemolysis
2	Sodium Sulphate (Na_2SO_4)	2.5 g	To prevents rouleax formation
3	Mercuric chloride ($HgCl_2$)	0.25 g	Acts as a preservative and lyses WBCs
4	Water (H_2O)	Upto 100 ml	As vehicle

7. Procedure

A. Keeping Apparatus Ready

a. Ensure all apparatus is clean and readily available.
b. Examine the counting chamber under the microscope to confirm it is clean and the ruled lines are clearly visible.
c. Check the RBC diluting pipette for blockage by blowing through the mouthpiece.
d. Pour about two ml of RBC diluting fluid into the watch glass.

B. Filling the capillary pipette and diluting blood sample

a. Use an aseptic finger prick to obtain blood sample.
b. Fill the pipette precisely up to the 0.5 mark, ensuring no air bubbles are present. If air bubbles
c. are introduced, discard the pipette, and replace it with a new, clean, and dry one.
d. Remove any blood residue adhering to the tip of the pipette by gently wiping it with a cotton swab.
e. Dip the pipette tip in the diluting fluid in the watch glass and draw the fluid up to the 101 mark.
f. Bring the pipette to a horizontal position, place a finger over the tip, tie a simple knot to the rubber tubing, and roll the pipette between the palms to thoroughly mix the blood with the RBC diluting fluid.

C. Charging the Chamber

a. Clean the counting chamber and Thomas glass cover slip.
b. Place the counting chamber on a flat horizontal surface or on the microscope stage.
c. Place the cover slip over the flanges on either side of the depressed platform.
d. Roll the pipette to ensure thorough mixing of the cells in the fluid just before charging.
e. Discard 2-3 drops of fluid, as the pipette stem contains no blood.
f. Hold the pipette at a 45° angle to the surface of the counting chamber and position the tip to the narrow slit between the counting chamber and the coverslip. A drop is allowed to come out from the pipette. The fluid will run into the capillary space automatically due to the capillary action.
g. If fluid runs into the H-shaped moat or if any air bubbles are present on the slide, remove the cover glass, clean the slide, replace it, and charge it again.

h. After correctly charging the counting chamber, allow the fluid to settle for 2 to 3 minutes on the microscope stage before beginning the actual counting. Counting cannot be done while cells are in motion.

D. Counting the Cells

a. Secure the slide with clips on the stage and ensure the mechanical stage is in place.
b. Focus on the R1 (upper left) section of 16 squares under low power, then switch to high power (45x) and adjust the light until cells and grid lines are clear.
c. Move the slide to bring the 16 smallest squares into view and confirm cells are settled and not moving.
d. Start counting cells in the upper-left small square, counting cells on the upper and left borders within the current square and on the lower and right borders in adjacent squares.
e. Count the cells in the upper four horizontal squares from left to right, then move down to the
f. next row and count cells from right to left, continuing this pattern until all sixteen small squares are counted. Record the readings.
g. Move the slide to the upper right block of 16 squares (R2) and count cells, then repeat for the lower right (R3), lower left (R4), and center block (R5).
h. Do not count if the preparation has dried.

Alternative procedure to prevent blocking of pipette

Collect Diluting Fluid: Fill a watch glass with RBC diluting fluid up to the 101 mark on the pipette.

↓

Remove Excess Fluid: Draw fluid up to the 0.5 mark on the pipette & discard, leaving 100.5 units in the watch glass

↓

Add Blood: Transfer blood up to the 0.5 mark on the diluting pipette into the watch glass with 100.5 units of RBC diluting fluid.

↓

Mix: Stir the blood and diluting fluid thoroughly (Test fluid).

↓

Fill Dropper: Fill the dropper with the mixed test fluid.

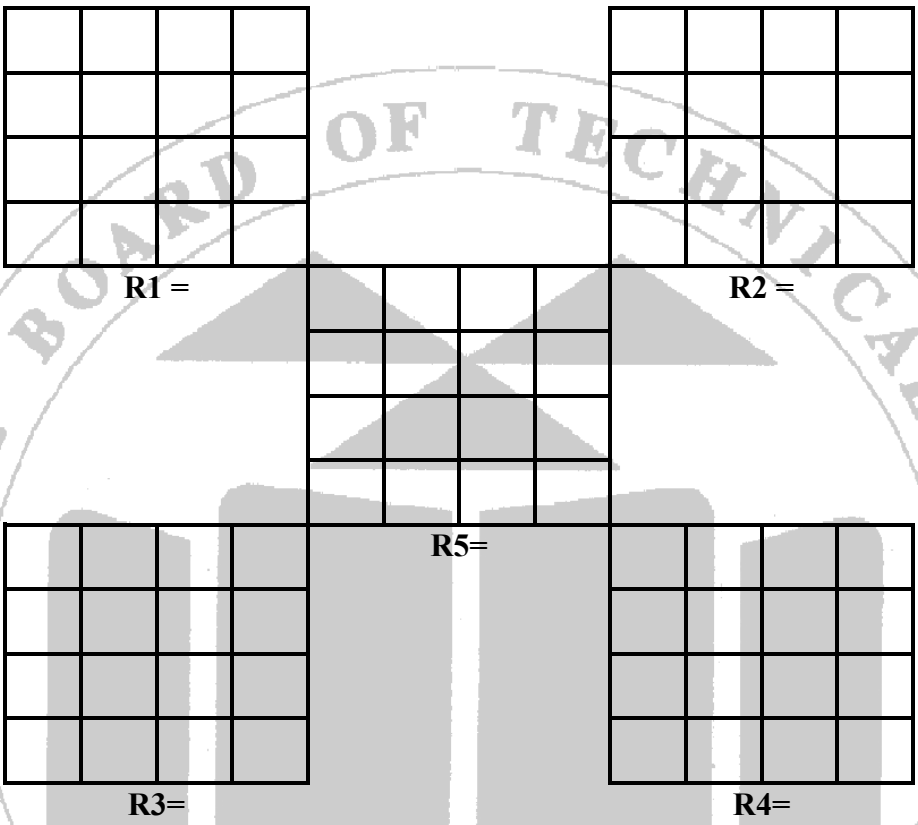
↓

Load Counting Chamber: Hold the dropper at a 45° angle and allow fluid to enter the counting chamber by capillary action.

8. Precautions to be taken

a. To avoid counting errors, fill the pipette precisely to the 0.5 mark.
b. The diluting fluid should be of analytical grade.
c. Dilute the blood in the pipette promptly to prevent clotting.
d. Before charging the chamber, ensure the diluting fluid and blood are thoroughly mixed in the bulb.

9. Observations



Blocks	R1	R2	R3	R4	R5	**Total No. of RBCs (R)**
No. of RBCs						= _____

10. Calculation

A. Dilution Factor

a. Blood taken up to 0.5 mark.
b. Blood + Diluting fluid taken up to mark of 101.
c. Means: 0.5 Blood + 100.5 diluting fluid.
d. The 1 part of diluting fluid present in stem of pipette means 99.5 parts of diluting fluid mixed with 0.5 part of blood in the bulb giving 100 parts of solution.
e. Hence dilution factor is, 100 parts/0.5=200.

B. Total RBC count

a. The length of each smallest square = 1/20 mm.
b. The breadth of each smallest square = 1/20 mm.
c. The height between cover slip and counting chamber = 1/10 mm.

d. Total area of each smallest square = 1/20 × 1/20 = 1/400 mm^2.
e. The RBCs counted from 5 medium squares i.e. 5 × 16 = 80 smallest squares.
f. The volume of fluid mixture from which RBCs are counted = 1/400 × 1/10 × 80 = 0.02 mm^3.
g. If the RBCs counted from the 80 smallest squares denoted as "R", one cubic mm of diluted blood contains RBCs = (R/0.02).
h. The dilution of blood is 1: 200.

$$\text{Hence, 1 mm3 of undiluted blood contains} = \frac{\text{Total No. of RBC counted (R)} \times \text{Dilution factor (200)}}{\text{Volume of fluid (0.02 mm}^3\text{)}}$$

$$= \frac{R \times 200}{0.02}$$

$$= R \times 100000 \text{ RBCs/mm}^3$$

$$= \_\_\_\_\_ \times 100000 \text{ RBCs/mm}^3$$

$$= \_\_\_\_\_ \text{ RBCs/mm}^3$$

$$= \_\_\_\_\_ \text{million RBCs/mm}^3$$

11. Result

From observation and calculation, the total RBC count of my own blood was found to be _____ million RBCs/mm^3.

12. Conclusion

My RBC count is _____ (normal/abnormal). If abnormal, it is _____ (increased/decreased), indicating _____ (polycythemia/ anemia).

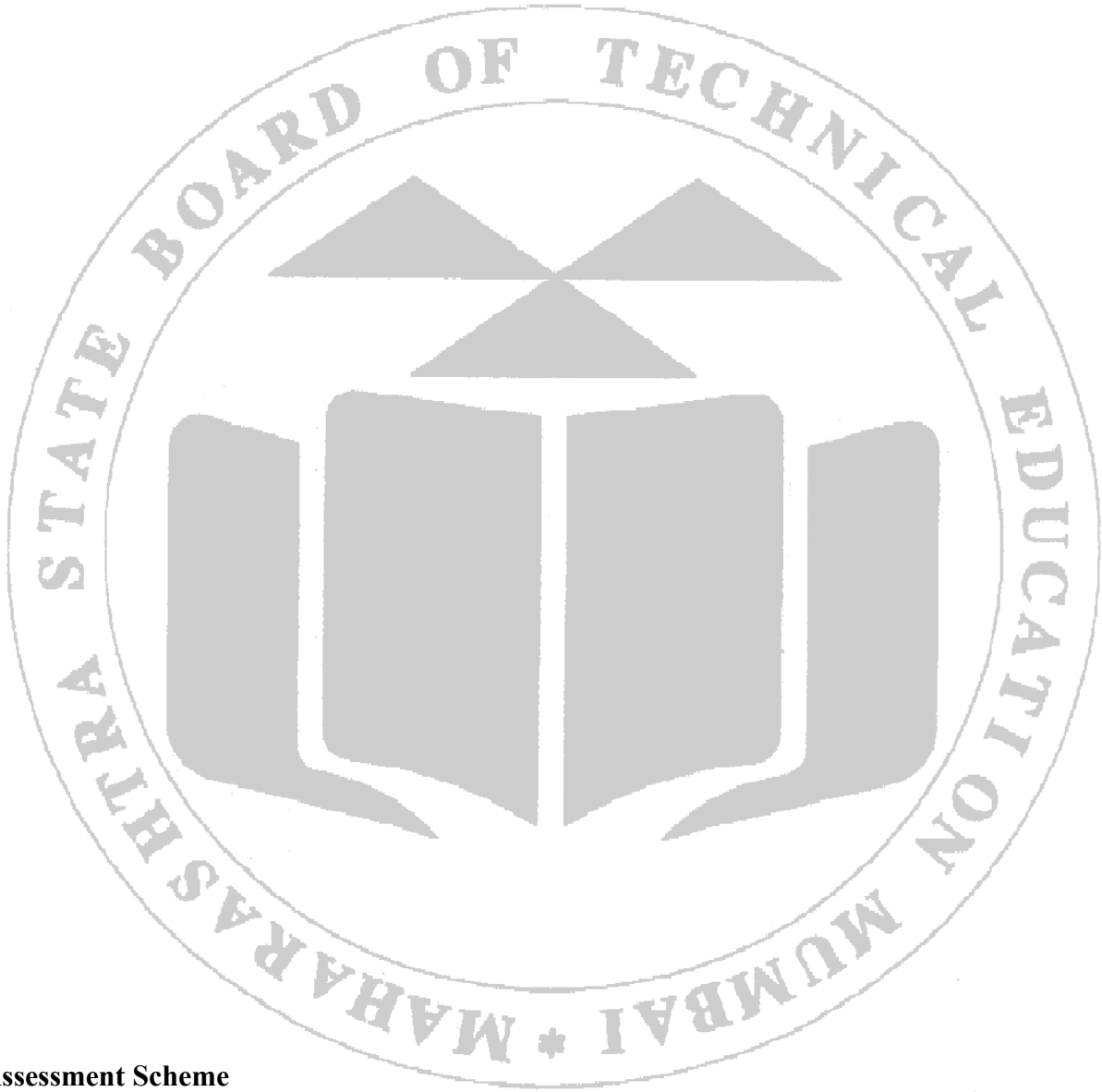
13. References

a. Goyal, R. K., Patel, N. M., (2010). Practical Anatomy and Physiology. B. S. Shah Prakashan, 14th edition.
b. Tortora, G. J., & Derrickson, B. (2014). Principles of Anatomy and Physiology (14th ed.). Hoboken, N.J.: John Wiley.
c. Waugh, A., Grant, A. (2023). Ross & Wilson Anatomy and Physiology in health and illness (14th ed.).

14. Practical Related Questions

a. Define anemia and polycythemia.
b. State the composition and functions of each component of Hayme's fluid.
c. What are the normal values of RBCs in adult males and females?
d. Give the functions of RBCs.
e. Why the total RBC count is less in pregnant women? Give reason.

(Space for writing answers)



15. Assessment Scheme

Particular	Understanding the basic concept (Intellectual skill)	Activities (Intellectual and motor skills)	Cleanliness & Handling (Affective domain)	Viva-voce / Answers Written	Total	Signature of teacher
Marks Obtained						
Max Marks	**02**	**05**	**01**	**02**	**10**	

Experiment No. 11
Determination of Differential Leukocyte Count of Blood

1. Aim
To determine the differential leukocyte (WBC) count of own blood.

2. Practical Significance
A differential leukocyte count means the number of different types of WBCs present in the blood. This count helps in the diagnosis of infectious diseases, autoimmune diseases, inflammatory diseases, anemia, leukemia and cancer. In this practical, students will learn to determine the differential leukocyte count and identify the pathological condition based on the result.

3. Practical Outcomes (PrOs)
After completion of this practical, the students will be able to:

PrO	Practical Outcomes	Mapped CO	BTL
1	Prepare blood smear and perform its staining.	CO1	4
2	Determine the different types of WBC under microscope.	CO1	4
3	Differentiate different types of WBC under microscope.	CO1	3

4. Relevant Theoretical Background
Leukocytes are the nucleated, non-hemoglobin containing cells derived from hemopoietic stem cells in red bone marrow. These cells contain nuclei and some of them have granules in their cytoplasm, hence they called Granulocytes and some of them have very small size granules in the cytoplasm which have very poor staining quality hence they called Agranulocytes.

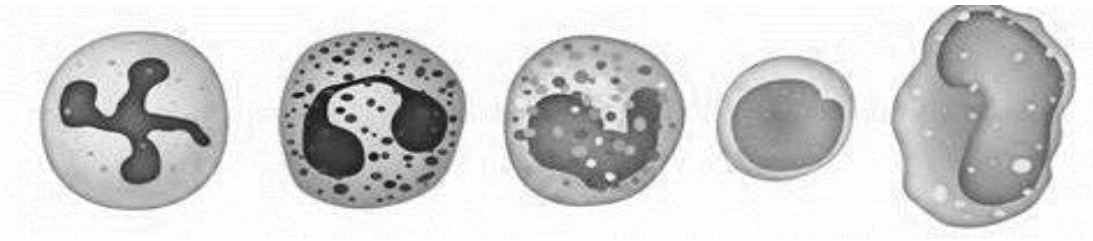
Granulocytes:

S. N.	Type of Cell	Nucleus	Size (μ)	Differential Count	Dye Absorb	Cytoplasmic Granules
1.	Eosinophil	2 lobed	10-14	2.3%	Acidic Eosin	Coarse red granules
2.	Neutrophils	1 to 4 lobed	10-14	60 to 70%	-----	Violet pink fine granules
3.	Basophil	2 to 3 lobed	8-12	0.4%	Basic methylene blue	Coarse blue granules

Agranulocytes:

S. N.	Type of Cell	Nucleus	Size (μ)	Differential count	Cytoplasmic
1.	Monocyte	Kidney shaped	12-24	5.3%	Muddy grey cytoplasm
2.	Lymphocyte	Round and large	7-14	30%	No granules

5. Diagram



Neutrophil **Eosinophil** **Basophil** **Lymphocyte** **Monocyte**

Fig 11.1: Types of leukocytes

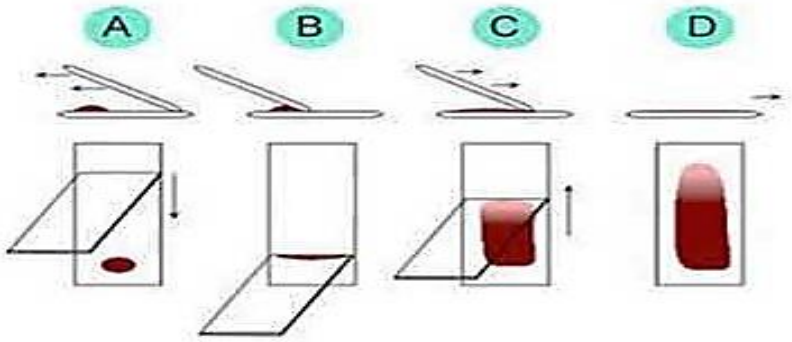


Fig 11.2: Preparation of blood smear

6. Requirements

Apparatus: Compound microscope with oil immersion lens, clean glass slide, staining rack, sterile disposable pricking needle or lancet, Leishman's stain, spirit and cotton swab.

7. Procedure

A. Preparation of smear

a. Prick the finger aseptically and collect the blood drop on one end of glass slide. First drop of blood should be discarded.

b. The clean glass slide is held along its long edge without touching its surface. One end of the slide is touched to the blood drop.

c. Thin blood film is made as follows-

   a) A slide (with a drop of blood) is put on the table and its one end is supported.

   b) Second slide with smooth edge is held along its long axis with the thumb and the index finger.

   c) Edge of the second slide is placed at an angle of 45° to the horizontal in front of the blood drop of the first slide.

   d) Second slide is then drawn little backward (along with the blood drop) so that blood spreads along the edge of the slide.

   e) The second slide is then steadily moved forward on the first slide to spread out the blood drop forming a tongue shaped blood smear. Smear should neither be too thick nor be too thin. It should also have a uniform thickness. If not so, smear should be discarded.

   f) Minimum 3-4 smears should be prepared and stained. Best one is selected for counting.

B. Staining of blood smear

a. Keep the slide across the staining rack (make sure smear should be dried).

b. Pour the Leishman stain on smear slowly to cover entire blood smear. Allow it to stand for 2 minutes. During this period, methyl alcohol fixes the blood smear to the slide.
c. Now pour the twenty drops of distilled water over slide for diluting the stain. Distilled water and stain are mixed by gently blowing.
d. Allow the slide to stand for 7 to 8 minutes (staining time). During this period, cells take up the stain. Wash the slide with tap water to remove excess stain. After washing the film should appear bluish pink in colour. If it is too purple, then kept the slide in distilled water till correct colour develops.
e. Slide is allowed to dry in air. Clear the back side of the slide.
f. Smears are first visualized under low power to see whether cells are evenly spread or not. The best part of the smear is chosen for counting.
g. Count is done under high power or oil immersion objective in a zigzag manner. Counting is started from left upper corner. Then the slide is moved horizontally to right viewing each field and counting the cells till upper right corner is reached.
h. Now slide is shifted up so that lower adjacent field comes in view. Then counting is done in each field by slowly moving the slide from right to left and same procedure is repeated. This procedure ensures that same cells are not counted again and again.
i. Fill the following 100 squares as a cell is identified in one square. The entry in the square is done by writing a letter e.g., 'N' for neutrophil, 'L' for lymphocytes, 'M' for monocytes, 'E' for eosinophil and 'B' for basophil.
j. Different WBCs are identified from their characteristics such as size, nucleus, presence or absence of granules in the cytoplasm.
k. Number of each type of cell is counted and expressed as percentage.

8. Precautions to be taken

a. The glass slide should be clean and non-greasy.
b. Thin and uniform smear should be prepared.
c. Staining should not be done until the blood smear becomes dry.

9. Observation:

Student to enter different types of WBC in the table.

N- Neutrophil, B- Basophil, E- Eosinophil , L- Lymphocyte , M- Monocyte

10. Result

The percentage of each type of observe WBCs was found to be-

a. Neutrophil : _____
b. Eosinophil : _____
c. Basophil : _____
d. Lymphocyte : _____
e. Monocyte : _____

11. References

a. Reddy, L. P., (2009). Practical Physiology, Paras Publishing, 2nd Edition.
b. Pal, G. K., Pal, P., (2001). Textbook of Practical Physiology, Orient Longman Ltd.

12. Practical Related Questions

a. Classify leukocytes with their subtype.
b. How is Leishman's stain prepared?
c. State the normal count of leukocytes.
d. What is neutrophilia? When does it occur?
e. State the two differences between neutrophil and eosinophil.
f. What is the clinical importance of doing differential count?
g. What are the functions of different types of WBCs?

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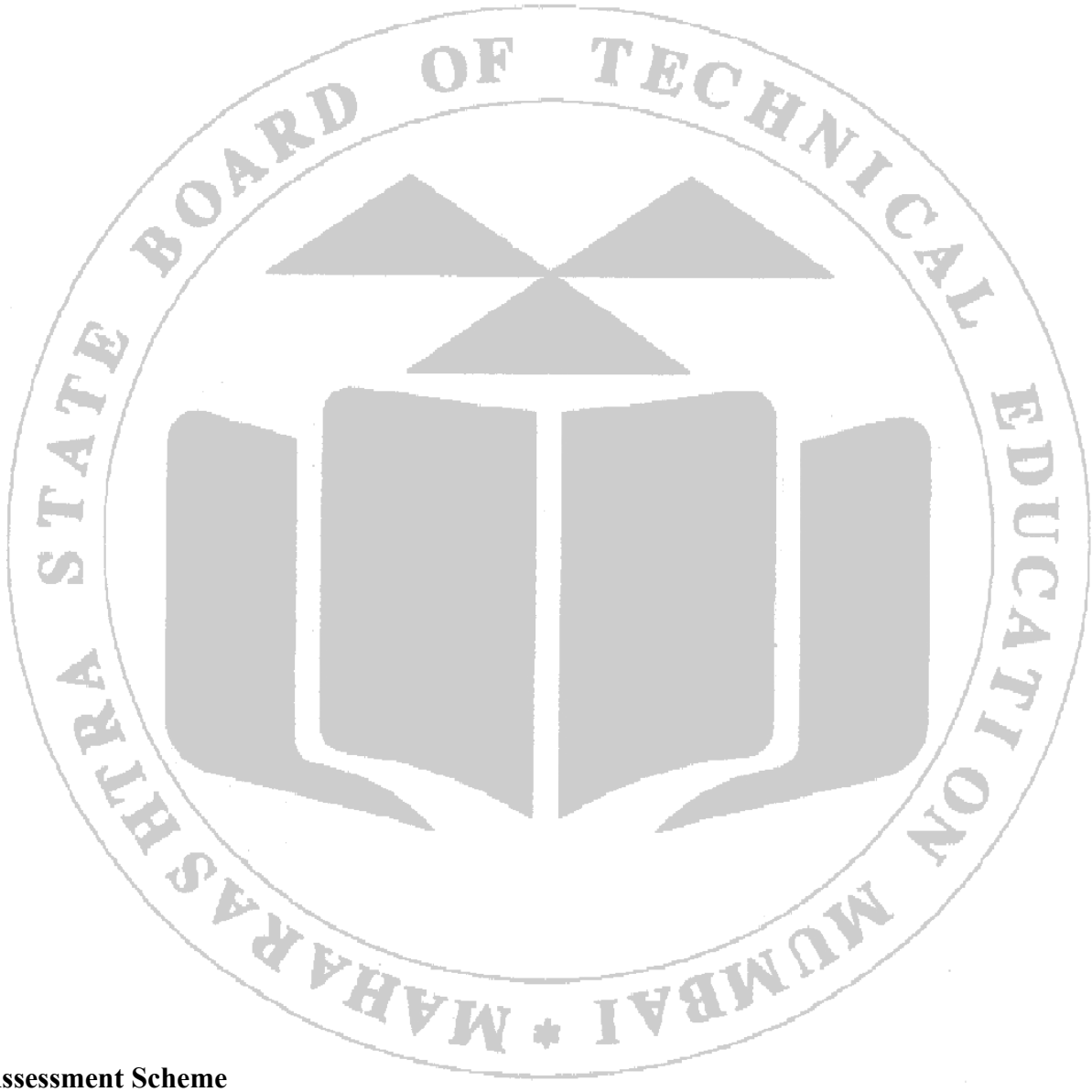

13. Assessment Scheme

Particular	Understanding the basic concept (Intellectual skill)	Activities (Intellectual and motor skills)	Cleanliness & Handling (Affective domain)	Viva-voce / Answers Written	Total	Signature of teacher
Marks Obtained						
Max Marks	**02**	**05**	**01**	**02**	**10**	

Experiment No. 12
Determination of Erythrocyte Sedimentation Rate

1. Aim
To determine the Erythrocyte Sedimentation Rate (ESR) of own blood.

2. Practical Significance
The Erythrocyte Sedimentation Rate (ESR) measures the rate at which red blood cells settle in a blood sample. Elevated ESR levels indicate inflammation, diagnose infections, autoimmune diseases, and certain cancers. It also helps assess prognosis in severe infections and cancers and screens for inflammation in patients with non-specific symptoms.

3. Practical Outcomes (PrOs)
After completion of this practical, the students will be able to:

PrO	Practical Outcomes	Mapped CO	BTL
1	Utilize the ESR apparatus accurately.	CO1	3
2	Conduct the ESR test on the provided blood sample.	CO1	3
3	Analyze the results and draw conclusions from the findings.	CO1	4
4	Collaborate and communicate with fellow students.	CO1	5

4. Relevant Theoretical Background
Blood contains cells suspended in a colloidal fluid known as plasma. The rate at which red blood cells settle is called the Erythrocyte Sedimentation Rate (ESR), measured in millimeters after one hour. The settling of red cells is significantly affected by rouleaux formation, where the cells clump together. Increased rouleaux formation results in a higher ESR, indicating conditions such as tuberculosis, anemia, and chronic infections. On the other hand, albumin reduces rouleaux formation and ESR, suggesting conditions like polycythemia and low fibrinogen levels.

Methods of ESR determination

A. Westergren's method

B. Wintrobe's method

Principle

When anticoagulated blood is allowed to stand in a vertical tube, red blood cells gradually settle due to gravity. The rate at which they settle is influenced by the presence of certain proteins in the blood that increase during inflammation, causing red blood cells to clump together and settle more rapidly.

Normal values

Method	Male reference range	Female reference range
	At the end of 1 hour	
Westergren's method	1-3 mm	4-7 mm
Wintrobe's method	0-9 mm	0-20 mm

5. Diagram

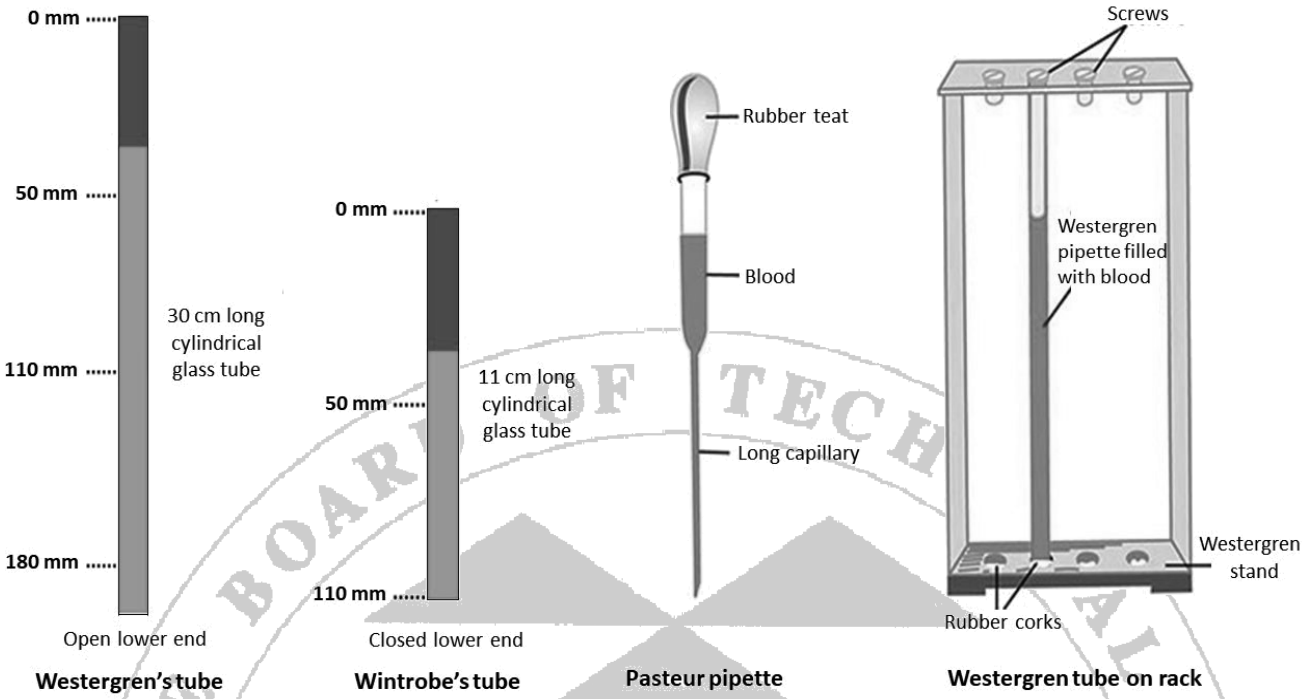

Fig 12.1: Methods of ESR determination

6. Requirements

A. Westergren's method

a. **Apparatus:** Westergren pipette, Westergren stand, and sample vial.

b. **Materials:** 70 % Alcohol or rectified spirit, blood sample (1.6 ml), 3.8 % w/v sodium citrate solution, and sterile cotton swabs.

B. Wintrobe's method

a. **Apparatus:** Wintrobe's tube, Wintrobe's stand, sterilized syringe and needle, and long nozzle dropper.

b. **Materials:** 1.2 % w/v Ammonium potassium oxalate, and blood sample (1.3 ml).

7. Procedure

A. Westergren's Method

a. Using aseptic precautions and the method of venipuncture, collect about 2 ml of venous blood.

b. Place the collected blood in a tube containing 0.5 ml of 3.8% sodium citrate solution, maintaining a proportion of 4 parts blood to 1 part sodium citrate solution (4:1).

c. Slowly draw the anticoagulated blood into the Westergren tube up to the zero mark, wiping off any excess blood from the outer surface tip.

d. While keeping a finger on the upper end, press the lower end of the tube onto the rubber cushion of the stand, ensuring no leakage of blood from the lower end.

e. Release your finger from the upper end of the tube and secure the tube with a screw cap, ensuring the tube is positioned exactly vertical.

f. Keep the vertically positioned tube in the stand undisturbed for one hour.

g. At the end of one hour, read the height of the clear plasma layer (in mm). This measurement indicates the ESR.

B. Wintrobe's Method

a. A sample of about 3 ml of blood is obtained by venipuncture and mixed with a 1.2% ammonium potassium oxalate solution in a proportion of 3 parts blood to 2 parts oxalate solution (3:2).
b. Approximately 1.3 ml of the anticoagulated blood is drawn into a dry capillary pipette. The capillary pipette is then inserted into a Wintrobe's tube, and gentle pressure is applied to the rubber tube to fill the Wintrobe's tube exactly up to the zero mark.
c. The Wintrobe's tube is set upright in the stand.
d. After one hour, the upper level of the red cell column is read. This measurement indicates the mm of clear plasma (ESR).

8. Precautions to be taken

a. The instrument must be placed on a horizontal surface.
b. The surface on which the instrument is placed must be free of vibration.
c. The tube should be dry and clean before filling.
d. Concentration of anticoagulant should be appropriate.
e. Blood should be properly mixed before filling the tubes.

9. Observations

Method	At the end of 1 hour	
	Male	Female
Westergren's method		
Wintrobe's method		

10. Result

From observation, ESR was found to be _____ mm at the end of 1 hour by _____ method.

11. Conclusion

From result, it is concluded that the given blood sample was found to be _____ (normal/abnormal). If abnormal, it was _____ (increased/decreased), indicating _____.

12. References

a. Goyal, R. K., Patel, N. M., (2010). Practical Anatomy and Physiology. B. S. Shah Prakashan, 14th edition.
b. Reddy, L. P., (2009). Practical Physiology, Paras Publishing, 2nd Edition.
c. Pal, G. K., Pal, P., (2001). Textbook of Practical Physiology, Orient Longman Ltd.

13. Practical Related Questions

a. What do you mean by ESR?
b. Mention the factors influencing the ESR.
c. State the principle of sedimentation of RBCs.
d. If a person is suffering from tuberculosis, what is the effect on ESR?
e. State the advantages of Westergren's method.

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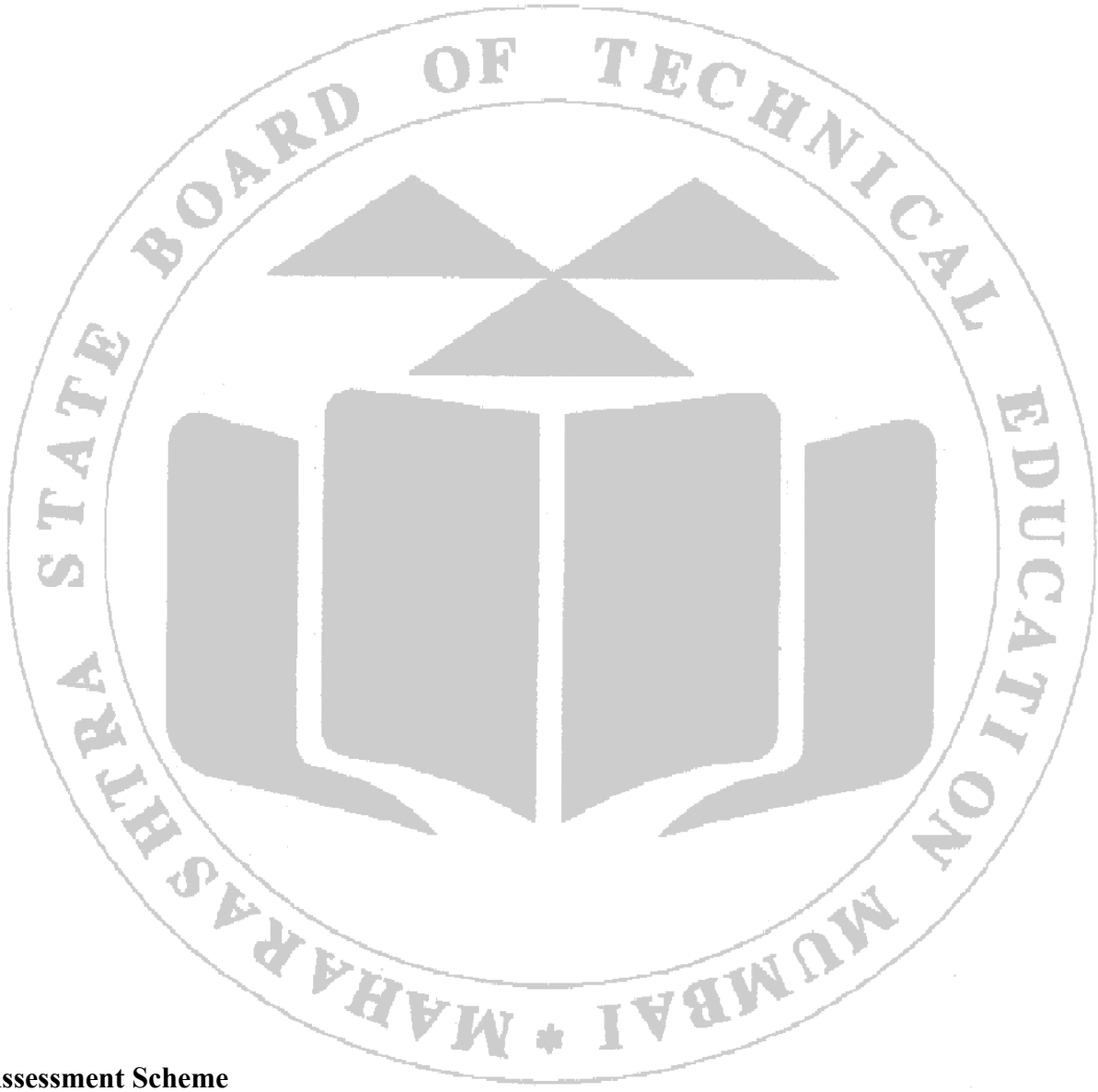


14. Assessment Scheme

Particular	Understanding the basic concept (Intellectual skill)	Activities (Intellectual and motor skills)	Cleanliness & Handling (Affective domain)	Viva-voce / Answers Written	Total	Signature of teacher
Marks Obtained						
Max Marks	**02**	**05**	**01**	**02**	**10**	

Experiment No. 13
Study of Cardiovascular System

1. Aim
To study the Human Cardiovascular System.

2. Practical Significance
The continuous flow of the blood throughout the body is known as blood circulation and it is done by heart & blood vessels. Cardiovascular system consists of heart and blood vessels. In this practical, students will learn about the basic anatomy and physiology of cardiovascular system.

3. Practical Outcomes (PrOs)
After completion of this practical, the students will be able to:

PrO	Practical Outcomes	Mapped CO	BTL
1	Identify the different parts of heart.	CO4	3
2	Locate different parts of heart.	CO4	2
3	Explain blood circulation through heart.	CO4	1
4	Draw and label the structure of heart.	CO4	3

4. Relevant Theoretical Background
Terminology

The cardiovascular system consists of the heart and blood vessels. Its most important function is the transportation of oxygen, nutrients, waste products, hormones, and other substances. The heart, functioning as a pump, ensures constant circulation of blood. The blood vessels, which include arteries and veins, are the pathways through which the blood flows.

Stroke Volume: The amount of blood ejected from the heart by each contraction of the ventricles called as stroke volume. Normal value- 70 ml.

Cardiac Output: The amount of blood ejected per minutes by the contraction of both ventricles is known as Cardiac Output.

Cardiac output= Stroke volume × Heart Rate = 70 × 72 = 5040 ml.

So, the normal value of Cardiac output is about 5040 ml.

Heart Rate: It is the speed of heartbeat measured by the number of contractions of the ventricles per minute (beats per minute). The heart rate may vary according to the body's physical needs. HR is usually close to the pulse measured at any peripheral point. The normal heart rate is 72 beats per minute (bpm). Increase in heart rate is called Tachycardia which is above 100 bpm while decrease in heart is called as Bradycardia which is below 60 bpm.

Pulse Rate: The pulse rate is the pulse feel over an artery as the pressure inside increases following each heartbeat. The average pulse rate is between 60-80 pulse per minute.

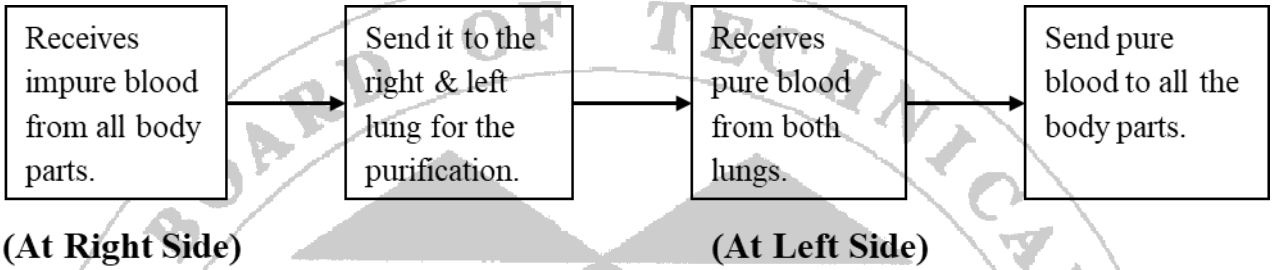
Blood Pressure: Blood pressure is the pressure exerted by the blood on the walls of blood. The blood pressure falls gradually as the blood passes from arteries to veins. It is measured in the terms of systolic & diastolic pressure. The systolic pressure is the maximum pressure produced by the ventricle during systole i.e., contraction while diastolic pressure is the lowest pressure during the diastole i.e., during relaxation of heart.

Heart

It is a pumping system, cone-shaped, weighing around 300 grams. It is situated near the middle of the thoracic cavity, above the diaphragm, and between the lungs. Its size is approximately 12 cm in length, 9 cm in width, and 6 cm in thickness. It consists of four chambers: 2 atria and 2 ventricles. It is covered by the pericardium and is made up of cardiac muscle.

Layers of heart: Pericardium- An outer cover sack, Epicardium- An outermost layer of heart, Myocardium- Middle layer made up of myocardium muscle, Endocardium- An innermost layer of heart.

Functions of heart.



Description of heart

Human heart system consists of a pair of valved muscular pump. Each pump is a functionally independent unit called right heart or right pump & left heart or left pump. The interior of heart is divided into right & left side by a vertical septum known as interventricular septum. Each side further divided into upper chamber & lower chamber by the valves i.e. Atria or auricles & Ventricles respectively. So, the heart consists of four chambers. Heart consists of four valves which prevents the back flow of blood. The right heart or right pump consists of right atrium & right ventricle. The right atrium is connected with superior & inferior venacava which carries impure blood & empty their content into the right atrium. Then the blood passes to the right ventricle through the opening of tricuspid valve. The pulmonary arteries then flow the blood towards the lungs for purification. The pairs of pulmonary veins collect the pure blood and empty their content into left atrium. The left heart or left pump consists of left atrium & left ventricle. Left atrium receives pure blood through pulmonary veins then sends it to left ventricle through the opening of bicuspid valve. The blood from left ventricle is pumped into the aorta and sends to all over the body.

Valves of the heart

The heart consists of four main valves which prevents the back flow of blood. The atrioventricular valve i.e., tricuspid & bicuspid valve separates the both right- left atria & right-left ventricles, respectively. These valves are opened in one direction only. The opening & closing of the valves is pressure dependent. The tricuspid valve consists of three cusps whereas bicuspid consists of two cusps. The bicuspid valve is also known as Mitral valve. On the other hand, the semilunar valve consists of pulmonary semilunar & aortic semilunar valve. The pulmonary semilunar valve present between the pulmonary artery & right ventricle which prevents the back flow of blood from pulmonary artery to the right ventricle whereas the aortic semilunar valve is present between aorta & left ventricle which prevents the back flow of blood from aorta to left ventricle.

Blood flow through heart

The two largest veins, superior and inferior vena cava, empty their contents into right atrium. This blood passes to the right ventricle through tricuspid valve. Then from right ventricle blood goes to the lungs via pulmonary artery. After the oxygenation of blood, it returns via pulmonary veins to the left atria and empty into left ventricle through mitral valve. From left ventricle blood circulates all over the body via aorta.

Coronary circulation: The heart itself requires a richly oxygenated blood supply to support its activity. This is delivered via the right and left coronary arteries, which lie on the epicardium and penetrate the myocardium with deeper branches to supply this highly active layer of muscle.

Pulmonary circulation: The blood flow from right ventricle to the left atrium via lungs is called pulmonary circulation. The deoxygenated blood from right ventricle is forced into pulmonary artery which is then divided into right & left pulmonary arteries carrying the blood towards the right & left lung respectively. These arteries again divided into the network of capillaries surrounded to the alveoli. The oxygen from the alveoli diffuses through the alveolar membrane & passes into the blood capillaries & the blood becomes oxygenated. The oxygenated blood from two lungs is collected by two pairs of pulmonary veins & emptying their content into the left atrium. In this mechanism the pulmonary circulation is takes place.

Conducting system of heart

An electric system transmits signals throughout the heart to control its pumping & maintain the rhythmic contraction. The electric signal starts at Sinoatrial or SA node which is located at the upper portion of the right atrium. This SA node is responsible for itself generation of rhythmical impulses hence it is known as natural pacemaker of the heart. The electrical signal passes down to the lower chamber of the heart by the atrioventricular or AV node which controls the electrical signals so the atria contracts before the ventricles. In the ventricles the pathways carry the signals throughout the muscles, so they contract at same time to pump the blood to the lungs & to the body.

Cardiac Cycle

The event which takes place during the circulation of blood through the heart are collectively known as cardiac cycle. These events occur in the heart from the beginning of one heartbeat to the beginning of other. The cardiac cycle begins with the activation of SA node & further contraction is through the conducting system.

Cardiac Cycle Time: The time required to complete one cardiac cycle is known as Cardiac cycle time & the time of cycle is 0.8 sec. 72 cardiac cycles take place in 1 minute. The cardiac cycles involve four main events & are as follows- a) Atrial Systole, b) Atrial Diastole, c) Ventricular Systole, d) Ventricular Diastole. The contraction of chambers of heart is known as Systole i.e., the phase of contraction. Diastole means the relaxation of chambers of heart. The heart is filled with blood during the relaxation of heart i.e., the phase of relaxation.

5. Diagram

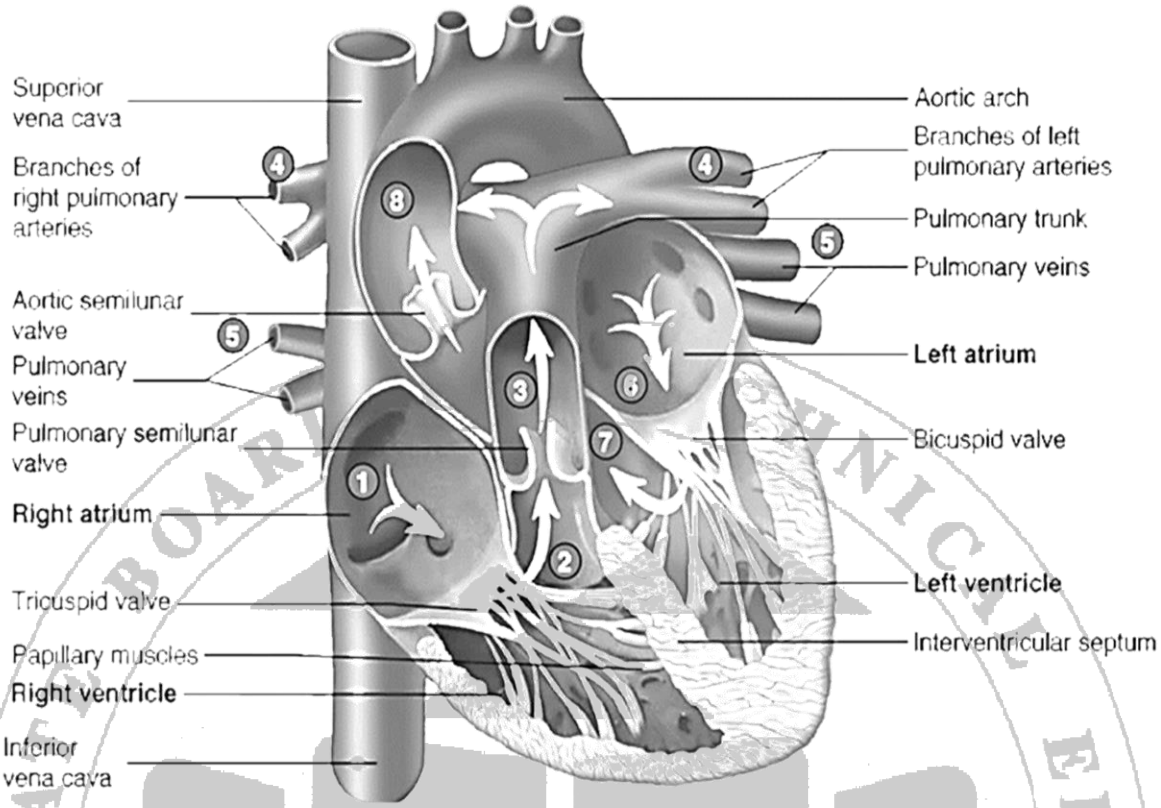


Fig 13.1: Internal structure of Heart

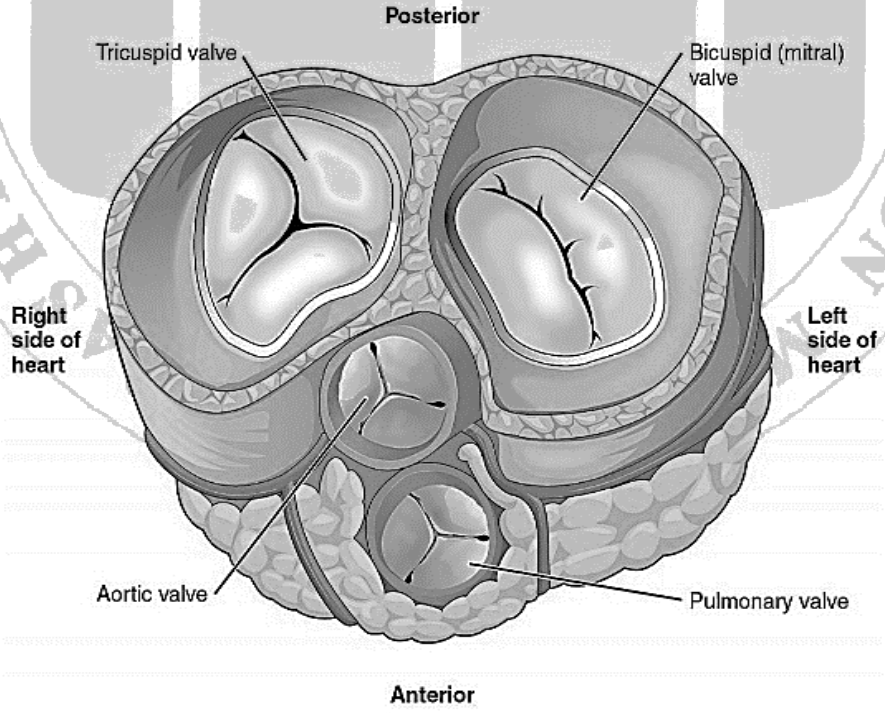


Fig 13.2: Valves of Heart

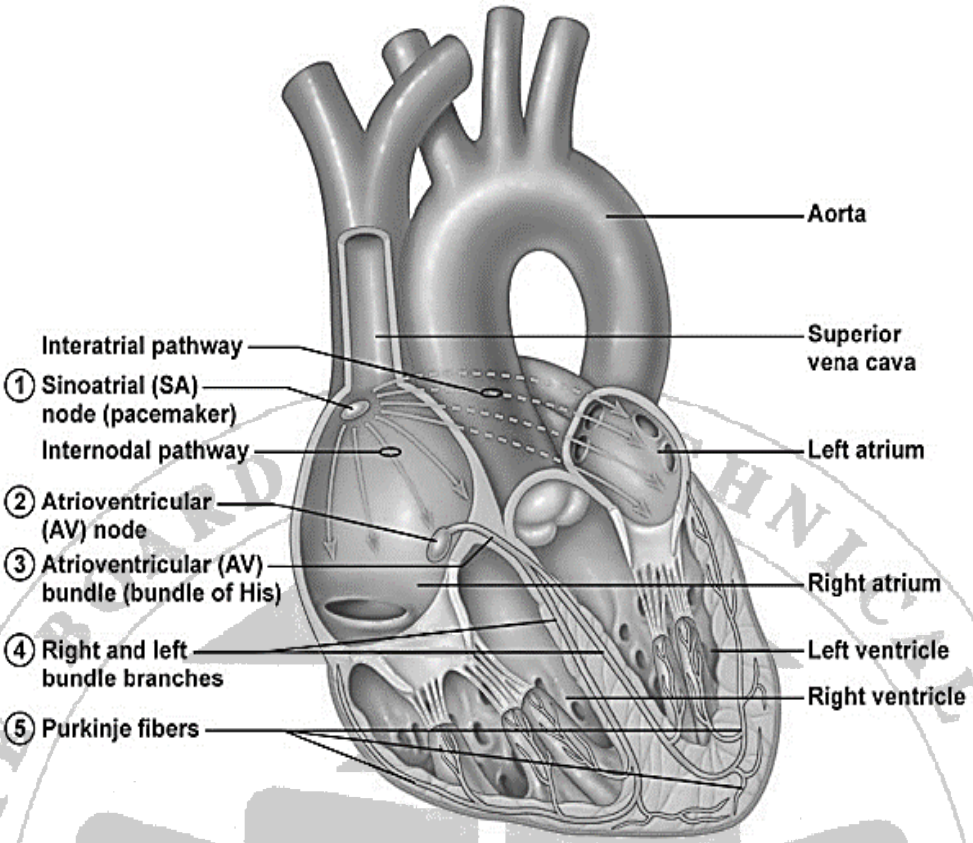


Fig 13.3: Conducting system of heart

6. Requirements:

Model of heart, specimen of heart and charts of Cardiovascular system.

7. Procedure

a. Put on gloves to handle specimens and models to maintain cleanliness and hygiene.
b. Read and review the theoretical aspects of the cardiovascular systems before observing the specimens or models.
c. Observe the specimens or models of the organs of cardiovascular system while correlating their positions with their anatomical locations in the human body.

8. Precautions to be taken

a. Do not touch the specimens or models with bare hands. Always wear gloves to prevent contamination and maintain hygiene.
b. Handle models or specimens with care and gentleness to avoid damage or breakage. Use both hands when necessary to support and stabilize items.
c. After completing the experiment or study session, clean the specimens following appropriate protocols and guidelines.

9. Observation and Exercise

a) Draw and label internal structure of heart.

b) Draw the diagrammatic representation of circulation of blood throughout the heart.

10. Result

_____

_____

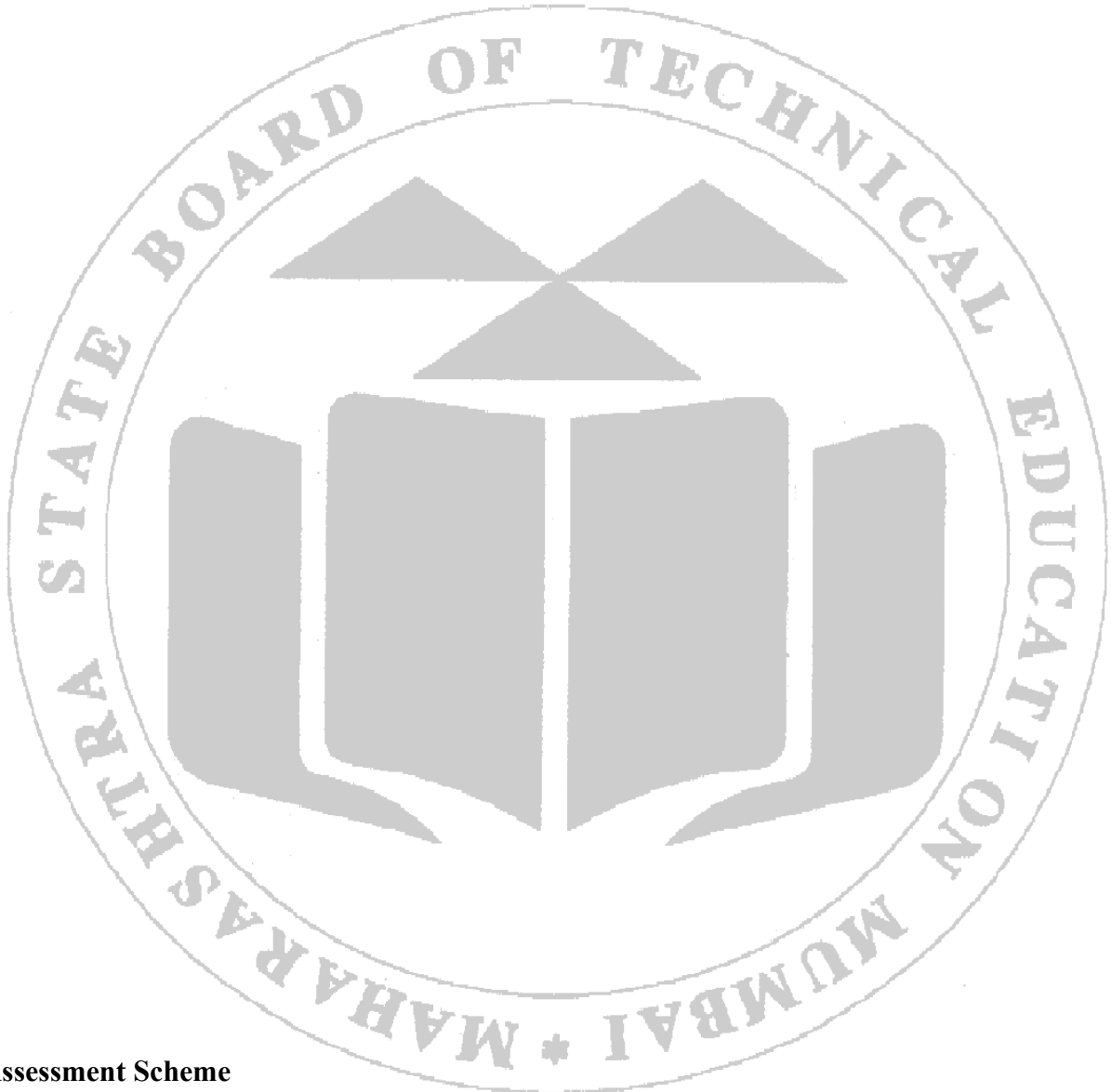
11. References

a. Waugh, A., Grant, A. (2023). Ross & Wilson Anatomy and Physiology in health and illness (14th ed.).
b. Tortora, G. J., & Derrickson, B. (2014). Principles of Anatomy and Physiology (14th ed.). Hoboken, N.J.: John Wiley.

12. Practical Related Questions

a. Define cardiac cycle and cardiac cycle time.
b. Define blood pressure.
c. What is Renin Angiotensin Aldosterone System?
d. Why is SA node called as principal pacemaker of heart?
e. Define systole and diastole.
f. Name the major blood vessels carrying blood away from the heart.
g. Define stroke volume and cardiac output.

(Space for writing answers)



13. Assessment Scheme

Particular	Understanding the basic concept (Intellectual skill)	Activities (Intellectual and motor skills)	Cleanliness & Handling (Affective domain)	Viva-voce / Answers Written	Total	Signature of teacher
Marks Obtained						
Max Marks	**02**	**05**	**01**	**02**	**10**	

Experiment No. 14
Recording of Pulse Rate and Heart Rate

1. Aim

To record the pulse rate and heart rate.

2. Practical Significance

Pulse rate and heart rate measurements are vital for assessing cardiovascular health. By measuring pulse and heart rates, students can gain practical skills and knowledge, learning to interpret the data obtained to understand normal ranges and recognize deviations indicative of underlying health issues like tachycardia, bradycardia, or arrhythmias.

3. Practical Outcomes (PrOs)

After completion of this practical, the students will be able to:

PrO	Practical Outcomes	Mapped CO	BTL
1	Record the pulse rate and heart rate.	CO2	3
2	Identify different locations of pulse.	CO2	1
3	Use stethoscope properly without damaging the ear.	CO2	3
4	Collaborate and communicate with fellow students.	CO2	5

4. Relevant Theoretical Background

Terminology

Pulse rate: It means frequency of pulse per minute. Normally it corresponds to heart rate.

Heart rate: The number of heart beats per minute.

Heart sound: Contraction and relaxation of heart produces sound mainly due to passive closing of valves (Lub and Dub).

Tachycardia: Abnormal increase in pulse/heart rate than normal (more than 100/minute).

Bradycardia: Abnormal decrease in pulse/heart rate than normal (less than 60/minute).

Arrhythmia: Abnormal heart rhythm characterized by irregularities in the rate, regularity, or sequence of heartbeats.

Significance of pulse

The pulse is the rhythmic wave of pressure in the arteries caused by ventricular ejection, felt as a regular pulsation due to pressure changes during heartbeats. Pulse provides information about following points:

Rate: Indicates whether the number of pulse/heartbeats has increased or decreased.

Rhythm: Determines if the pulse/heartbeat is regular or irregular.

Volume: The extent of uplift or amplitude of the pulse indicates the blood volume.

Force and Tension: Reflects systolic and diastolic blood pressure, respectively.

Character: Describes the pattern of rise, maintenance, and fullness of the pulse.

Condition of vessel wall: By pressing the brachial artery with the thumb and rolling it against the underlying bone, one can assess if the vessel wall is soft and palpable, thick and hard, or tortuous.

Normal values: 60 – 80 pulse/heart beats per minute.

Heart sounds

The two primary heart sounds, often referred to as "lub" and "dub," are essential indicators of heart function and are typically heard using a stethoscope. The first heart sound (lub) is caused by the closure of the mitral and tricuspid valves at the start of ventricular systole, marking the beginning of the heart's contraction phase (Systolic sound). The second heart sound (dub) is caused by the closure of the aortic and pulmonary valves at the start of ventricular diastole, marking the beginning of the heart's relaxation phase (Diastolic sound).

5. Diagram

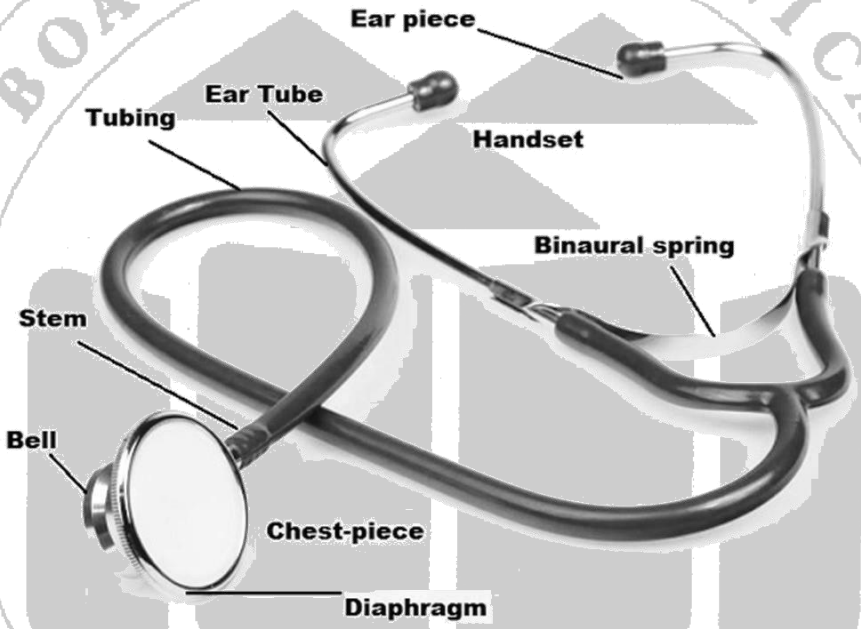


Fig 14.1: Parts of stethoscope

6. Requirement:

Stethoscope and stopwatch.

7. Procedure

A. Pulse rate measurement

a. Ask the subject to sit calmly.
b. Put the middle and index fingers at the site from where pulse is to be recorded
c. Start the stopwatch.
d. Radial Pulse: Use the index and third fingers to feel the pulse in the radial artery at the
e. wrist.
f. Temporal Pulse: Use the index and third fingers to feel the pulse over the temporal bone in front of the ear.
g. Brachial Pulse: Feel the pulse in the brachial artery at the elbow by pressing gently with the middle and index fingers.
h. Count the pulse for one minute.
i. Take three readings and calculate the average.

B. Heart rate measurement

a. Instruct the subject to lie down in the supine position.
b. Prepare the stethoscope by unlocking it.
c. Position the chest piece of the stethoscope slightly to the left on the chest.
d. Begin timing with the stopwatch.
e. Listen to the heart sounds through the earpiece.
f. Count the number of heartbeats, comprising the lub-dub sounds, for one minute.
g. Record three readings and calculate the average.

8. Precautions

a. Ensure the subject is relaxed and seated comfortably.
b. Use reliable methods and equipment for accurate recordings.
c. Minimize movement and talking during measurements.
d. Take multiple readings to ensure accuracy and note any irregularities.
e. Ensure proper calibration and functioning of equipment before use.

9. Observations

S. N.	Pulse rate/minute				Heart rate/minute
	Radial pulse		Brachial pulse		
	Before exertion	After exertion	Before exertion	After exertion	
1					
2					
3					
Average					

10. Result

The pulse rate and heart rate were found to be _____per minute and _____per minute respectively.

11. Conclusion

My pulse rate and heart rate were _____ (normal/abnormal). If abnormal, they were _____ (increased/decreased), indicating _____ (tachycardia/bradycardia).

12. References

a. Goyal, R. K., Patel, N. M., (2010). Practical Anatomy and Physiology. B. S. Shah Prakashan, 14th edition.
b. Reddy, L. P., (2009). Practical Physiology, Paras Publishing, 2nd Edition.
c. Pal, G. K., Pal, P., (2001). Textbook of Practical Physiology, Orient Longman Ltd.

13. Practical Related Questions

a. Define pulse rate and heart rate.
b. What is tachycardia and bradycardia?
c. State the normal value of heart rate.
d. What is the indication of rhythm?
e. What are the causes of heart sounds?

(Space for writing answers)

14. Assessment Scheme

Particular	Understanding the basic concept (Intellectual skill)	Activities (Intellectual and motor skills)	Cleanliness & Handling (Affective domain)	Viva-voce / Answers Written	Total	Signature of teacher
Marks Obtained						
Max Marks	**02**	**05**	**01**	**02**	**10**	

Experiment No. 15
Recording of Blood Pressure

1. Aim

To record the blood pressure.

2. Practical Significance

An increase in blood pressure (BP) is a leading cause of death and disability, emphasizing the crucial role of accurate BP measurement in preventing and treating cardiovascular diseases. Through this experiment, students will grasp BP measurement techniques and learn to identify hypertension (high blood pressure) and hypotension (low blood pressure), recognizing associated risk factors and potential complications.

3. Practical Outcomes (PrOs)

After completion of this practical, the students will be able to:

PrO	Practical Outcomes	Mapped CO	BTL
1	Measure the systolic and diastolic blood pressure.	CO2	3
2	Learn to handle sphygmomanometer.	CO2	3
3	Detect sound variations with changes in pressure.	CO2	4
4	Collaborate and communicate with fellow students.	CO2	5

4. Relevant Theoretical Background

Terminology

Blood pressure: The lateral pressure exerted by the flowing blood on the walls of blood vessels.

Hypertension: High blood pressure, defined as systolic above 140 mmHg or diastolic above 90 mmHg.

Hypotension: Low blood pressure, defined as systolic below 90 mmHg or diastolic below 60 mmHg.

Blood pressure (BP) is defined as the lateral pressure exerted on the walls of the vessels by the contained blood. The maximum pressure, typically around 120 mmHg during systole, is called systolic blood pressure. The minimum pressure, typically around 80 mmHg during diastole, is called diastolic blood pressure.

Normal value: 120 mmHg systolic pressure and 80 mmHg diastolic pressure (120/80 mmHg).

Methods of determination of blood pressure

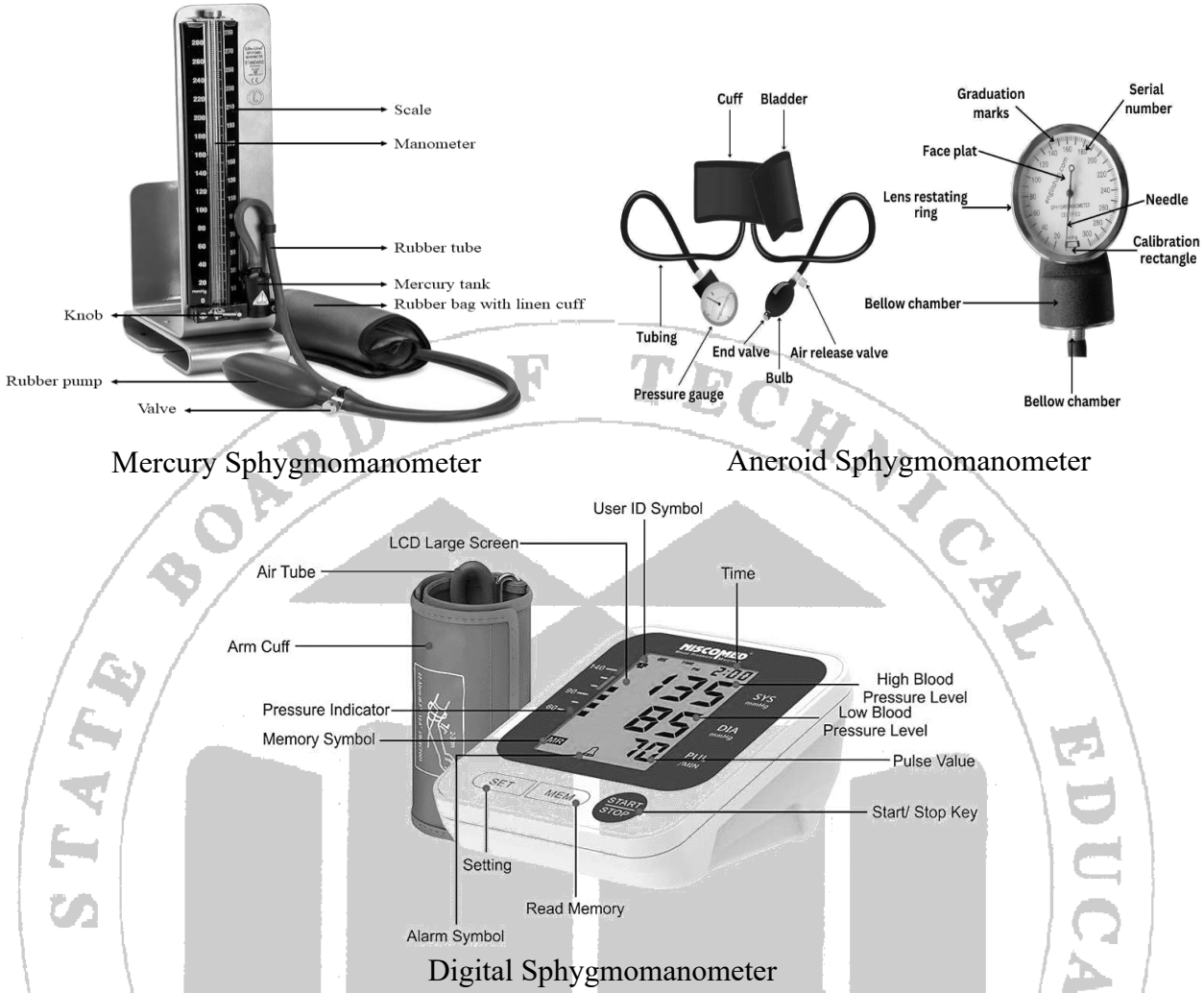
There are three methods to measure blood pressure.

a. Palpatory method (feeling pulse).

b. Oscillatory method (observing oscillations)

c. Auscultatory method (hearing sound).

5. Diagram



Mercury Sphygmomanometer Aneroid Sphygmomanometer

Digital Sphygmomanometer

Fig 15.1: Types of Sphygmomanometers

6. Requirement:

Stethoscope and Sphygmomanometer.

7. Procedure

A. Keeping the apparatus ready

a. Ensure all apparatus are in good condition.
b. Check the mercury column for any air bubbles.
c. Connect the manometer to the cuff via a rubber tube.
d. Connect the cuff to the rubber pump via a rubber tube.
e. Check the position of the knob; if closed, rotate, and open it.

B. Developing Pressure around the Arm

a. Instruct the subject to sit or lie down in the supine position.
b. Raise the sleeves to expose the upper arm.
c. Adjust the arm's position to be level with the heart.
d. Secure the cuff around the arm comfortably, avoiding excessive tightness or looseness.
e. Place the manometer at the subject's side, at heart level.
f. Tighten the screw of the rubber pump and inflate the cuff to approximately 200 mmHg.

C. Recording Blood Pressure

a) **Palpatory Method (Recording only Systolic BP)**

i Place a finger on the wrist to feel the pulse.
ii Inflate the cuff 25-30 mmHg higher after the radial pulse disappears.
iii Keep an eye on the manometer.
iv Slowly release pressure by unscrewing the valve.
v Note the mercury level/needle position when the pulse is felt (indicating systolic pressure).

b) **Oscillatory Method**

i When the pulse reappears, mercury starts oscillating, indicating systolic pressure.
ii As oscillations increase, continue releasing pressure.
iii At a certain point, oscillations gradually diminish.
iv The maximum oscillation indicates diastolic pressure.

c) **Auscultatory Method**

i Position the chest piece of the stethoscope over the brachial artery near the cuff.
ii Inflate the cuff to a pressure higher than the systolic pressure determined in the palpatory method.
iii Gradually release pressure by unscrewing the valve.
iv Note the level at which the sound (lub/dub) appears, indicating systolic pressure.
v Continue releasing pressure until the sound disappears, indicating diastolic pressure.

8. Precautions

a. Ensure the subject is relaxed and seated comfortably.
b. Use reliable methods and equipment for accurate recordings.
c. Minimize movement and talking during measurements.
d. Inflate the cuff slowly and avoid overinflation to prevent discomfort.
e. Position the arm at heart level for blood pressure measurement.
f. Take multiple readings to ensure accuracy and note any irregularities.
g. Ensure proper calibration and functioning of equipment before use.

9. Observations

S. N.	Blood pressure (mmHg)							
	Systolic				Diastolic			
	Seating		Supine		Seating		Supine	
	Left arm	Right arm	Left arm	Right arm	Left arm	Right arm	Left arm	Right arm
1								
2								
3								
Average								

10. Result

The blood pressure is found to be _____mmHg systolic and _____mmHg diastolic.

11. Conclusion

My blood pressure was _____ (normal/abnormal). If abnormal, it was _____ (increased/decreased), indicating _____ (hypertension/hypotension).

12. References

a. Goyal, R. K., Patel, N. M., (2010). Practical Anatomy and Physiology. B. S. Shah Prakashan, 14th edition.
b. Reddy, L. P., (2009). Practical Physiology, Paras Publishing, 2nd Edition.
c. Pal, G. K., Pal, P., (2001). Textbook of Practical Physiology, Orient Longman Ltd.

13. Practical Related Questions

a. Define blood pressure.
b. Compare the reading from all the three methods of measurement of BP as above and draw a conclusion, which method is most suitable and useful, and why?
c. Mention the factors influencing the BP measurement.
d. Mention different sound heard during BP measurement.
e. Define hypertension and hypotension.

(Space for writing answers)

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14. Assessment Scheme

Particular	Understanding the basic concept (Intellectual skill)	Activities (Intellectual and motor skills)	Cleanliness & Handling (Affective domain)	Viva-voce / Answers Written	Total	Signature of teacher
Marks Obtained						
Max Marks	**02**	**05**	**01**	**02**	**10**	

Experiment No. 16
Study of Respiratory System

1. Aim
To study the human Respiratory system.

2. Practical Significance
Respiratory system performs the function of respiration in which it helps in getting oxygen into the body and exhale waste material like carbon dioxide out from the body. In this practical student will learn the basic anatomy and physiology of respiratory system.

3. Practical Outcomes (PrOs)
After completion of this practical, the students will be able to:

PrO	Practical Outcomes	Mapped CO	BTL
1	Identify the different parts of human respiratory system.	CO4	1
2	Locate the parts of respiratory organs.	CO4	2
3	Draw and label the structure of respiratory system with their functions.	CO4	1

4. Relevant Theoretical Background
Terminology

Respiration is the process of exchange of gases between environment, lungs, and the body cells. Respiration is the action of breathing. Exchange of gases between lungs and blood is called as external respiration and between blood and cells is called as internal respiration.

Parts of respiratory system

Main organs: Nose and nasal cavity, pharynx, larynx, trachea, bronchi, bronchioles, alveolar membrane, alveoli, and lungs.

Accessory organs: Diaphragm, ribs, and intercostal muscles.

Nose: The first organ of the respiratory system. It consists of two large irregular cavities. The nose is lined by ciliated columnar epithelium and is divided into external and internal portions. The external nose has two openings called external nostrils. The space inside the internal nose is the nasal cavity, which is divided into right and left nostrils by the nasal septum. Just inside the nostrils is the vestibule, which is surrounded by the internal lining of the nasal cavity and is lined with ciliated epithelium and sensory epithelium.

Functions:

Warm and moisten the air as it passes over surface of nose.

Filter the air as dust particles adhere to the mucus.

Nose is organs of sense of smell.

Pharynx: It is a tube 12 to 14 cm in length. It starts from the base of the skull and extends up to the sixth cervical vertebra. It lies behind the nose, mouth, and larynx. It is wider at its upper end and is lined by a mucous membrane, fibrous tissue, and muscle tissue. The branches of the facial arteries supply blood to the pharynx.

Functions: It is an organ involved in both respiratory and digestive function.

Larynx: The lymphatic tissue of the palatine and laryngeal tonsils helps to prevent micro-organisms from entering the body. It is also called the "voice box." It starts from the root of the tongue and the hyoid bone and extends to the trachea. It lies at the level of 3rd, 4th, 5th and 6th cervical vertebrae. There is a little difference in the size of the larynx until the puberty. After puberty it grows large in the male. It is composed of irregular cartilages e.g., thyroid cartilage, cricoid cartilage, arytenoids cartilage which are attached to each other by ligaments and membranes.

Functions: It provides a passageway for air between the pharynx and the trachea. The vocal cords produce sound of varying loudness and pitch. During swallowing the larynx moves upwards occluding the opening into it from the pharynx. This ensures the food passes into the oesophagus and not in respiratory passage.

Trachea: It is also referred as windpipe. It is a continuation of larynx. It extends up to the level of the fifth thoracic vertebra. At this level it bifurcates into the right and left bronchus which enters into each lung. It lies in median plane in front of the oesophagus and is about 11 cm in length. It is composed of 16-20 incomplete "C" shaped rings situated one above the other and made up of hyaline cartilages. It is composed of fibrous tissue, elastic tissue, connective tissue, and ciliated columnar tissue.

Bronchi: The two bronchi start at the level of 5th thoracic vertebra. The right bronchus is a wider, shorter tube as compared to the left bronchus. The right bronchus is 2.5 cm in length while the left bronchus is 5 cm in length. After entering in the right lung, the right bronchus divides into three branches each entering to each lobe while the left branches after entering left lung, divides in two branches, one of which goes to each lobe of the lung. Each branch then divides subdivides into smaller branches; Bronchi are lined with ciliated columnar epithelium.

Bronchioles: The air passages without the cartilages in their walls are referred as bronchioles. The minute bronchioles which further divides to form alveolar ducts. These ducts lead to a sac like structure called as alveoli. Alveoli are responsible for exchange of gases.

Functions of trachea, bronchi, and bronchioles: The presence of cartilage keeps these airways open, providing an unobstructed passage of air between the external atmosphere and the lungs. The mucous

coating on the lining membrane is sticky, allowing particles such as dust and bacteria to adhere to it. The wave-like motion of the cilia on the lining membrane moves the mucus towards the throat.

Lungs: The Lungs are two in number. They lie one on each side of the midline in the thoracic cavity lungs are cone shaped and shows apex, base, costal surface, medial surface. The right lung is divided in three lobes superior, middle, inferior while left lung is divided into two lobe- superior and inferior. The lungs are composed of bronchi, smaller air passages, alveoli, connective tissues, blood vessels and nerves.

Physiology of respiration: Respiration is a process by which the lungs expand to take air in and contract to expel it. Respiratory cycle occurs about 15 times per minute. It includes three phases. 1. Inspiration 2. Expiration 3. Pause. When the capacity of the thoracic cavity is increased by contraction of intercostals muscles and diaphragm, the pressure inside the cavity falls as compared with atmospheric pressure. This results in air being drawn into the lungs to equalize the alveolar and atmospheric pressure. This process is termed as inspiration. When the diaphragm and intercostal muscles relax the ribs regain their original position, the diaphragm ascends, lungs recoil and net

result of all this is expiration. After expiration and before inspiration there is gap between called a pause and cycle begins again.

5. Diagram

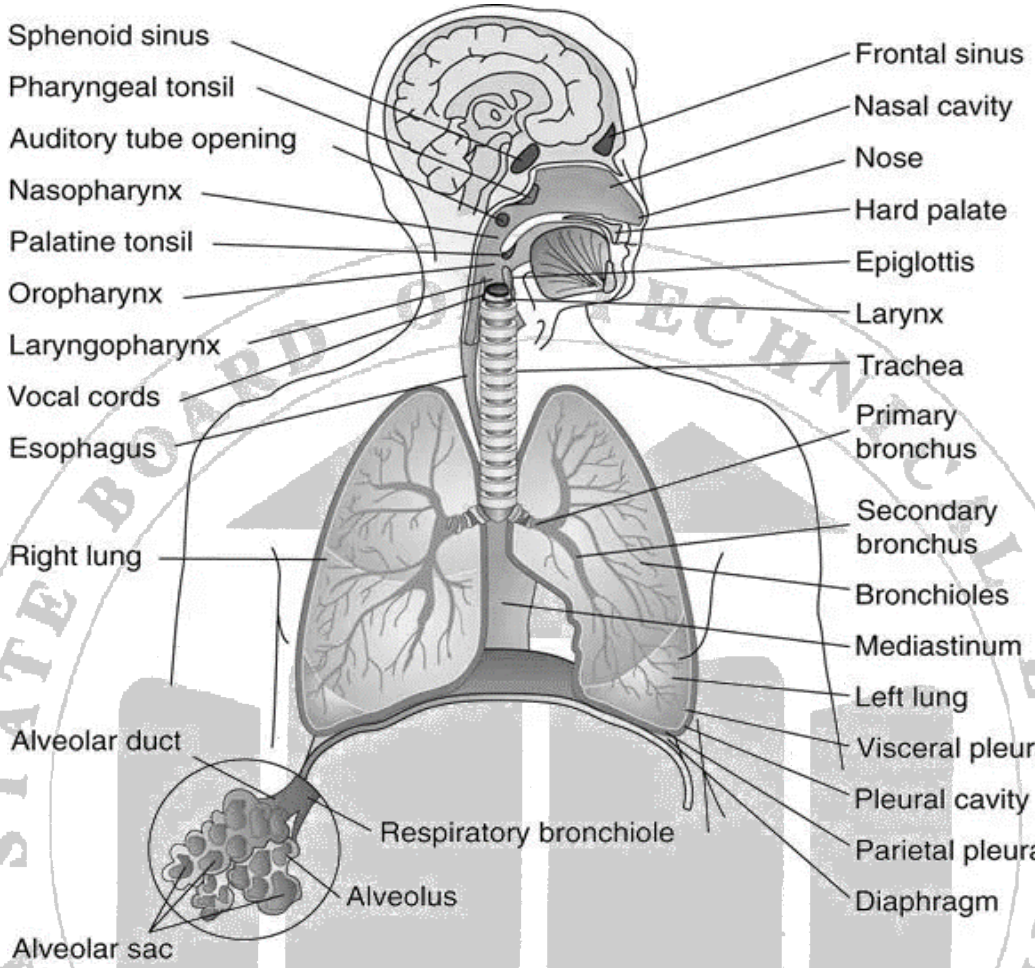


Fig 16.1: Respiratory System

6. Requirements

Model, specimen, and charts of Respiratory system.

7. Procedure

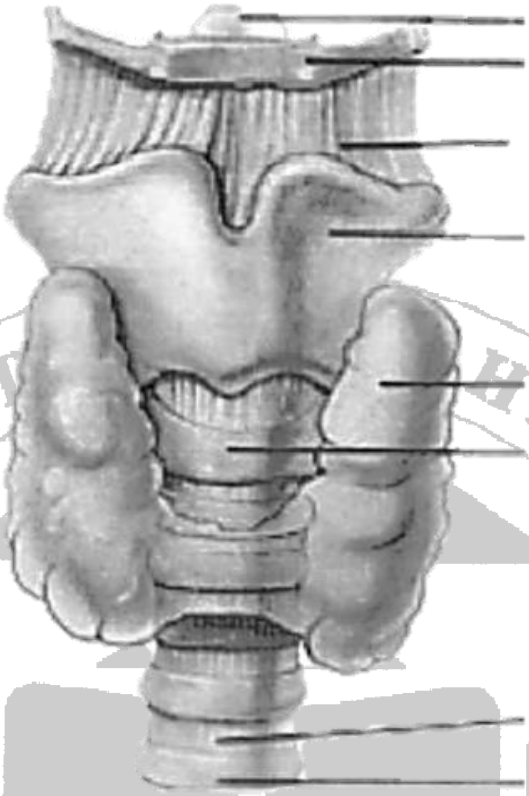
a. Put on gloves to handle specimens and models to maintain cleanliness and hygiene.
b. Read and review the theoretical aspects of the respiratory systems before observing the specimens or models.
c. Observe the specimens or models of the organs of respiratory system while correlating their positions with their anatomical locations in the human body.

8. Precautions to be taken

a. Do not touch the specimens or models with bare hands. Always wear gloves to prevent contamination and maintain hygiene.
b. Handle models or specimens with care and gentleness to avoid damage or breakage. Use both hands when necessary to support and stabilize items.
c. After completing the experiment or study session, clean the specimens following appropriate protocols and guidelines.

9. Observation

A. Label the different areas shown with lines in the following picture.



B. Label the different areas shown with lines in the following picture.

10. Result

_____

_____

11. References

a. Waugh, A., Grant, A. (2023). Ross & Wilson Anatomy and Physiology in health and illness (14th ed.).
b. Tortora, G. J., & Derrickson, B. (2014). Principles of Anatomy and Physiology (14th ed.). Hoboken, N.J.: John Wiley.

12. Practical Related Questions

a. Name the three cartilages of larynx.
b. What is respiration? Explain the physiology of respiration.
c. How many C shaped cartilage ring present in trachea?
d. Which muscle is responsible for breathing?
e. Define Tidal volume, Residual volume, and Vital capacity.
f. Which part prevents the entering of food into the trachea?
g. Name the structural and functional unit of Respiratory system.

(Space for writing answers)

13. Assessment Scheme

Particular	Understanding the basic concept (Intellectual skill)	Activities (Intellectual and motor skills)	Cleanliness & Handling (Affective domain)	Viva-voce / Answers Written	Total	Signature of teacher
Marks Obtained						
Max Marks	**02**	**05**	**01**	**02**	**10**	

Experiment No. 17
Record of Respiratory Rate, Pulse Oxygen & force of Air

1. Aim
To record the respiratory rate, pulse oxygen & force of air expelled using a peak flow meter.

2. Practical Significance
Recording respiratory rate, pulse oxygen saturation (SpO_2), and peak flow meter readings is crucial for comprehensive respiratory assessment. Respiratory rate assesses breathing status, detects distress early, and aids in triage and emergencies. SpO_2 monitors blood oxygen levels, detecting hypoxemia and guiding therapy. The peak flow meter measures lung airflow and assesses conditions like asthma or COPD, and guides treatment. Together, these recordings provide essential data for evaluating respiratory health, enabling timely interventions, and optimizing patient care.

3. Practical Outcomes (PrOs)
After completion of this practical, the students will be able to:

PrO	Practical Outcomes	Mapped CO	BTL
1	Measure the respiratory rate.	CO2	3
2	Estimate Pulse Oxygen.	CO2	4
3	Record the Pulse Rate and Pulse Oxygen.	CO2	3
4	Handle the peak flow meter and observe the changes.	CO2	5

4. Relevant Theoretical Background
Terminology

Respiratory rate: Respiratory rate (RR) refers to the number of breaths a person takes per minute. It is a vital sign that reflects the efficiency of breathing and the exchange of oxygen and carbon dioxide in the lungs.

Pulse oxygen: Pulse Oxygen Saturation (SpO_2) is a measure of the amount of oxygen carried in the blood, expressed as a percentage. It is a vital sign commonly measured using a pulse oximeter, a non-invasive medical device that clips onto a finger, toe, or earlobe.

Peak expiratory flow rate: The amount of air a person can quickly force out of the lungs in one breath.

Peak Flow Meter: Peak flow meters are valuable tools in the management of respiratory conditions. They provide objective measurements of lung function. They aid in the assessment, monitoring, and treatment of asthma, COPD, and other lung diseases. Together with other recordings, such as respiratory rate and pulse oxygen saturation, peak flow meter readings provide essential data for evaluating respiratory health.

The three peak flow zones are color-coded for easy identification as follows:

Green zone: 80 to 100 percent of your usual flow rate	This is the ideal zone. It means your condition is under control.
Yellow zone: 50 to 80 percent of your usual flow rate	Your airways may be starting to narrow. Talk to your doctor about how to handle yellow zone results.

Red zone: less than 50 percent of your normal rate	Your airways are severely narrowing. Take your rescue medications and contact emergency services.

PFM can also assess other lung problems, such as COPD, including emphysema and chronic bronchitis.

Standard values

Vital signs	Score 1- Normal (Safe)	Score 2- Bradypnoea	Score 2- Tachypnoea	Score 3- Critical
Respiratory rate	12-20 BPM	9-11 BPM	26-29 BPM	< 8 or > 30 BPM
SpO_2 %	> 96%	> 91%	-	< 83%
Peak flow rate	Ranges between 400 and 700 liters per minute (L/min)			

Principle

The pulse oximeter measures blood oxygen saturation by analyzing light absorption. It emits red and infrared light, measuring how much is absorbed by oxygenated and deoxygenated hemoglobin. Photodetectors gauge the intensity of transmitted light, and a microprocessor calculates SpO_2. The device displays SpO_2 and determines heart rate.

A peak flow meter assesses how effectively the lungs can expel air. It records the airflow in liters per minute, displaying the measurement on a numbered scale by blowing a quick, strong breath through a mouthpiece at one end.

Emphysema: This is a chronic lung condition that affects the smallest air sacs in the lungs (alveoli).

Chronic bronchitis: This is long-term inflammation of the bronchi. It creates too much mucus and a chronic cough.

5. Diagram

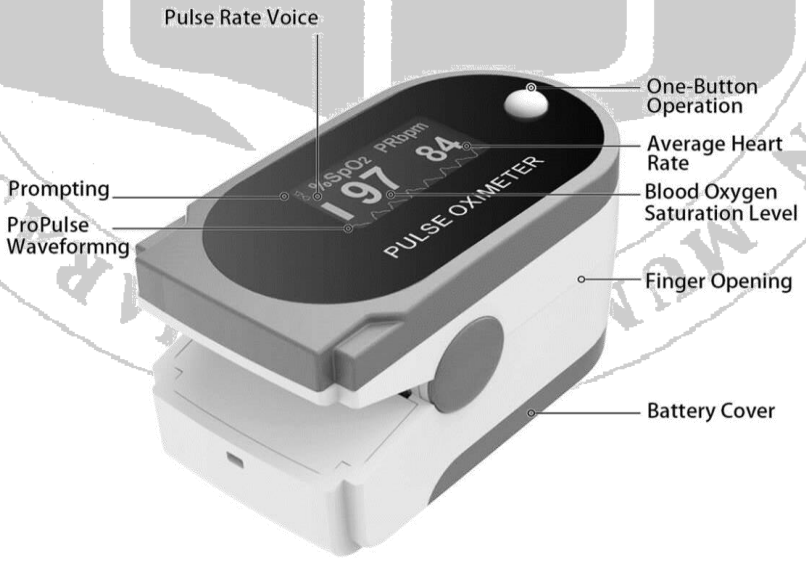


Fig 17.1: Pulse Oximeter

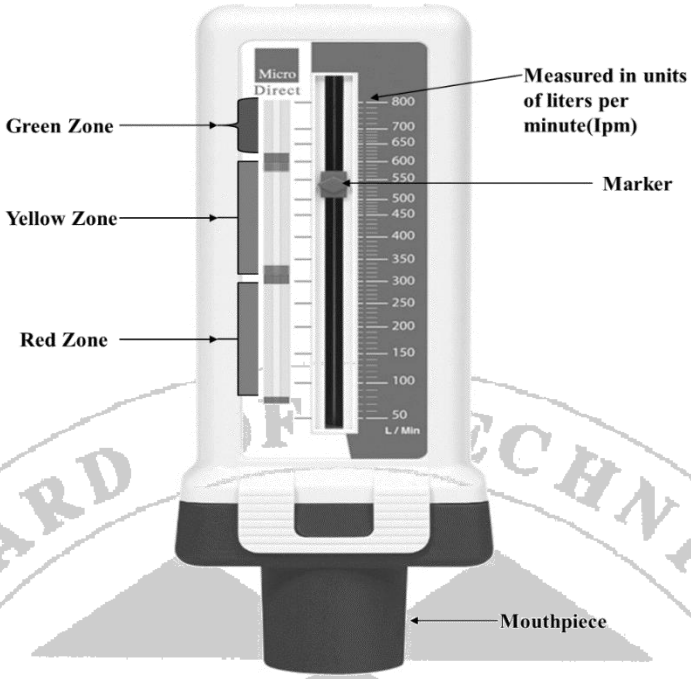


Fig 17.2: Peak Flow Meter

6. Requirements

Pulse oximeter, peak flow meter, and stopwatch.

7. Procedure

A. Respiratory Rate

a. The subject should be calm for 20 minutes before recording.
b. Start the stopwatch.
c. Count the breaths by counting the number of times the chest or abdomen rises over one minute by placing a hand on the subject's chest to feel the rise and fall.
d. One rise and fall should be counted as 1 breath.
e. Listen to the sounds of breaths.
f. Record and report the count.

B. Pulse Oximetry

a. Wash the hands and sterilize the finger that is going to be used for measurement.
b. Put the finger at the position on the pulse oximeter.
c. The oximeter results may change in the first few seconds.
d. After a certain period, it provides a steady reading.
e. Record and report the count.

C. Peak flow meter

a. Prepare, clean, and assemble the peak flow meter, ensuring the marker is at the lowest point on the scale.
b. Stand or sit upright with feet flat on the floor.
c. Inhale deeply to fill your lungs.
d. Insert the mouthpiece, sealing your lips tightly around it.
e. Exhale forcefully through the mouthpiece to empty your lungs and note the peak flow rate shown on the meter.
f. Repeat the measurement two more times, resting between attempts.

g. Record the highest peak flow rate obtained and compare it with your personal best peak flow rate.
h. Interpret the results using color-coded zones.
i. Finally, clean the mouthpiece and store the meter properly.

8. Precautions

A. Respiratory Rate

a. Ensure the individual is comfortable and relaxed, preferably sitting or lying down.
b. Avoid measuring immediately after physical activity or eating.
c. Encourage natural breathing and refrain from speaking during measurement.
d. Aim for a full-minute measurement for accuracy.

B. Pulse Oximetry (Pulse Oxygen)

a. Check proper calibration and good connection with the finger or earlobe.
b. Ensure cleanliness of the finger or earlobe to avoid interference.
c. Minimize movement to ensure accurate pulse detection.
d. Note potential accuracy issues in individuals with poor circulation or certain medical conditions.

C. Peak Flow Meter (Force of air expelled)

a. Instruct on proper technique, emphasizing a tight seal and forceful exhalation.
b. Keep the meter clean and free from obstructions.
c. Encourage consistent effort for accurate results.
d. Remind to avoid blocking airflow with the tongue or teeth.
e. Consider factors like recent bronchodilator use or respiratory muscle weakness that may affect results.

9. Observations

A. Respiratory Rate (RR) and Pulse Oximeter

S. N.	RR (Breath/min)	SpO_2 %
1		
2		
3		
Average		

B. Peak expiratory flow rate (PEFR)

S. N.	PEFR (L/min)
1	
2	
3	
Best	

10. Result

a. The respiratory rate was found to be _____ per minute and the oxygen saturation level was _____%.
b. The Highest peak flow rate was found to be_____L/Min.

11. Conclusion

a. Respiratory rate and oxygen saturation were _____ (normal/abnormal). If abnormal, they were _____ (increased/decreased), indicating _____ (tachypnoea/bradypnoea/hypoxia).

b. The PEFR was _____ (normal/less than normal). If less than normal, person may be suffering from _____ (asthma/COPD/Cough).

12. References

a. Reddy, L. P., (2009). Practical Physiology, Paras Publishing, 2nd Edition.

b. Pal, G. K., Pal, P., (2001). Textbook of Practical Physiology, Orient Longman Ltd.

c. https://www.hopkinsmedicine.org/health/treatment-tests-and-therapies/peak-flow-measurement

13. Practical Related Questions

a. Define Peak expiratory flow rate.

b. Describe the use of the Peak flow meter.

c. What are asthma and COPD.

d. Give the effects of age, weight, and sex on the PEFR.

e. Define Respiratory rate.

f. Give a reason, why breathing is increased during exercise or stress.

g. Give the respiration cycle.

h. Define bradypnea and tachypnoea.

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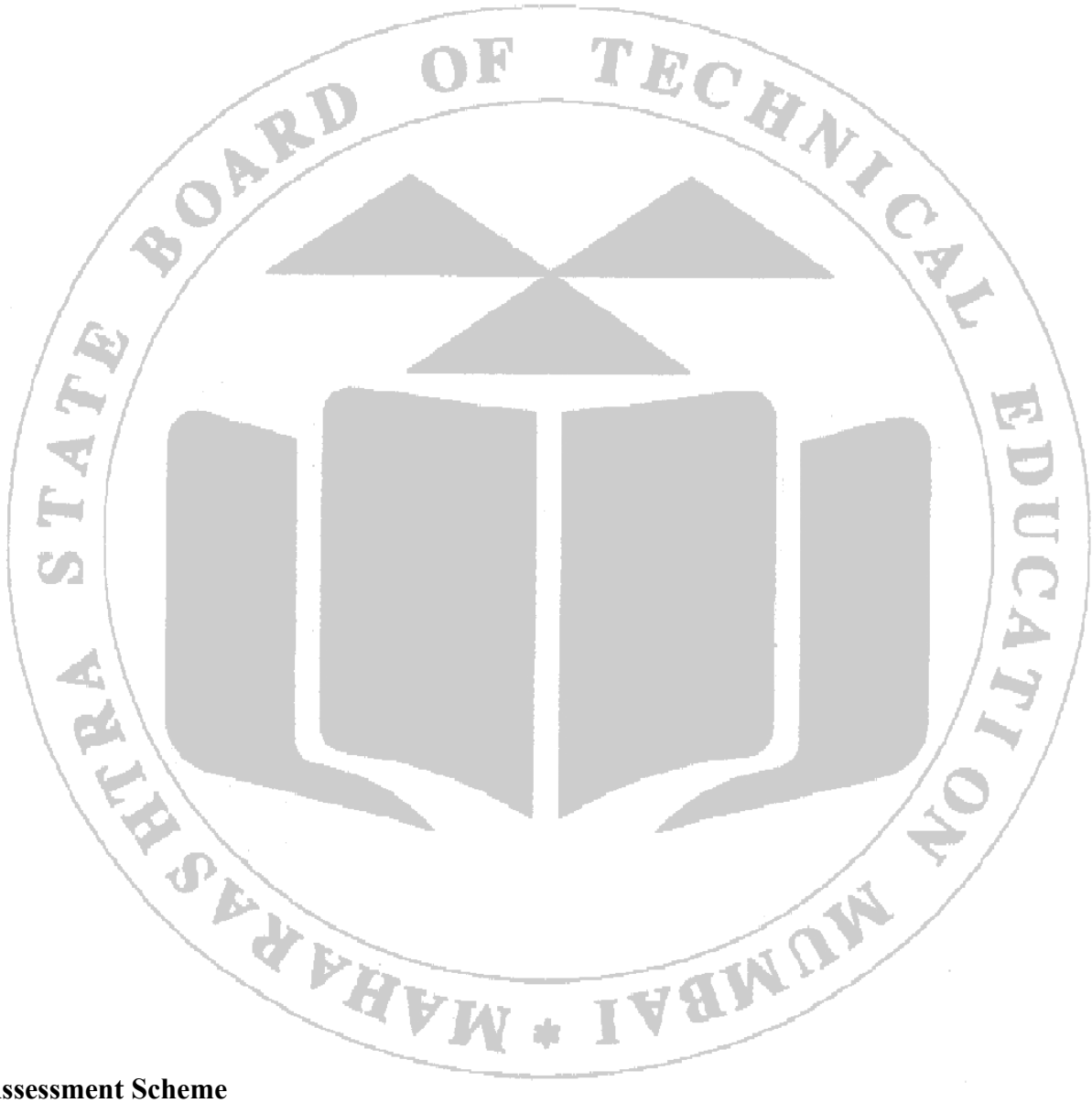

14. Assessment Scheme

Particular	Understanding the basic concept (Intellectual skill)	Activities (Intellectual and motor skills)	Cleanliness & Handling (Affective domain)	Viva-voce / Answers Written	Total	Signature of teacher
Marks Obtained						
Max Marks	**02**	**05**	**01**	**02**	**10**	

Experiment No. 18
Study of Sense Organs

1. Aim
To study various human sense organs: Eye, Ear, and Skin.

2. Practical Significance
The sense organs are a group of specialized structures in the human body that are responsible for detecting and processing sensory information from the external environment. Each sense organ contains specialized sensory receptors that detect specific types of stimuli, and the information they gather is then transmitted to the brain for processing and interpretation. In this practical, students will know basic anatomy and physiology of sense organs.

3. Practical Outcomes (PrOs)
After completion of this practical, the students will be able to:

PrO	Practical Outcomes	Mapped CO	BTL
1	Locate the different sense organs.	CO4	1
2	Identify the parts of sense organs.	CO4	1
3	Explain the sense mechanism.	CO4	1

4. Relevant Theoretical Background
There are five sense organs include: the eyes, ears, nose, tongue, and skin, which work together to help us perceive and respond to stimuli such as light, sound, smell, taste, and touch. Understanding how these sense organ's function and interact with each other for our overall sensory experience and ability to interact with the world around us.

The five main sense organs are the eyes for vision, the ears for hearing, the nose for smell, the tongue for taste, and the skin for touch, pressure, temperature, and pain sensations.

A. Eye

The eye is a complex organ that plays a crucial role in vision. It consists of several structures that work together to transmit light and images to the brain for interpretation.

Anatomy of the Eye

Cornea: The clear outer layer that covers the front of the eye and helps focus light.

Sclera: The white, protective outer layer of the eye.

Iris: The coloured part of the eye that controls the size of the pupil and the amount of light entering the eye.

Pupil: The adjustable opening in the centre of the iris that regulates the amount of light entering the eye.

Lens: The clear, adjustable structure behind the pupil that helps focus light onto the retina.

Retina: The inner layer of the eye that contains photoreceptor cells (rods and cones) responsible for detecting light and colour.

Optic nerve: The nerve that carries signals from the retina to the brain.

Vitreous humour: The clear gel-like substance that fills the space between the lens and the retina.

Physiology of the Eye

The cornea and lens help to focus light onto the retina, where photoreceptor cells detect light and send signals to the brain. The iris regulates the amount of light entering the eye by controlling the size of the pupil. The retina contains photoreceptor cells that convert light into electrical signals that

are transmitted to the brain through the optic nerve. The brain then interprets the signals as images. The muscles in the eye control eye movements and adjust the shape of the lens to maintain focus. The tear glands in the eye produce tears to keep the surface of the eye moist and provide protection from foreign objects.

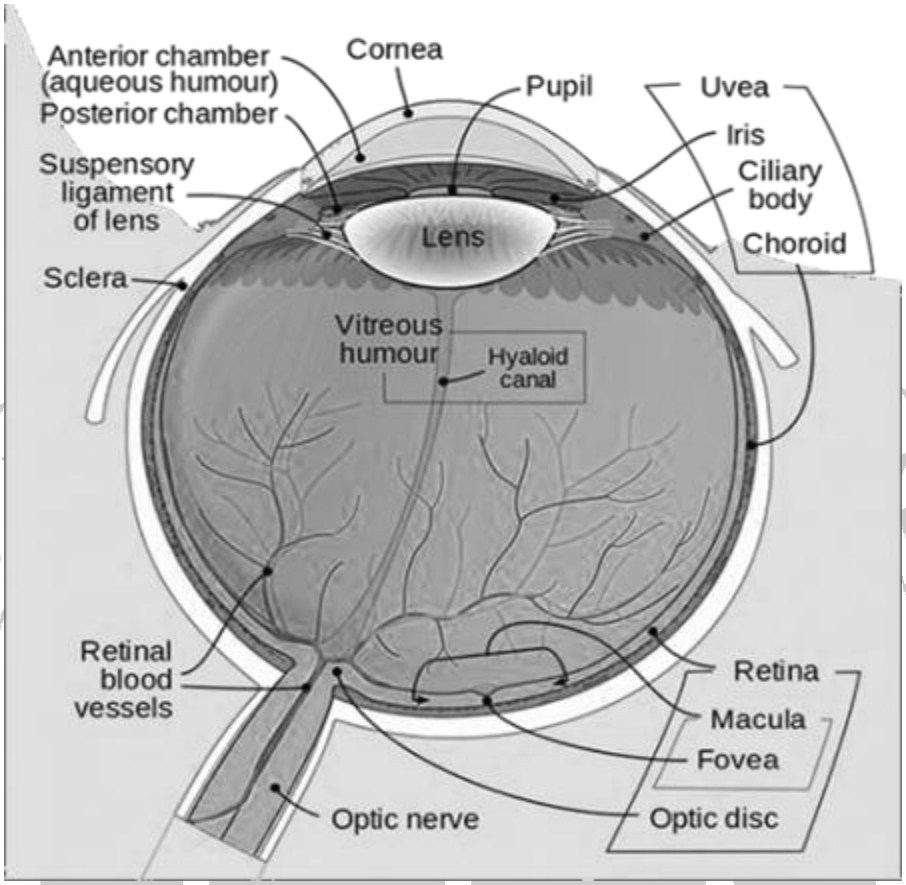

Fig 18.1: Anatomy of Eye

B. Ear

The ear is a complex organ that plays a crucial role in hearing and balance. It consists of several structures that work together to receive, transmit, and interpret sound waves.

Anatomy of the Ear

Outer Ear: The visible part of the ear that includes the pinna and the ear canal.

Pinna: The visible part of the ear that collects and directs sound waves into the ear canal.

Ear canal: The passage that carries sound waves from the pinna to the eardrum.

Middle Ear: The part of the ear that contains the ossicles (the malleus, incus, and stapes) and the Eustachian tube.

Eardrum: The thin membrane that separates the outer and middle ear and vibrates in response to sound waves

Ossicles: The three small bones (malleus, incus, and stapes) in the middle ear that transmit sound waves from the eardrum to the inner ear.

Inner Ear: The part of the ear that contains the cochlea, vestibular system, and auditory nerve.

Cochlea: The spiral-shaped organ that converts sound waves into electrical signals that are sent to the brain.

Vestibular System: The part of the inner ear responsible for detecting changes in head position and movement.

Auditory Nerve: The nerve that carries signals from the inner ear to the brain.

Physiology of the Ear

The outer ear collects and directs sound waves into the ear canal, where they reach the eardrum (Tympanic Membrane) and cause it to vibrate. The ossicles in the middle ear transmit the vibrations from the eardrum to the inner ear. The foot plate of stapes backs & froth into the oval window, setting the fluid wave in perilymph of scala vestibuli. Most of the pressure of this wave is transmitted to cochlear duct. This causes wave in endolymph resulting in stimulation of the auditory receptors in the hair cells in spiral organ in cochlear duct. The nerve impulses generated pass to the brain through the cochlear portion of the eighth cranial nerves i.e., Auditory nerve (Vestibulocochlear nerve).

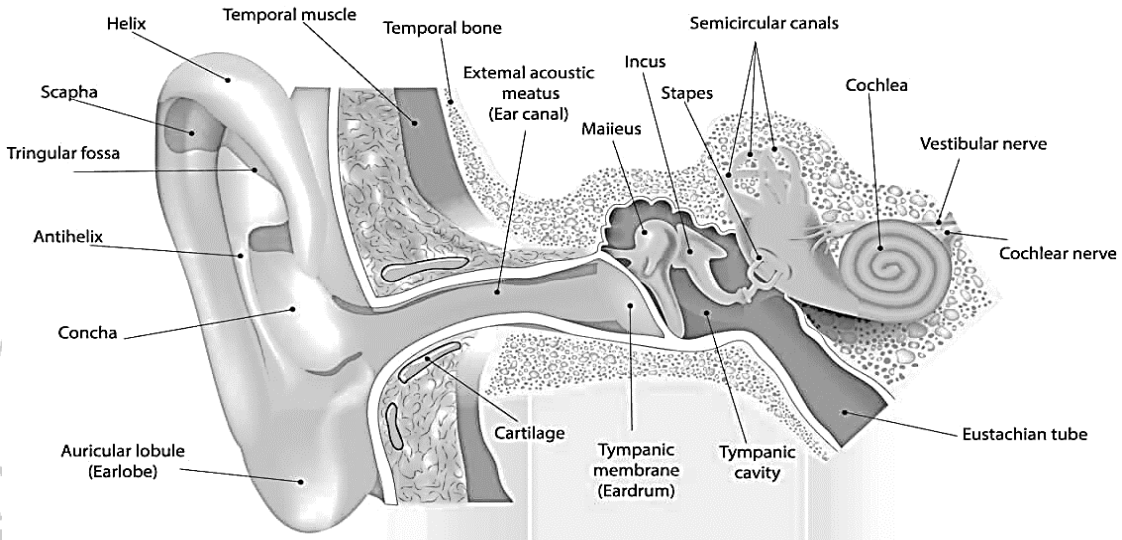

Fig 18.2: Anatomy of Ear

C. Skin

The skin is the largest organ in the human body and plays a vital role in protecting the body from external harm. Its weigh about 15% of the total adult body weight. It also serves as a sensory receptor for touch, pressure, temperature, and pain sensations. The skin is composed of three layers: the epidermis, the dermis, and subcutaneous tissue (hypodermis).

Anatomy of the skin

Epidermis: the outermost layer of the skin that provides a protective barrier. It is the most superficial layer composed of stratified keratinized squamous epithelium, which varies in thickness in different parts of the body. It is thickest on the palms & soles. There are no blood vessels in the epidermis. Layers of epidermis are, Stratum Basale, Stratum spinosum, Stratum Granulosum, Stratum lucidum and Stratum corneum: It forms a protective layer.

Dermis: The underlying layer of the skin. It is tough and elastic. It is made up of connective tissue (the collagen and elastic fibres). Fibroblasts, macrophages, and masts cells are found in dermis. There are blood vessels, lymph vessels, sensory nerve ending, sweat glands, hair, arrector pili muscles & sebaceous glands in the dermis.

Subcutaneous layer (hypodermis): The deepest layer of skin is made of connective tissue and fat. Subcutaneous tissue is well-vascularized. The hypodermis produces fat cells (adipocytes), which store energy.

Functions of skin

a. Protection: It forms the waterproof layer & protects the inner delicate structures. It acts as barrier against the invasion of the microbes, chemicals & dehydration. The melanin pigment protects against the harmful UV rays.
b. Regulation of body temperature.
c. Formation of vitamin D.

d. Sensation: There are different sensations like touch, pain, pressure, etc. are felt due to the presence of sensory receptors in the skin.
e. Absorption: Some drugs & chemicals are absorbed through the skin.
f. Excretion: Skin is a minor excretory organ & excretes NaCl, urea & aromatic substances like garlic and other spices.

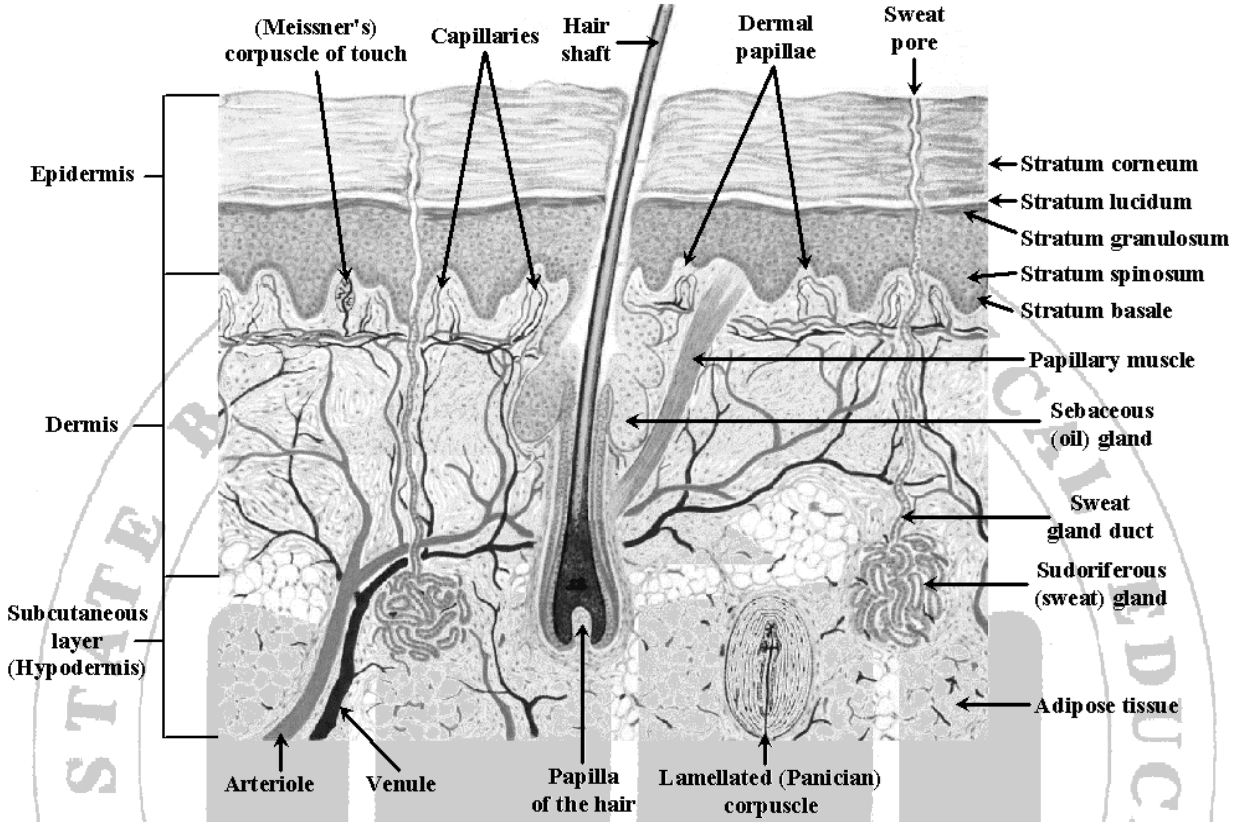

Fig 18.3: Anatomy of Skin

D. Nose

The nose, apart from being a part of the respiratory system, also serves as a crucial sense organ for the detection of smells. It contains specialized olfactory receptors located in the olfactory epithelium at the roof of the nasal cavity. These receptors detect airborne odour molecules and send signals to the olfactory bulb in the brain, which processes the information and allows us to perceive different smells. This olfactory function plays a vital role in taste, detection of hazards (such as smoke or spoiled food), and overall sensory experience.

E. Tongue

The tongue is a vital sense organ responsible for the perception of taste. It is covered with tiny bumps called papillae, which contain taste buds. These taste buds house taste receptor cells that detect five basic tastes: sweet, sour, salty, bitter, and umami (savory). When food or other substances come into contact with these receptors, signals are sent to the brain via the gustatory nerves, allowing us to perceive and distinguish different flavours. The tongue also plays a crucial role in speech, chewing, and swallowing, contributing to our overall sensory experience and oral health.

5. Requirements:

Charts, models, and specimens of human sense organs.

6. Procedure

a. Put on gloves to handle specimens and models to maintain cleanliness and hygiene.
b. Read and review the theoretical aspects of the sense organs before observing the specimens or models.
c. Observe the specimens or models of the organs of sensory system while correlating their positions with their anatomical locations in the human body.

7. Precautions to be taken

a. Do not touch the specimens or models with bare hands. Always wear gloves to prevent contamination and maintain hygiene.
b. Handle models or specimens with care and gentleness to avoid damage or breakage. Use both hands when necessary to support and stabilize items.
c. After completing the experiment or study session, clean the specimens following appropriate protocols and guidelines

8. Result

_____

_____

9. References

a. Waugh, A., Grant, A. (2023). Ross & Wilson Anatomy and Physiology in health and illness (14th ed.).
b. Tortora, G. J., & Derrickson, B. (2014). Principles of Anatomy and Physiology (14th ed.). Hoboken, N.J.: John Wiley.

10. Practical Related Questions

a. Name the different sensory receptor present in the skin.
b. What is meant by "Goose Skin"?
c. Name any two diseases related to skin.
d. State the functions of retina.
e. Give the differences between rod and cone cells.
f. Name the bones present in the middle ear.
g. In which part of ear, the sound waves are amplified?

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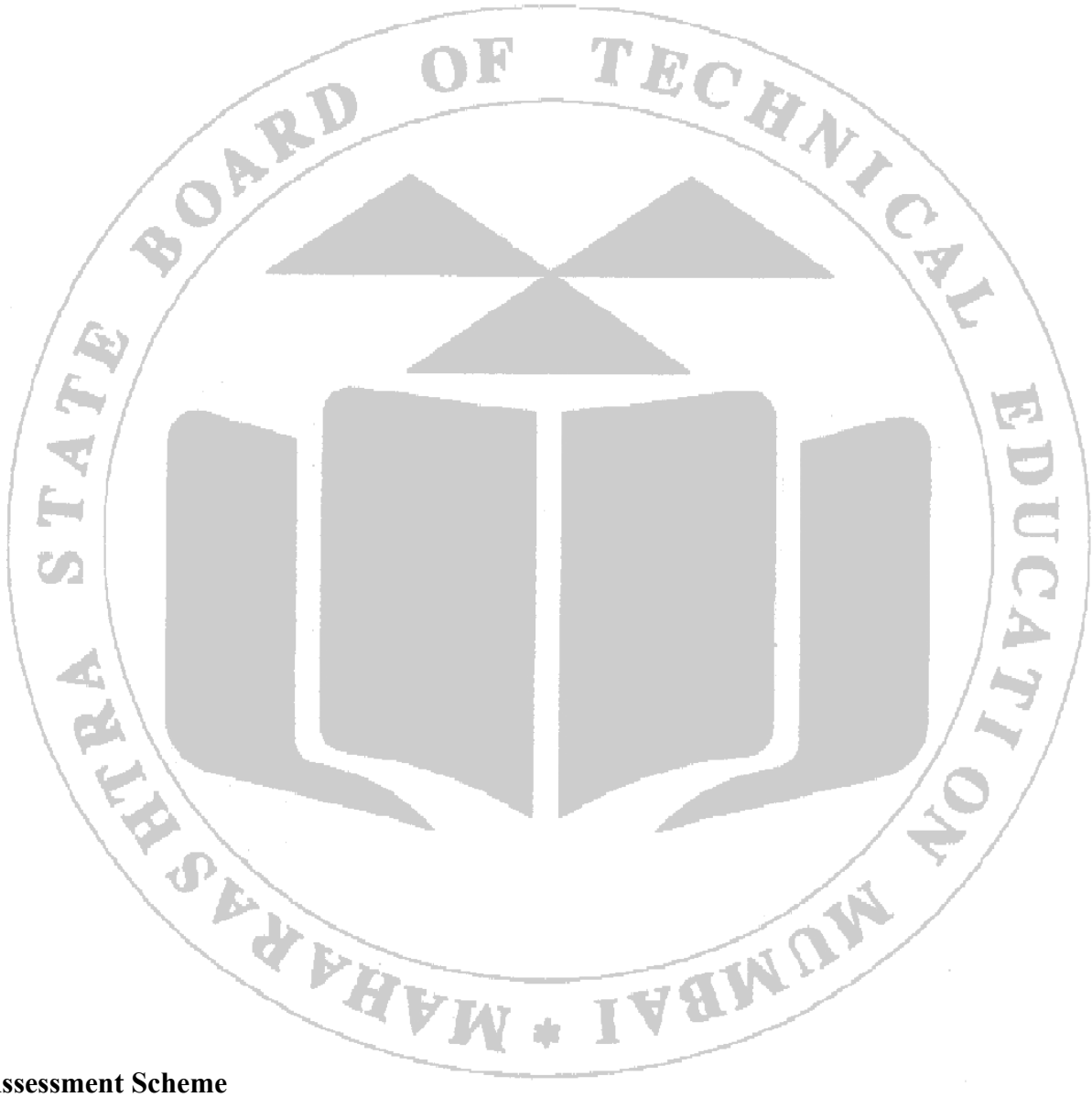


11. Assessment Scheme

Particular	Understanding the basic concept (Intellectual skill)	Activities (Intellectual and motor skills)	Cleanliness & Handling (Affective domain)	Viva-voce / Answers Written	Total	Signature of teacher
Marks Obtained						
Max Marks	**02**	**05**	**01**	**02**	**10**	

Experiment No. 19
Recording of the Body Temperature

1. Aim
To record the body temperature using mercury, digital and IR thermometers at various locations.

2. Practical Significance
A fever is a normal response of the body to illness or infection. It is not an illness itself but rather a symptom of various health conditions. When you have a fever, it indicates that your body is responding to fight off an infection or illness. Measuring body temperature is important because it can help detect illness and monitor the effectiveness of treatment.

3. Practical Outcomes (PrOs)
After completion of this practical, the students will be able to:

PrO	Practical Outcomes	Mapped CO	BTL
1	Identify the temperature variations in different areas of human body part.	CO2	1
2	Handle the mercury, digital, & IR thermometers.	CO2	3
3	Determine the human body temperature.	CO2	3
4	Correlate the body temperature with the illness.	CO2	4
5	Collaborate & communicate with fellow students.	CO2	5

4. Relevant Theoretical Background:-
Terminology

Temperature: Temperature is the measurable extent of hotness or coldness, representing a mathematical representation of heat. Units of temperature include Celsius (˚C), Kelvin (K), and Fahrenheit (˚F).

Core Temperature: Core temperature refers to the internal temperature of the body. It is typically maintained within a relatively constant range (± a few degrees Fahrenheit or Celsius) under normal conditions.

Surface Temperature: Surface temperature refers to the temperature of the skin and underlying tissues.

Fever or Pyrexia: Fever, or pyrexia, is a condition where the body temperature rises above the normal range.

Hyperpyrexia: Hyperpyrexia is an extreme form of fever characterized by a very high body temperature, typically above 106˚F (41.1˚C).

Hypothermia: Hypothermia refers to a condition where the body temperature decreases significantly below the normal range.

Heat is normally lost from the body through conduction, convection, radiation, and evaporation, primarily from the skin, lungs, and excretions. The thalamus plays a crucial role in heat conservation and loss. Shivering and antirise centers in the brain trigger responses such as sweating and vasodilation to increase heat loss. The rise in body temperature (pyrexia and fever) occurs due to a derangement of heat-regulating mechanisms. Toxins, infections, dehydration, tissue destruction, and

other factors can lead to increased metabolism, blood pressure, pulse rate, cardiac output, and respiratory rate, resulting in elevated body temperature.

Normal value of body temperature

The normal value of body temperature is typically considered to be 98.6°F (37°C). However, normal body temperature can vary due to factors such as:

- Age (in children over 6 months, daily temperature can vary by 1 to 2 °C or °F)
- Differences among individuals
- Time of day (often highest in the evening)
- Method of measurement (oral, rectal, forehead, or armpit)

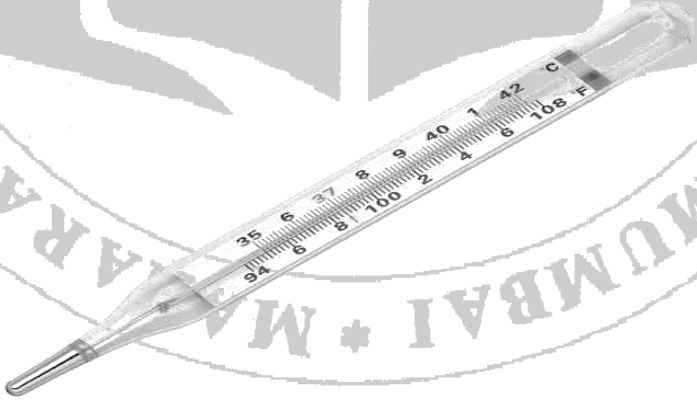
Principle

A clinical thermometer works on the principle that certain substances, like mercury, expand when heated. As the temperature rises, the mercury or alcohol in the thermometer expands, causing it to move upwards and indicate the temperature.

A digital thermometer uses temperature sensors, such as thermistors or semiconductor devices, that change electrical properties (like resistance) with temperature. Electronics convert these changes into a digital signal, processed by a microprocessor to display a numerical temperature reading on a screen. This principle enables accurate and convenient temperature measurement through digital data conversion.

An infrared (IR) thermometer operates based on the absorption of infrared radiation. When infrared radiation falls on the thermopile surface, it is absorbed and converted into heat. This heat generates a voltage output proportional to the incident infrared energy. The detector uses this output to determine the temperature, which is displayed on the screen.

5. Diagram



Clinical Thermometer

IR Thermometer

Digital Thermometer

Fig 19.1: Types of Thermometer

6. Requirements

Clinical, Digital, and IR thermometers.

7. Procedure

A. Clinical Thermometer

a. Clean the thermometer with soap and cold water or use disinfectant wipes before and after use.
b. Hold the thermometer firmly and shake it down with a quick wrist motion to bring the mercury level below 95°F (35°C).
c. Perform each measurement separately:
d. Oral (Sublingual): Place the thermometer under the tongue, close the mouth, and keep the lips sealed around the thermometer.
e. Axillary (Armpit): Place the thermometer in the deepest part of the armpit, holding the arm close to the body.
f. Hold the thermometer in place for the recommended time: Oral: 3-4 minutes and axillary: 5-7 minutes, or until the mercury level stabilizes and does not increase further.
g. After the specified time, carefully remove the thermometer and observe the mercury level.
h. Read the temperature value at eye level while holding the thermometer steady. Note the temperature reading.
i. Repeat steps 2 to 6 two more times with one-minute interval between measurements.
j. Take the average of the three temperature readings obtained.
k. Clean the thermometer with soap and cold water or use disinfectant wipes.

B. Digital Thermometer

a. Wipe the thermometer with an antiseptic wipe or lukewarm water and dry it before use.
b. Press the reset button on the thermometer to prepare for a new measurement.

c. Perform step number 3 as with the clinical thermometer above.
d. Keep the thermometer in place until you hear a beep indicating the measurement is complete (usually within one minute).
e. Check the temperature displayed on the digital thermometer and note the reading.
f. Repeat the procedure two more times with one-minute interval between measurements.
g. Take the average of the three temperature readings obtained.

C. IR thermometer

a. Turn on the thermometer.
b. Hold the thermometer 1-2 inches (2.5-5 cm) away from the forehead or wrist.
c. Aim the thermometer at the center of the forehead or wrist, perpendicular to the skin.
d. Press the button to activate the thermometer. Hold it steady while aiming.
e. Wait a few seconds for the temperature reading to display.
f. Note the temperature displayed on the thermometer.
g. Repeat the measurement two more times with one-minute intervals.
h. Take the average of the three temperature readings obtained.

8. Precautions to be taken

a. Ensure that the thermometer is clean and sanitized before and after each use to prevent contamination.
b. Rest for a few minutes before taking temperature measurements to avoid artificially elevated readings.
c. When measuring temperature in the mouth, ensure the person has not consumed hot or cold
d. drinks immediately prior to the recording.
e. When using the armpit method and IR thermometer, ensure the area is dry, clean, and not covered by clothing.

9. Observations

S.N.	Mercury reading (^{O}F)		Digital reading (^{O}F)		IR reading (^{O}F)	
	Oral	Armpit	Oral	Armpit	Forehead	Wrist
1						
2						
3						
Average						

10. Result

The body temperature at different locations was found to be…

Mercury reading (^{O}F)		Digital reading (^{O}F)		IR reading (^{O}F)	
Oral	Armpit	Oral	Armpit	Forehead	Wrist

11. Conclusion

Body temperature was _____ (normal/abnormal). If abnormal, it was _____ (increased/decreased), indicating _____ (hyperpyrexia/hypopyrexia).

12. References

a. Goyal, R. K., Patel, N. M., (2010). Practical Anatomy and Physiology. B. S. Shah Prakashan, 14th edition.
b. Reddy, L. P., (2009). Practical Physiology, Paras Publishing, 2nd Edition.
c. Pal, G. K., Pal, P., (2001). Textbook of Practical Physiology, Orient Longman Ltd.
d. https://byjus.com/question-answer/how-is-the-general-variation-of-the-core-body-temperature-in-humans/

13. Practical Related Questions

a. Enlist the causes for elevation in body temperature.
b. State the principle of IR thermometer.
c. Which precautions should be taken while measuring body temperature?
d. Define core temperature.
e. State the normal value of body temperature.

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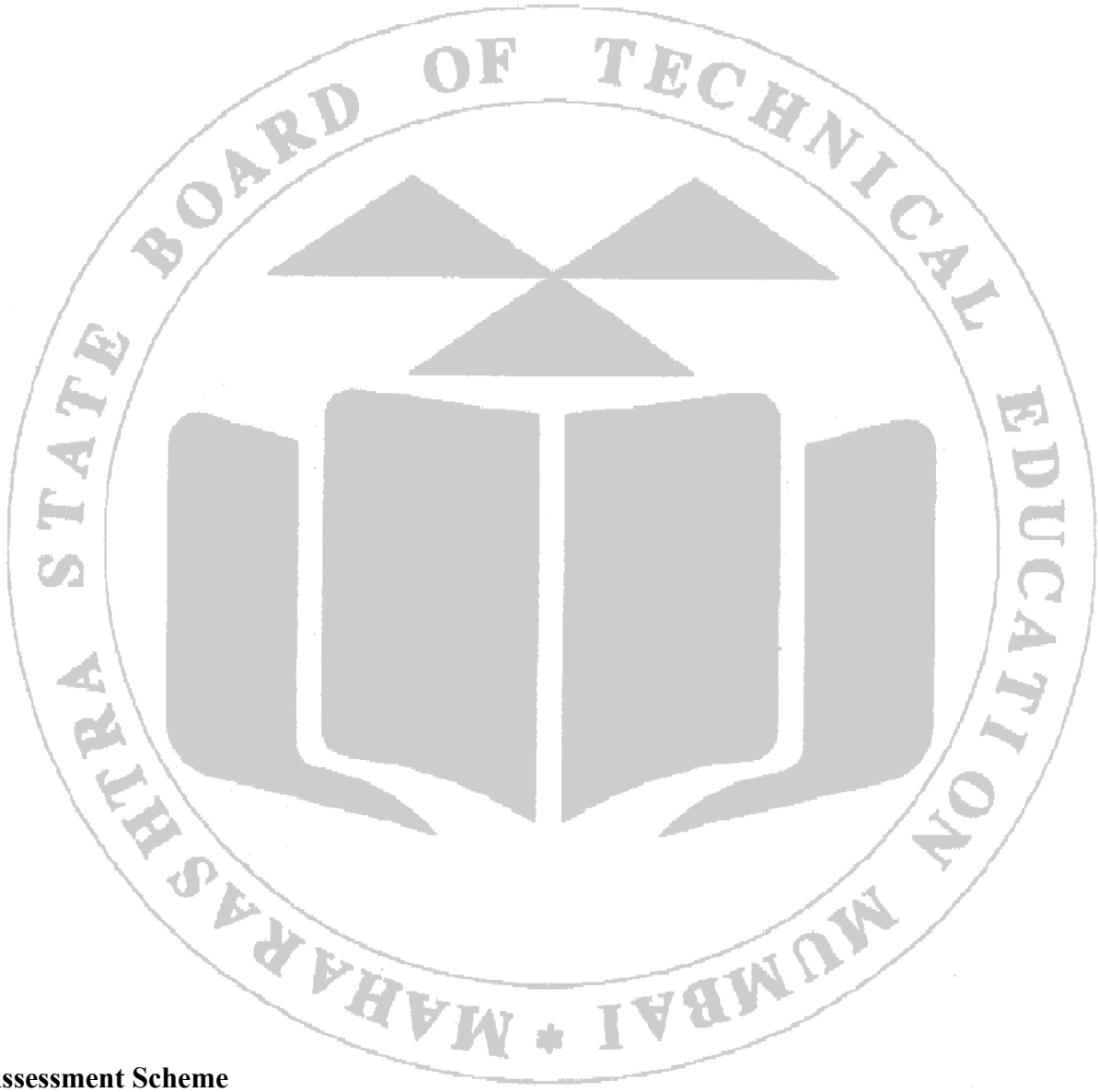


14. Assessment Scheme

Particular	Understanding the basic concept (Intellectual skill)	Activities (Intellectual and motor skills)	Cleanliness & Handling (Affective domain)	Viva-voce / Answers Written	Total	Signature of teacher
Marks Obtained						
Max Marks	**02**	**05**	**01**	**02**	**10**	

Experiment No. 20
Measurement of Height, Weight, and BMI

1. Aim

To measure the height weight and body mass index.

2. Practical Significance

Body mass index (BMI) is a medical screening tool that measures the ratio of your height to your weight to estimate the amount of body fat. In this practical, students will corelate BMI with probable severity of future diseased conditions like diabetes, hypertension, obesity etc.

3. Practical Outcomes (PrOs)

After completion of this practical, the students will be able to:

PrO	Practical Outcomes	Mapped CO	BTL
1	Measure the height and weight.	CO 2	3
2	Calculate the BMI.	CO 2	4
3	Correlate BMI with health status.	CO 2	4

4. Relevant Theoretical Background

Terminology

BMI: It is the ratio of weight in kg to the height in meter square, expressed as kg/m^2. BMI is a tool to estimate the amount of fat in body. It provides an indication of whether a person's weight falls within a healthy range or if it may lead to health problems. However, it does not directly diagnose body fatness or overall health.

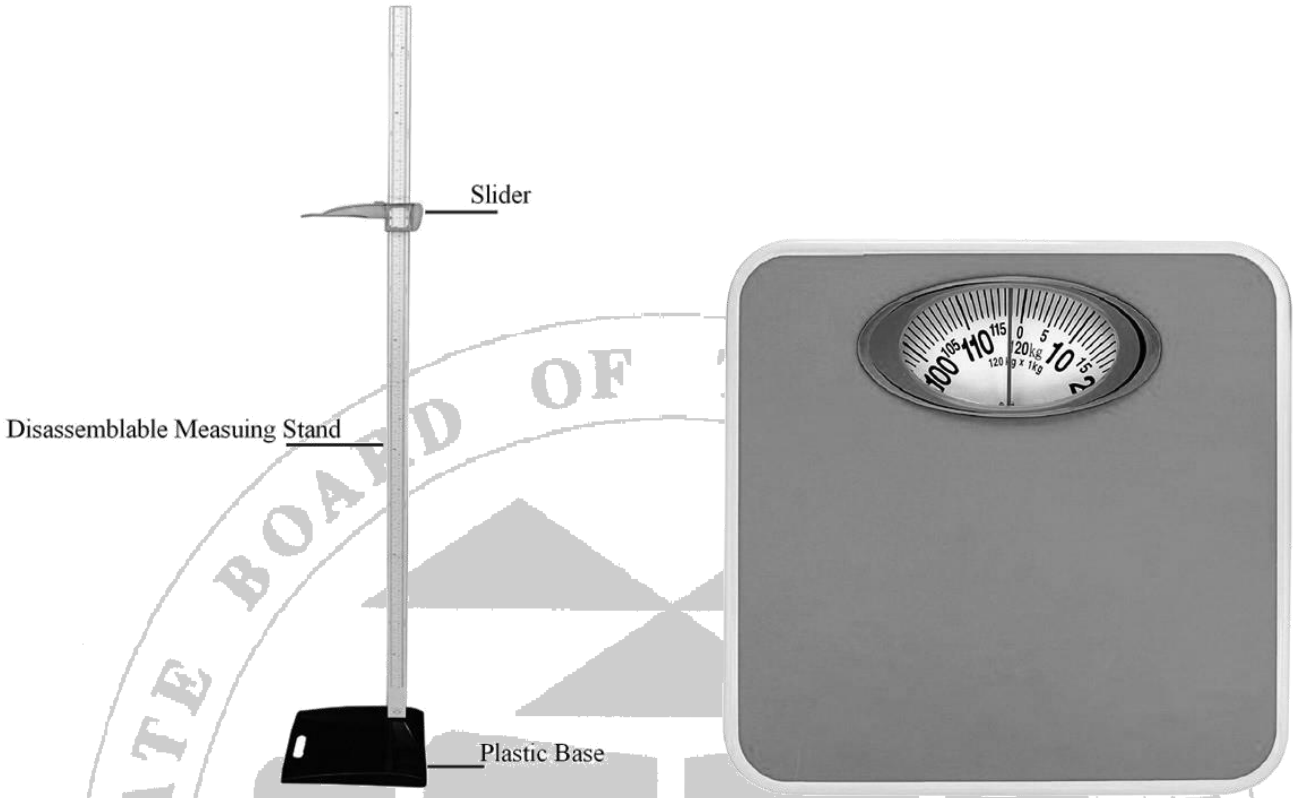
Formula for calculating BMI

$$\textbf{BMI} = \frac{\text{Weight (kg)}}{\text{Height } (m^2)}$$

Normal values

S. N.	BMI	Weight Status
1	Below 18.5	Underweight
2	18.5-24.9	Healthy Weight
3	25.0-29.9	Overweight
4	30.0 and above	Obesity

5. Diagram



Stadiometer **Weighing machine**

Fig 20.1: Instruments for BMI

6. Requirements

Stadiometer or length measurement tape, weighing scale, and standard scale for BMI.

7. Procedure

a. Remove all heavy wearable before weighing.
b. Measure and record the weight in kg.
c. Measure and record the height in meter.
d. Calculate the BMI using formula.

8. Observation

Weight = _____ kg

Height = _____ m = _____ m^2

9. Calculation

$$\textbf{BMI} = \frac{\text{Weight (kg)}}{\text{Height } (m^2)} = \_\_\_\_\_ \text{ Kg/m}^2$$

10. Result

_____

_____

11. Conclusion

The BMI was found to be _____ (Normal/below/above normal), hence the subject is _____ (healthy/underweight/overweight/obese).

12. References

a. https://www.cdc.gov/healthyweight/assessing/bmi/index.html.

13. Practical Related Questions

a. Define Body mass index.
b. Is BMI interpreted the same way for children and teenagers as it is for adults?
c. What is clinical significance of BMI?
d. What will be BMI of a male whose weight is 80 kg and height is 170 cm?

(Space for writing answers)

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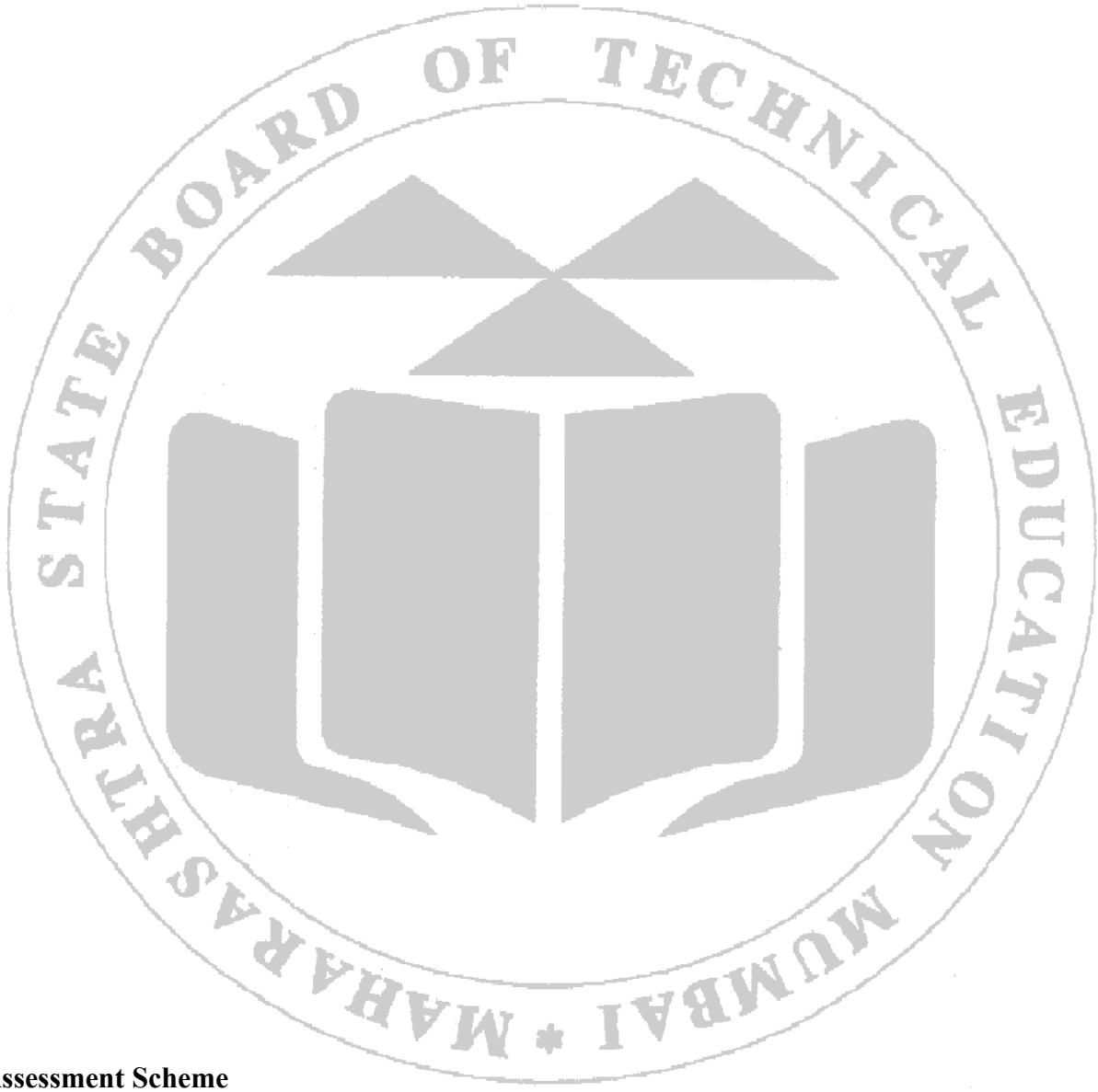


14. Assessment Scheme

Particular	Understanding the basic concept (Intellectual skill)	Activities (Intellectual and motor skills)	Cleanliness & Handling (Affective domain)	Viva-voce / Answers Written	Total	Signature of teacher
Marks Obtained						
Max Marks	**02**	**05**	**01**	**02**	**10**	

Experiment No. 21
Study of Nervous System

1. Aim
To study human nervous system using charts, models, and specimens.

2. Practical Significance
The nervous system is composed of the brain, spinal cord, and nerves. It controls many aspects of our thoughts, emotions, and bodily functions. It allows us to perform both voluntary and involuntary actions. It also regulates the body's response to stressful situations. The nervous system interprets and responds to sensory information. In this experiment, students will gain a visual understanding of the anatomy and physiology of the nervous system.

3. Practical Outcomes (PrOs)
After completion of this practical, the students will be able to:

PrO	Practical Outcomes	Mapped CO	BTL
1	Classify nervous system**.**	CO4	1
2	Differentiate central nervous system and peripheral nervous system.	CO4	2
3	Locate different parts of nervous system on the specimens.	CO4	1
4	Collaborate and communicate with fellow students.	CO4	5

4. Relevant Theoretical Background
The nervous system connects and coordinates various body systems, ensuring they function properly despite changes in the environment. Along with the endocrine system, it regulates vital body functions and maintains homeostasis. Comprising a complex network of neurons, the nervous system transmits signals throughout the body. It is divided into:

a. Central Nervous System (CNS): Includes the brain and spinal cord.

b. Peripheral Nervous System (PNS): Comprises nerves connecting the CNS to the rest of the body.

Neurons

Neurons are the structural and functional units of the nervous system. The nervous system is made up of billions of neurons. A neuron, also called a nerve cell, is a cell within the body that receives, processes, and transmits information through electrical and chemical signals.

Parts of a neuron

Cell body: The cell body, also known as the soma, contains genetic information, maintains the neuron's structure, and provides energy to drive its activities.

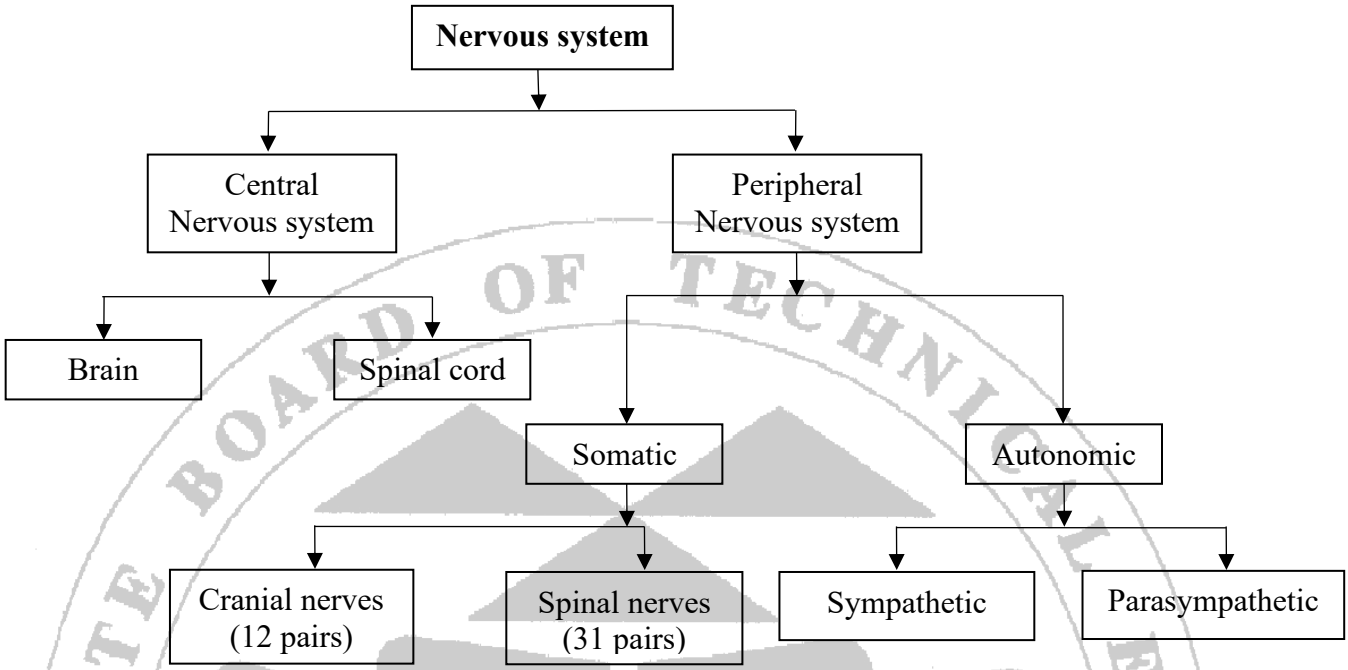
Dendrites: Dendrites are the receiving or input portions of a neuron. They are usually short, tapering, and highly branched, receiving and carrying incoming impulses toward the cell body.

Axon: An axon is a thin fiber that connects neurons so that they can communicate. Each nerve cell has only one axon, which begins at a tapered area of the cell body and is usually longer than the dendrites, sometimes extending as long as 100 cm.

Central Nervous System

The parts of the central nervous system (CNS) are protected by the skull and the spinal canal formed in the vertebral column. Additionally, the CNS is protected by membranes called meninges, which consist of three layers of tissue, dura mater (outermost layer), arachnoid mater (middle layer), and pia mater (innermost layer). The dura mater and the arachnoid mater are separated by the subdural

space. The arachnoid mater and the pia mater are separated by the subarachnoid space, which contains cerebrospinal fluid (CSF). The CSF is formed by ependymal cells in structures known as the choroid plexuses, which are located within the brain's ventricles.



Ventricles

The brain contains four irregularly shaped cavities, or ventricles, that contain CSF. These ventricles are:

a. Right and Left Lateral Ventricles: Located in each hemisphere of the brain.
b. Third Ventricle: Located in the midline of the brain, beneath the lateral ventricles.
c. Fourth Ventricle: Located between the brainstem and the cerebellum.

Cerebrospinal fluid

Cerebrospinal fluid (CSF) is secreted at about 0.5 ml per minute, totaling 720 ml per day, but its volume remains constant at around 150 ml due to balanced absorption. CSF flows from the fourth ventricle into the subarachnoid space, surrounding the brain and spinal cord. It cushions and protects these structures, keeps them moist, and facilitates the exchange of nutrients and waste products.

The brain

The brain is the largest and most important organ of the human nervous system, acting as the control unit. It enables us to learn, remember, understand, and make decisions. Enclosed within the skull for protection, the brain weighs about 1.4 kg and is divided into following major parts.

a) Cerebrum b) Thalamus c) Hypothalamus
d) Midbrain e) Pons varolii f) Medulla oblongata
g) Cerebellum

Cerebrum: The cerebrum, the brain's largest part, comprises the cerebral cortex and subcortical structures. It is divided into right and left hemispheres by the longitudinal cerebral fissure, connected by the corpus callosum. Each hemisphere contains lobes named after cranial bones:

a. Frontal Lobe: Speech, planning, reasoning, problem-solving, and movements.
b. Parietal Lobe: Movements, perception of stimuli, and orientation.
c. Occipital Lobe: Visual processing.
d. Temporal Lobe: Memory, auditory stimuli, and speech recognition.

Functional areas include:

a. Motor: Directs voluntary muscle movements.

b. Sensory: Receives and decodes sensory impulses.

c. Association: Integrates complex mental functions like intelligence, memory, reasoning, judgment, and emotions.

Thalamus: The thalamus, situated within the cerebral hemispheres just below the corpus callosum, is a small structure responsible for relaying sensory information from the sense organs and transmitting motor information for movement and coordination. It is also a part of the limbic system within the cerebrum, which is mainly responsible for the formation of new memories and storing past experiences. The thalamus plays a crucial role in recognizing sensory impulses from the skin and viscera.

Hypothalamus: The hypothalamus, a small yet integral brain structure weighing approximately 7 grams, comprises numerous nuclei. Situated inferiorly and anteriorly to the thalamus, and directly superior to the pituitary gland, it assumes a pivotal role in diverse physiological functions. These encompass the regulation of the autonomic nervous system, cardiovascular dynamics, thermoregulation, osmoregulation, appetite modulation, lactation, uterine contractility, emotional and behavioral modulation, as well as the synchronization of circadian rhythms and alterations in states of consciousness.

Midbrain: The midbrain, or mesencephalon, is a part of the brainstem located between the forebrain and the hindbrain, specifically between the cerebrum and above the pons. It consists of nuclei and nerve fibers (tracts) that connect the cerebrum with the lower parts of the brain and with the spinal cord. The midbrain plays a crucial role in motor movement, particularly movements of the eye, and in auditory and visual processing. It is involved in functions such as regulating movement, producing dopamine, and processing sensory information.

Pons Varolii: The pons, located in the brainstem between the midbrain and medulla oblongata, serves as a relay between the cerebellum, spinal cord, midbrain, and cerebrum. It controls sleep cycles, regulates respiration, and transfers information between the cerebellum and motor cortex. The pons also contains nuclei associated with cranial nerves and respiratory control centers.

Medulla Oblongata: The medulla oblongata, about 2.5 cm long, is the lowest part of the brainstem, located between the pons and the spinal cord. It controls autonomic functions like heartbeat, breathing, and digestion. It contains vital centers for cardiovascular and respiratory regulation and reflex centers for vomiting, coughing, sneezing, and swallowing. It also connects the spinal cord, pons, and cerebral cortex, aiding in posture and reflex control.

Cerebellum: The cerebellum, the second largest part of the brain, is ovoid in shape and located behind the pons and below the cerebrum, in the posterior cranial fossa. The main functions of the cerebellum are sensing equilibrium, coordinating eye movement, controlling voluntary movements, predicting body position, managing skeletal movements, fine-tuning motor actions, and maintaining balance and posture.

Spinal cord: The spinal cord is an elongated, cylindrical bundle of nerve fibers and associated tissues, suspended in the vertebral canal and surrounded by meninges and cerebrospinal fluid. It is continuous with the medulla oblongata above, extending from the upper border of the atlas (first cervical vertebra) to the lower border of the first lumbar vertebra, measuring approximately 45 cm long in adult males and about the thickness of a little finger. Enclosed in the vertebral column and

surrounded by dura, pia, and arachnoid mater, the spinal cord connects all parts of the body to the brain. It is responsible for conducting nerve impulses to and from the brain and controlling certain activities independently through spinal reflexes.

Peripheral nervous system

The Peripheral Nervous System (PNS) is the lateral part of the nervous system that connects different parts of the body to the Central Nervous System (CNS), facilitating both voluntary and involuntary actions through peripheral nerves. The PNS consists of 31 pairs of spinal nerves, 12 pairs of cranial nerves, somatic and autonomic nervous system.

Spinal nerves: Spinal nerves exit the vertebral canal through the intervertebral foramina created by adjacent vertebrae. They are categorized based on their location in the vertebral column: 8 cervical, 12 thoracic, 5 lumbar, 5 sacral, and 1 coccygeal. These nerves transmit sensory and motor impulses between the higher centers and the peripheral regions they serve.

Cranial nerves. There are 12 pairs of cranial nerves, so named because they pass through various foramina in the bones of the cranium. Some of these nerves are sensory, some are motor, and some are mixed.

Sensory	Motor	Mixed
I. Olfactory II. Optic VIII. Vestibulocochlear	III. Oculomotor IV. Trochlear VI. Abducens XI. Accessory XII. Hypoglossal	V. Trigeminal VII. Facial IX. Glossopharyngeal X. Vagus

Somatic nervous system: This system controls the voluntary actions in the body by transmitting impulses from CNS to skeletal muscle cells. It consists of the somatic nerves.

Autonomic nervous system (ANS): The autonomic nervous system regulates involuntary functions like digestion, respiration, and salivation. It transmits impulses from the CNS to smooth muscles and involuntary organs, such as the heart, bladder, and pupils. It is divided into Sympathetic and Parasympathetic nervous system.

Sympathetic nervous system

The sympathetic nervous system (SNS) is a division of the autonomic nervous system responsible for the body's rapid involuntary response to stressful or emergency situations. It activates the 'fight or flight' response, which includes increasing heart rate and blood pressure, dilating pupils to enhance vision, redirecting blood flow to skeletal muscles, relaxing airways to improve breathing, and inhibiting digestion and other non-essential functions. The SNS uses neurotransmitters like norepinephrine and epinephrine to transmit signals, preparing the body to either face or escape from threats.

Parasympathetic nervous system

The parasympathetic nervous system (PNS) is a division of the autonomic nervous system responsible for conserving energy and promoting 'rest and digest' activities. It helps maintain homeostasis by slowing the heart rate, constricting pupils, stimulating digestion, and promoting the functions of the digestive and urinary systems. The PNS uses the neurotransmitter acetylcholine to transmit signals, encouraging relaxation and recovery after stress or exertion.

5. Diagram

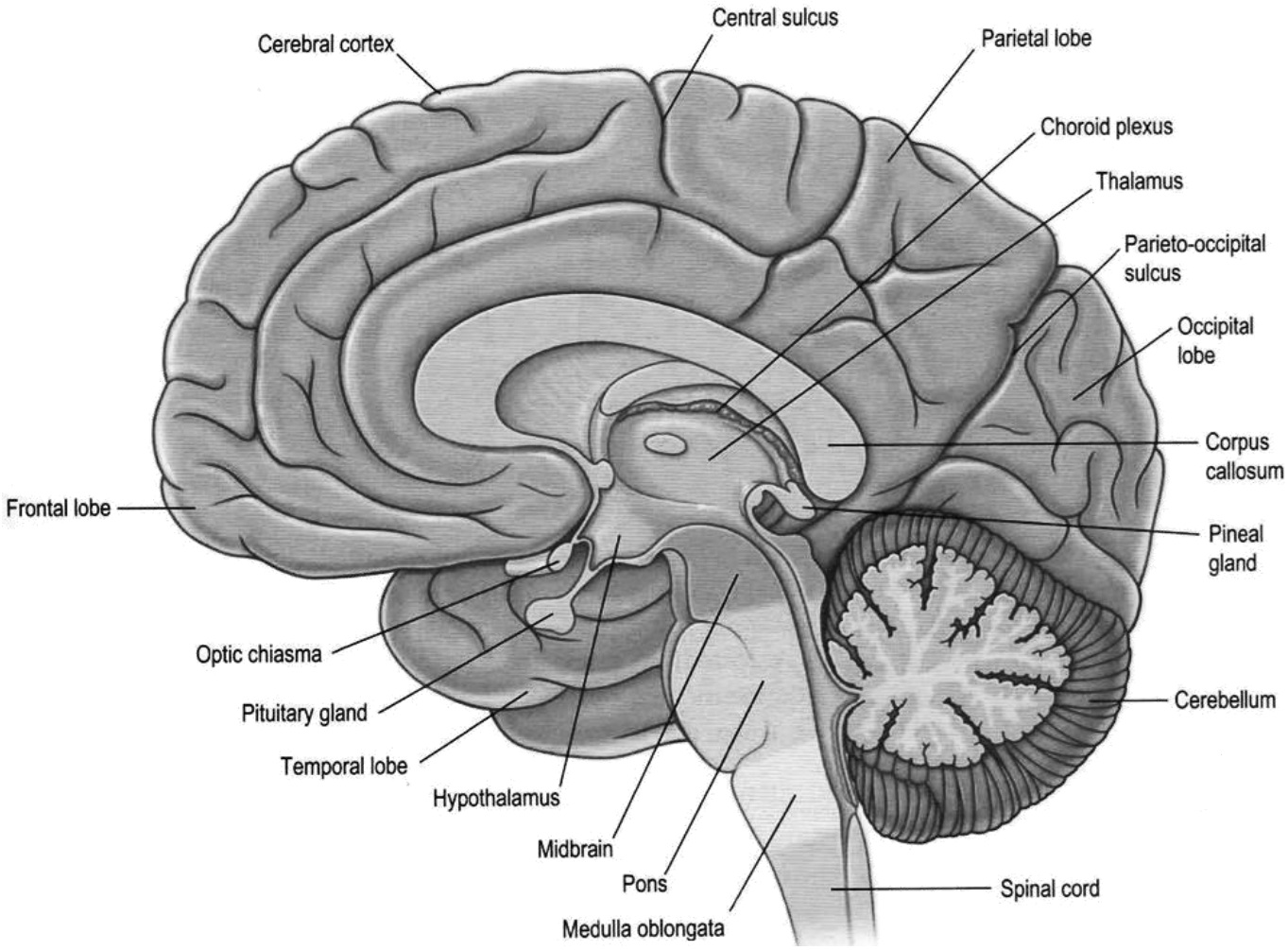


Fig 21.1: Structure of human brain

6. Requirements

Charts, models, and specimens of human nervous system.

7. Procedure

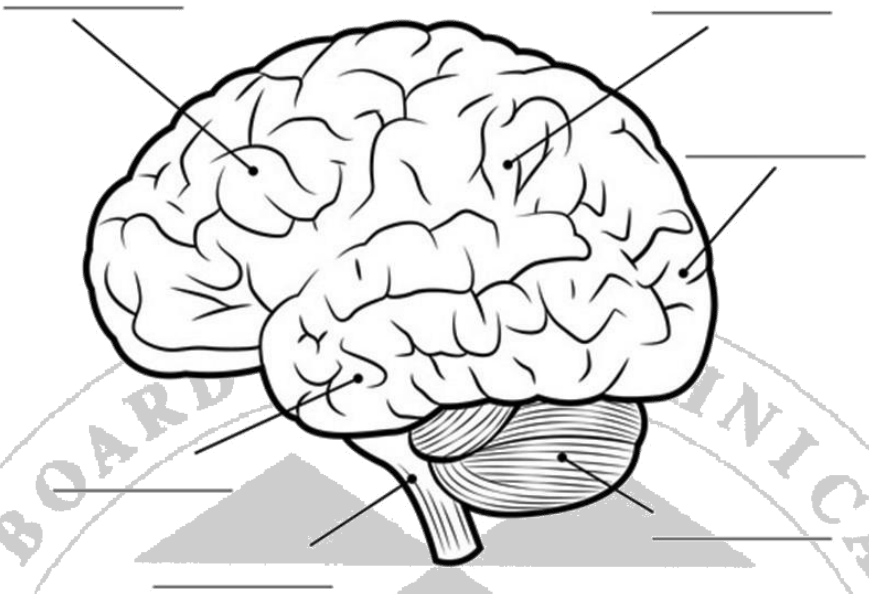
a. Put on gloves to handle specimens and models to maintain cleanliness and hygiene.
b. Read and review the theoretical aspects of the nervous systems before observing the specimens or models.
c. Observe the specimens or models of the organs of nervous system while correlating their positions with their anatomical locations in the human body.

8. Precautions to be taken

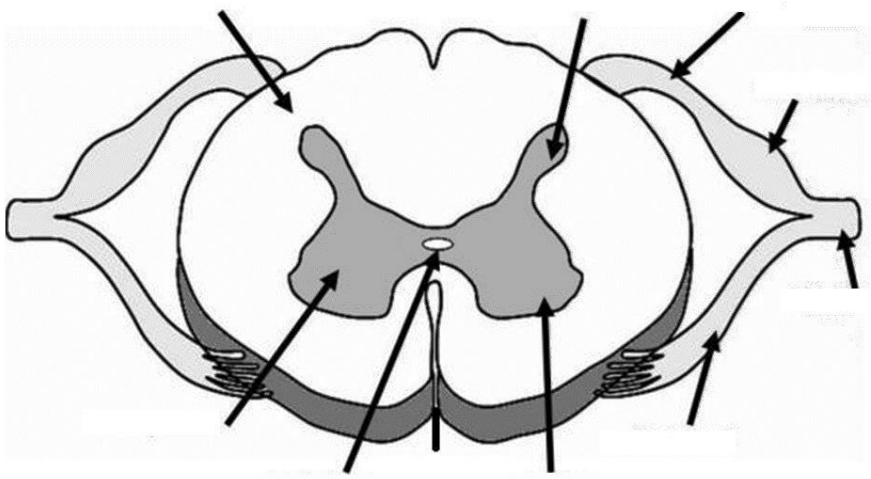
a. Do not touch the specimens or models with bare hands. Always wear gloves to prevent contamination and maintain hygiene.
b. Handle models or specimens with care and gentleness to avoid damage or breakage. Use both hands when necessary to support and stabilize items.
c. After completing the experiment or study session, clean the specimens following appropriate protocols and guidelines.

9. Observations

A. Observe the parts of human brain from the chart/model and label the following Fig.



B. Label different areas shown with the arrows.



C. Draw a well labelled structure of Neuron.

10. Result

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11. References

a. Waugh, A., Grant, A. (2023). Ross & Wilson Anatomy and Physiology in health and illness (14th ed.).
b. Tortora, G. J., & Derrickson, B. (2014). Principles of Anatomy and Physiology (14th ed.). Hoboken, N.J.: John Wiley.

12. Practical Related Questions

a. State the functions of sensory and motor neurons.
b. What is CSF? Give its functions.
c. State the functions of medulla oblongata.
d. Name the lobes of cerebrum.
e. Enlist spinal and cranial nerves.

(Space for writing answers)

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13. Assessment Scheme

Particular	Understanding the basic concept (Intellectual skill)	Activities (Intellectual and motor skills)	Cleanliness & Handling (Affective domain)	Viva-voce / Answers Written	Total	Signature of teacher
Marks Obtained						
Max Marks	**02**	**05**	**01**	**02**	**10**	

Experiment No. 22
Study of Digestive System

1. Aim
To study the human digestive system.

2. Practical Significance
Digestive system performs the function of digestion means breaking down the food into nutrients, which further digested by body for energy, cellular growth, and development. In this practical, students will learn the theoretical aspects Practical Related to anatomy and physiology of digestive system.

3. Practical Outcomes (PrOs)
After completion of this practical, the students will be able to:

PrO	Practical Outcomes	Mapped CO	BTL
1	Identify the different parts of digestive system.	CO4	1
2	Locate the different parts of digestive system.	CO4	1
3	Draw the structure of digestive system.	CO4	2

4. Relevant Theoretical Background
Terminology
Digestion: It is the mechanical and chemical process in which breakdown of large insoluble food molecules into small water-soluble food molecules so that they can be absorbed into the blood plasma.

Mastication: It means chewing in which food is crushed and mixed with saliva to form a bolus for swallowing.

Absorption: It is the process by which nutrients pass through the lining of the alimentary canal into the bloodstream.

Defecation: It is the final step in which the undigested material is voluntarily removed from the body as faeces.

Parts of digestive system
Alimentary canal: Mouth, pharynx, oesophagus, stomach, small intestine (duodenum, jejunum, and ileum), large intestine (Ascending colon, transverse colon, descending colon and sigmoid colon), rectum, and anus.

Accessory organs: Teeth (Incisors, canine, premolar, and molar), tongue, salivary gland, liver, gall bladder, and pancreas.

Overview on digestive system
Digestion includes six basic processes: ingestion, secretion, mixing and propulsion, mechanical and chemical digestion, absorption, and defecation. Mechanical digestion consists of mastication and movement of the food materials in gastrointestinal tract that aid in chemical digestion. Chemical digestion is a series of hydrolysis reactions that break down large molecules of carbohydrates, proteins, and lipids in the food into smaller molecules that are usable by body cells. Absorption involves the uptake of water, minerals, and vitamins.

Mouth: The mouth is formed by the cheeks, hard and soft palates, lips, and tongue. The vestibule is the space bounded externally by the cheeks and lips and internally by the teeth and gums. The tongue

forms the floor of the mouth and is composed of skeletal muscle covered with mucous membrane. It helps in the movements of food and swallowing during mastication. The upper surface of the tongue is covered with papillae that contain taste buds, allowing it to sense taste.
There are three pairs of salivary glands - parotid, submandibular, and sublingual glands. Saliva moistens and lubricates the food and begins the chemical digestion of carbohydrates. The teeth project into the mouth from the upper and lower jaws and are adapted for mechanical digestion, such as cutting, tearing, and grinding food.

Pharynx: Pharynx (throat) is a funnel shaped tube extending from the internal nares to the posterior parts of oesophagus and anterior of larynx. Also, a common part of respiratory as well as digestive System.
Functions: Passageway for the air and food, taste sensation, warming and humidifying, and hearing.

Epiglottis: It is a flap-like structure at the back of the throat that closes the trachea preventing food from entering in it.

Oesophagus: Food pipe about 25 cm long tube extending from pharynx to stomach. The oesophagus joins the stomach at the gastro-oesophageal junction.

Function: A wave of peristalsis is stimulated when the bolus is present in the pharynx thus, food is propelled to the stomach via oesophagus.

Stomach: The stomach is a hollow, muscular, J-shaped bag-like structure located between the oesophagus and the small intestine. Food enters the stomach through a muscular valve called the lower oesophageal sphincter. The second phase of digestion takes place in the stomach. The main parts of the stomach are the fundus, body, and pylorus.

Function: Receives food material and acts as reservoir for food. It provides highly acidic environment due to gastric acid production (By Gastric Parietal Cells) and secretion, which is able to breakdown large molecules into smaller molecules.

Small intestine: Small intestine is a portion between the stomach and the large intestine. In adult it measures about 7 meter in length (22 feet) and 2-3 cm in diameter. It is a long, highly convoluted tubes in the digestive system that absorbs about 90% of the nutrients from the ingested food. It is the main site of absorption. The presence of villi and microvilli increase the surface area available for nutrients absorption.
Structurally the small intestine can be divided into 3 parts as follows:

- **Duodenum**: It is a hollow jointed C shaped tube about 25–38 centimetres (10–15 inches) long connecting the stomach to the middle part of the small intestine.
- **Jejunum**: The jejunum is the middle portion of the small intestine, connecting the first portion of the small intestine (duodenum) with the last section (ileum).
- **Ileum**: The ileum is the final and longest segment of the small intestine, connecting to the caecum (the first part of the large intestine). It is primarily responsible for the absorption of vitamin B_{12}.

Function: The ileum provides a site for the absorption of nutrients following the chemical digestion of carbohydrates, proteins, and fats. It secretes hormones such as cholecystokinin and secretin.
Large intestine: Large intestine forms the last part of alimentary canal. Its extents from caecum to the anus including the ascending colon, transverse colon, descending colon, sigmoid colon and the

rectum. It is about 1.5 meter (5 feet) in length and 6-7 cm in diameter. The main function is the absorption of water and electrolytes from digestive residues.

Rectum: It acts to store the faeces temporarily.

Anus: It is the external opening of rectum. It surrounded by sphincter muscles, which control its opening and closing.

Function: It forms the site for absorption of water, glucose, and salt. Its walls form the site for excretion of excess amount of calcium, iron, and drugs of heavy metals.

Teeth: Food is taken in the mouth and chewed with the help of teeth to convert it in smaller particle. The process is known as mastication.
Teeth can functionally divide in following two parts.

a. Deciduous (Temporary) teeth (baby or milk teeth 20 in no.)
b. Permanent teeth (adult teeth 32 in no.)

Types and function of teeth

a) Incisors: These teeth aid in biting off large pieces of food.
b) Canines: These conical shaped teeth to grasp and tearing of food.
c) Premolars: These teeth help in grinding the food, they are absent in the children (after 9 year of age).
d) Molars: These are the largest teeth and are present at the back of the mouth.

Tongue: It is a muscular organ situated on the floor of the mouth that helps in chewing and swallowing food (deglutition). A taste bud is a saclike, oval-shaped structure about 50 micrometres in size.

Salivary glands: Saliva is the mixed glandular secretion that constantly bathes the teeth and the oral mucosa, playing a vital role in oral health. The daily secretion is approximately 1.2-1.5 litres. Salivary glands are present in the form of three large multicellular pairs: the parotid glands, submandibular glands, and sublingual glands

Functions: Saliva provides a cleaning effect by washing away food debris, makes swallowing food easier, has an antibacterial effect by fighting off bacteria entering the mouth, and acts as a pH buffer that prevents dental caries and promotes the remineralization of teeth.

Pancreas: The pancreas is an organ and gland that produces and releases substances in the body. It is an elongated digestive gland, approximately 6-10 inches long and weighing around 65 grams. Located behind the stomach in the upper left abdomen and close to the duodenum, it is the largest gland of the digestive system. The pancreas is a mixed gland that produces both endocrine hormones (such as insulin and glucagon) and exocrine secretion (pancreatic juice containing digestive enzymes).

Liver: Liver is the largest gland of the human body. It forms the second largest organ which performs many essential biological functions such as secretion of bile, glycogenic function, formation of urea, metabolism of fat, formation of RBCs in foetal life, destruction of RBCs forming bile pigments and iron, formation of plasma protein, formation of heparin, storage of iron and vitamin B_{12}, maintenance of body temperature, and inactivation of toxic substances.
Gall bladder: Gall bladder is a pear-shaped, muscular sac like structure is nearly 8 cm in length and 4 cm in width. Its function to store and concentrate bile which is produce by the liver and helps in

digestion process. It has a capacity of about 70 ml. Gall bladder comprises of a fundus (broad part) the body (central part) and the neck (tapered parts).

5. Diagram

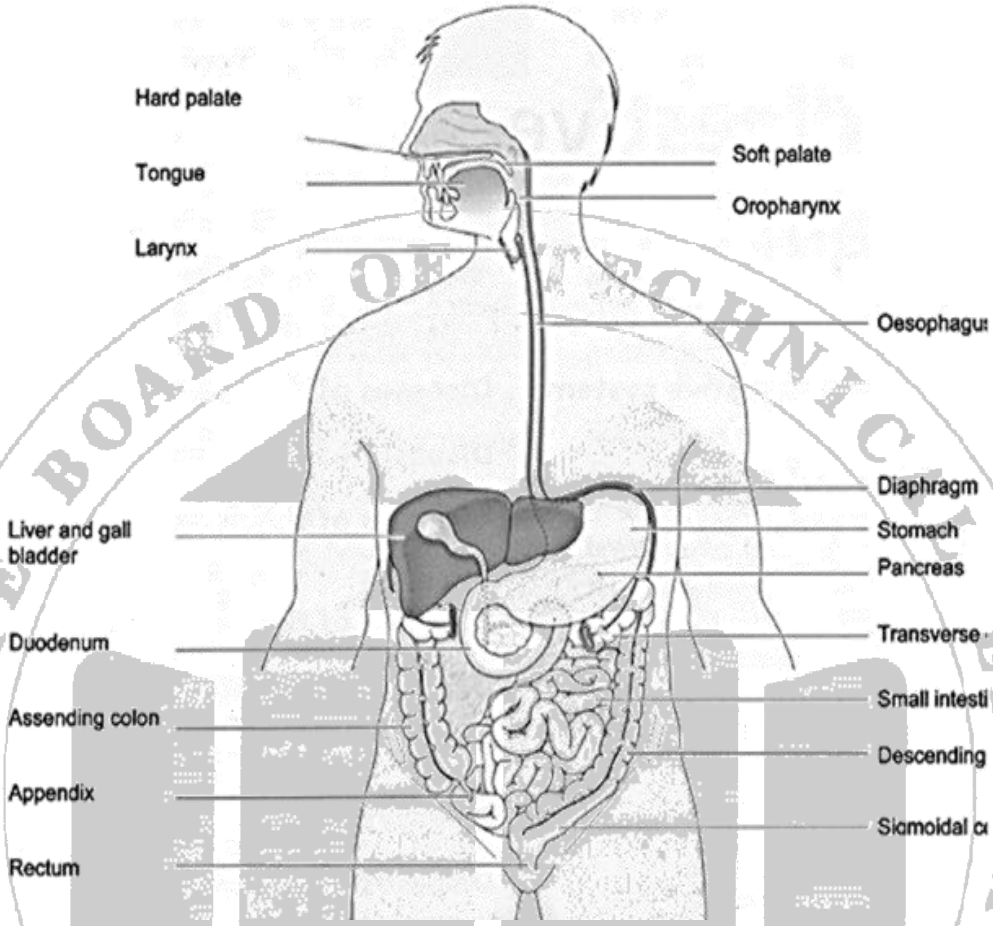

Fig 22.1: Digestive System

6. Requirements

Charts, models, and specimens of human digestive system.

7. Procedure

a. Put on gloves to handle specimens and models to maintain cleanliness and hygiene.
b. Read and review the theoretical aspects of the digestive systems before observing the specimens or models.
c. Observe the specimens or models of the organs of digestive system while correlating their positions with their anatomical locations in the human body.

8. Precautions to be taken

a. Do not touch the specimens or models with bare hands. Always wear gloves to prevent contamination and maintain hygiene.
b. Handle models or specimens with care and gentleness to avoid damage or breakage. Use both hands when necessary to support and stabilize items.
c. After completing the experiment or study session, clean the specimens following appropriate protocols and guidelines.

9. Observation and Exercise

A. Students should fill the information in given table.

S. N.	Nutrient	Enzyme	Produced in	Site of release
1	**Carbohydrate**			
2	**Protein**			
3	**Nucleic Acid**			
4	**Fat**			

B. Draw and label the diagram of stomach.

10. Result

11. References

a. https://www.brainkart.com/article/Human-Digestive-System_39912/

b. Tortora, G. J., Derrickson, B. (2014). Principles of Anatomy and Physiology (14th ed.). Hoboken, N.J.: John Wiley.

c. Waugh, As., Grant, A. (2023). Ross & Wilson Anatomy and Physiology in Health and Illness (14th ed.).

12. Practical Related Questions

a. Give the composition of gastric juice.
b. Define digestion and peristalsis.
c. Give the composition and function of saliva.
d. What are the main secretions of pancreas?
e. Explain the physiology of digestion.
f. State the sites for digestion of carbohydrates, proteins, and fats.

(Space for writing answers)

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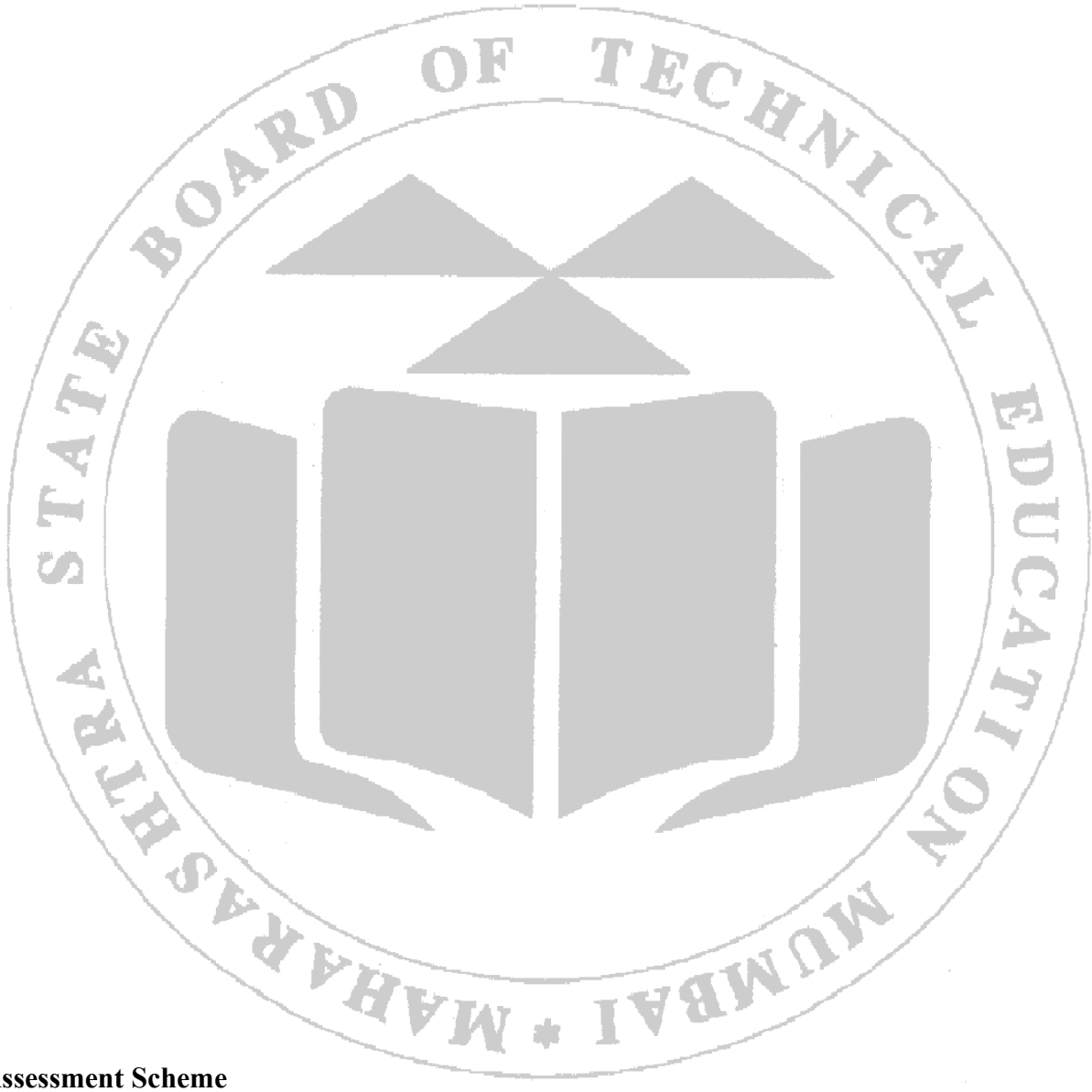


13. Assessment Scheme

Particular	Understanding the basic concept (Intellectual skill)	Activities (Intellectual and motor skills)	Cleanliness & Handling (Affective domain)	Viva-voce / Answers Written	Total	Signature of teacher
Marks Obtained						
Max Marks	**02**	**05**	**01**	**02**	**10**	

Experiment No. 23
Study of the Human Urinary System

1. Aim
To study the human urinary system using charts, models, and specimens.

2. Practical Significance
The urinary system consists of group of organs that filter blood, remove waste products and excess substances from the body, regulate fluid balance and electrolytes, and produce urine for excretion, maintaining overall body homeostasis. In this experiment, students will gain visual insights that enhance understanding of the anatomy and physiology of the urinary system.

3. Practical Outcomes (PrOs)
After completion of this practical, the students will be able to:

PrO	Practical Outcomes	Mapped CO	BTL
1	Identify the parts of human urinary system.	CO4	1
2	Draw and label the structures of urinary system.	CO4	2
3	Locate the parts of urinary system in body.	CO4	1
4	Collaborate and communicate with fellow students.	CO4	5

4. Relevant Theoretical Background
The urinary system is the main excretory system of the human body which consists of a pair of kidneys, a pair of ureters, one urinary bladder, and one urethra.

Kidneys: The paired kidneys are reddish, bean–shaped organs located just above the waist between the peritoneum and the posterior wall of the abdomen. The kidneys are located between the levels of the last thoracic and third lumbar vertebrae. The right kidney is slightly lower than the left because the liver occupies considerable space on the right-side above the kidney. A typical adult kidney is 10-12 cm long, 5-7 cm wide and 3 cm thick. Additionally, the adrenal gland is located superiorly to each kidney.

Microscopic structure of kidney

There are three areas of tissue that can be distinguished when a longitudinal section of the kidney is viewed with naked eye.

a. **Fibrous Capsule:** This is a dense, fibrous membrane that surrounds the kidney.
b. **ortex:** The cortex is a reddish-brown outer layer of tissue located directly beneath the fibrous capsule and outside the renal pyramids. It has a smooth texture. The areas of renal cortex that extend between the renal pyramids are known as renal columns.
c. **Medulla:** The medulla is the innermost layer of the kidney, consisting of 8-10 pale, conical-shaped striations called renal pyramids. The tip of each pyramid is known as the papilla.

Other notable features include:

Hilum or Hilus: This is a notch located on the concave medial surface of the kidney. The renal artery enters the kidney through the hilum, while the renal vein and ureter exit through this same area.

Renal Pelvis: The renal pelvis is a funnel-shaped structure that acts as a reservoir for the urine formed by the kidney.

Calyces (Major and Minor): The renal pelvis is divided into several cup-like structures called calyces. There are minor calyces that surround each papilla and collect urine from the renal pyramids, which then join together to form major calyces.

Urine formed in the kidney passes through the papillae into the minor calyces, then into the major calyces, which eventually drain into the renal pelvis. From the renal pelvis, urine exits the kidney through the ureter and is temporarily stored in the urinary bladder.

Nephrons: The nephrons are indeed the functional units of the kidneys, responsible for filtering blood and forming urine. Each kidney contains approximately 1-2 million nephrons. A nephron consists of two main parts:

a) Renal Corpuscle

- Glomerulus: This is a network of capillaries where blood is filtered under pressure to form a filtrate.
- Bowman's Capsule (Glomerular Capsule): This structure surrounds the glomerulus and collects the filtrate that is produced.

b) Renal Tubule

- Proximal Convoluted Tubule (PCT): The filtrate from Bowman's capsule enters the PCT, where reabsorption of water, ions, and nutrients into the bloodstream occurs.
- Loop of Henle: The loop of Henle consists of a descending and ascending limb and plays a crucial role in concentrating urine by creating a concentration gradient in the surrounding tissue.
- Distal Convoluted Tubule (DCT): The remaining filtrate passes through the DCT, where further reabsorption and secretion take place to regulate the final composition of urine.
- This organized structure of the nephron allows for the precise regulation of water and solute balance in the body through processes of filtration, reabsorption, and secretion.

Functions of the kidney

- Formation of urine by a) glomerular filtration b) selective reabsorption c) tubular secretion.
- Removes metabolic waste products, chemicals, and drugs from the blood & excrete them in urine.
- Regulate the balance of water, electrolyte, and various inorganic ions.
- Hormone secretion –
- Renin (an enzyme that controls blood pressure)
- Erythropoietin (stimulates the formation of blood cells)
- Maintain acid-base (pH) balance and blood pressure.

Ureters:

The ureters are two hollow muscular tubes, each about 25-30 cm long and approximately 3 mm in diameter. They originate from the renal pelvis, which is the funnel-shaped structure at the upper end of the ureter connected to the kidney. Peristaltic contractions of the muscular walls of the ureters propel urine from the kidneys towards the urinary bladder. As the urinary bladder fills with urine, the pressure inside the bladder compresses the oblique openings of the ureters at the bladder wall (ureterovesical junction), preventing the backflow of urine (vesicoureteral reflux).

Function: The primary function of the ureters is to transport urine from the kidneys to the urinary bladder through peristaltic contractions of their muscular walls.

Urinary bladder:

The urinary bladder is a hollow, muscular organ situated in the pelvic cavity behind the pubic symphysis. It stores urine, relaxing and expanding as it fills, then contracting to expel urine during urination. In women, it is in front of the vagina and below the uterus; in men, it is in front of the rectum and above the prostate gland. The bladder's shape changes with urine volume: it is spherical when slightly full, flattens when empty, and becomes pear-shaped as it fills more. In the floor of the urinary bladder is a small triangular area called the trigone.

The bladder's average capacity is 700-800 ml when full. Its wall consists of three layers:

a. The outer layer (adventitia) is areolar connective tissue continuous with the ureters.
b. The middle layer (muscularis or detrusor muscle) surrounds the mucosa.
c. The innermost layer (mucosa) is a mucous membrane made of transitional epithelium.

Function: The bladder stores urine from the kidneys via the ureters and empties it during urination.

Urethra:

The urethra is a tube that carries urine from the bladder to outside the body during urination. In males, it also transports semen during ejaculation. Male urethra is longer (about 20 cm) and more complex, extending from the bladder through the prostate gland and the length of the penis. Female urethra is shorter (about 3-4 cm) and simpler, located in front of the vaginal opening and behind the clitoris. Both male and female urethras are lined with mucous membranes and surrounded by smooth muscle tissue. Both structures are essential for the elimination of waste from the body and play unique roles in the male and female reproductive systems.

Functions: a) It is the passageway for discharging urine. b) In males, it also serves as the passageway for discharging semen.

Common signs and symptoms of disorders of the urinary system

S. N.	Sign/symptom	Definition and description
1	Oliguria	Urine output of less than 400 ml per day
2	Hematuria	Presence of blood in the urine.
3	Proteinuria	Presence of proteins in the urine.
4	Anuria	Absence of urine
5	Dysuria	Pain on passing urine, often described as a burning sensation
6	Glycosuria	Presence of sugar glucose in the urine.
7	Ketonuria	Presence of ketones in the urine.
8	Nocturia	Passing urine during the night
9	Polyuria	Passing unusually large amounts of urine
10	Incontinence	Involuntary leakage of urine
11	Frequency of micturition	Passing urine frequently, often in small amounts

5. Diagram

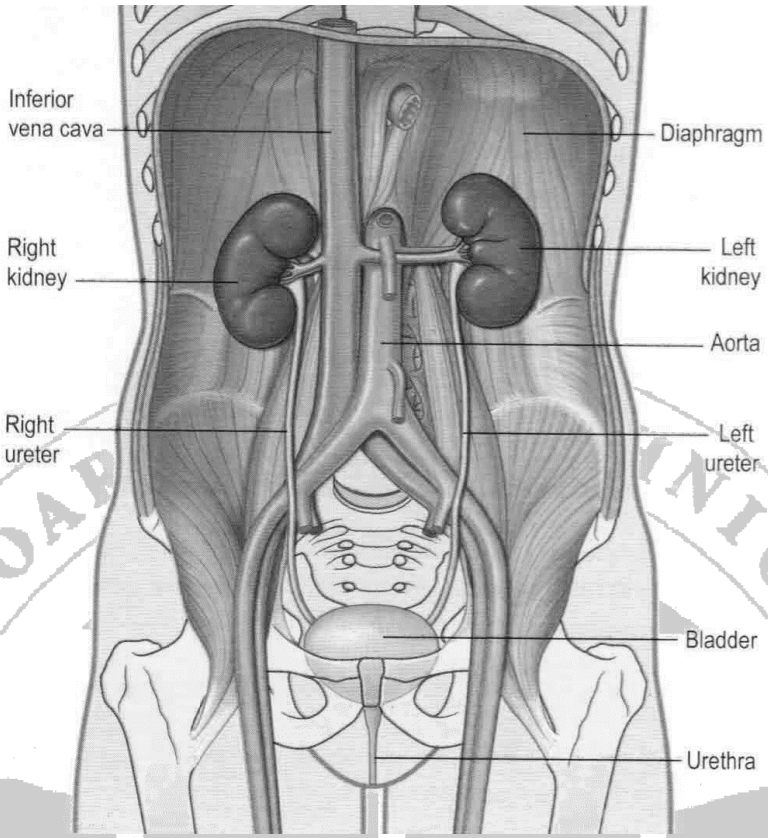


Fig 23.1: Human Urinary System

6. Requirements

Charts, models, and specimens of the human urinary system.

7. Procedure

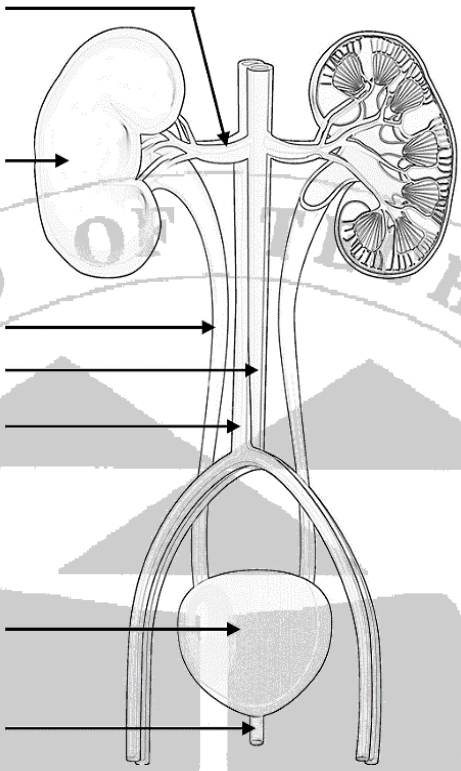
a. Put on gloves to handle specimens and models to maintain cleanliness and hygiene.
b. Read and review the theoretical aspects of the urinary system before observing the specimens or models.
c. Observe the specimens or models of the urinary system while correlating their positions with their anatomical locations in the human body.

8. Precautions to be taken

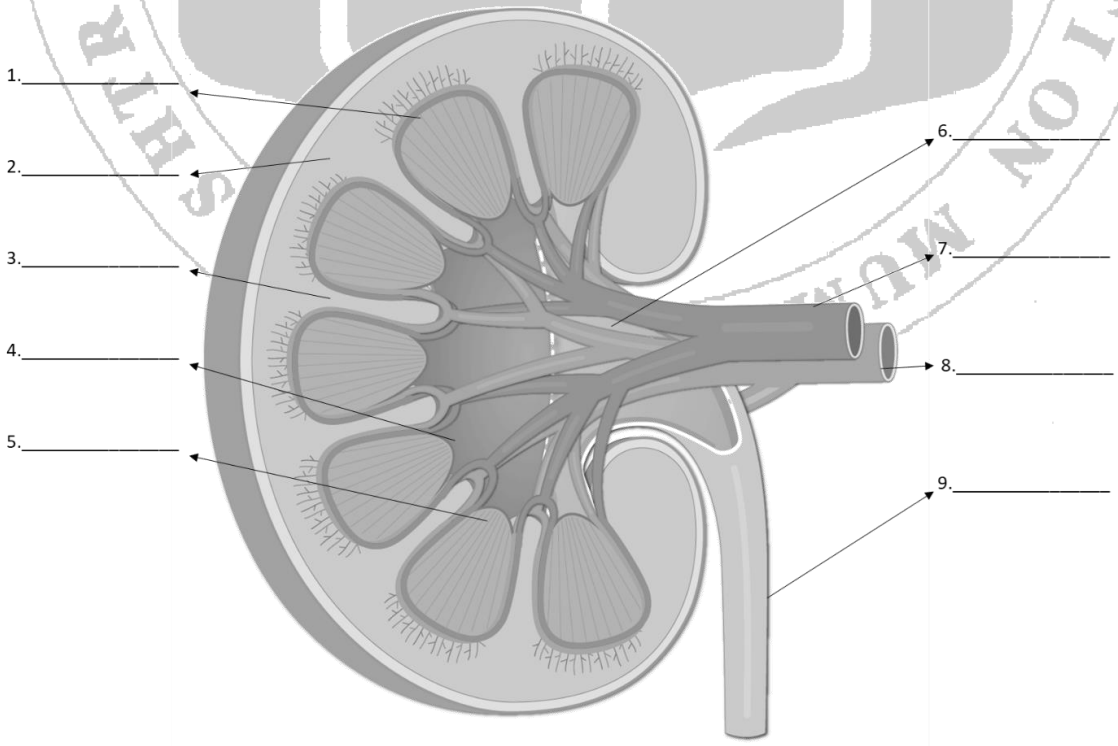
a. Do not touch the specimens or models with bare hands. Always wear gloves to prevent contamination and maintain hygiene.
b. Handle models or specimens with care and gentleness to avoid damage or breakage. Use both hands when necessary to support and stabilize items.
c. After completing the experiment or study session, clean the specimens following appropriate protocols and guidelines.

9. Observations

A. Observe the parts of the human urinary system from the chart/model and label the following Fig.



B. Observe the parts of the human kidney from the chart/model and label the following Fig.



10. Result

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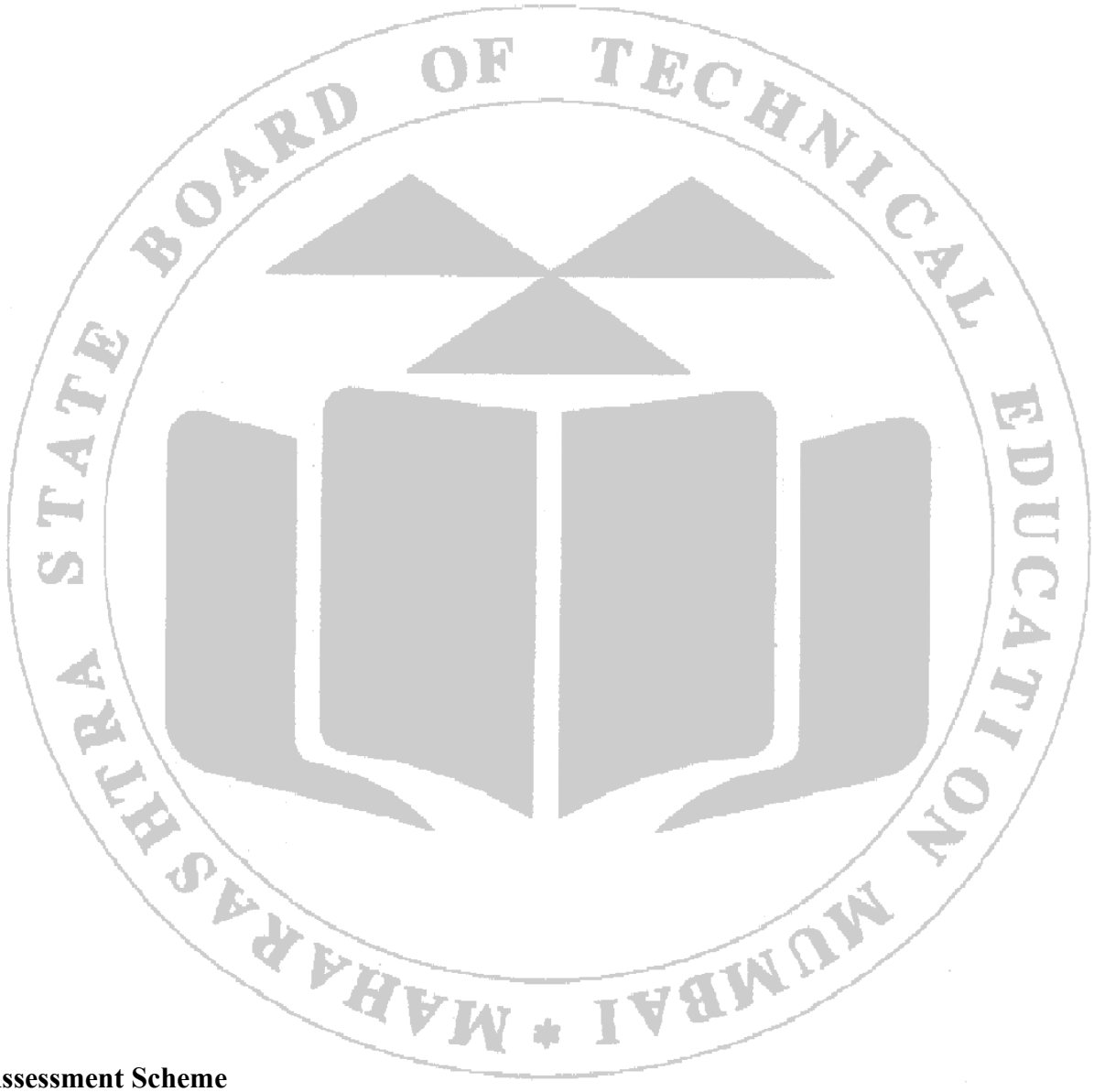
11. References

a. Tortora, G. J., & Derrickson, B. (2014). Principles of Anatomy and Physiology (14th ed.). Hoboken, N.J.: John Wiley.
b. Waugh, A., Grant, A. (2023). Ross & Wilson Anatomy and Physiology in health and illness (14th ed.).
c. https://www.byjus.com
d. https://www.visiblebody.com

12. Practical Related Questions

a. Explain the physiology of urine formation.
b. What are renal column and renal pyramids?
c. Give different functions of kidney.
d. What is micturition? Explain the physiology of micturition.

(Space for writing answers)



13. Assessment Scheme

Particular	Understanding the basic concept (Intellectual skill)	Activities (Intellectual and motor skills)	Cleanliness & Handling (Affective domain)	Viva-voce / Answers Written	Total	Signature of teacher
Marks Obtained						
Max Marks	**02**	**05**	**01**	**02**	**10**	

Experiment No. 24
Study of Endocrine System

1. Aim

To study the human endocrine system.

2. Practical Significance

Endocrine system consists of different glands which performs the various functions for normal growth and development of body. It also maintains the homeostasis. In this practical, students will learn the functions of endocrine glands and the secretion of hormones associated with them.

3. Practical Outcomes (PrOs)

After completion of this practical, the students will be able to:

PrO	Practical Outcomes	Mapped CO	BTL
1	Identify the various anatomical parts of endocrine system.	CO4	1
2	Enumerates the different hormones secreted by various glands.	CO4	2
3	Explain the release and functions of different hormones.	CO4	1
4	Locate different glands on the specimen.	CO 4	1

4. Relevant Theoretical Background

The endocrine system is defined as a complex glandular structure that secretes hormones and neurotransmitters, regulating the body's physiology and playing a major role in the body's defence mechanisms.

Hormones:

These are chemical substances synthesized and produced by the specialized glands to control and regulate the activity of certain cells and organs.

There are two types of glands.

Exocrine glands:

Exocrine glands secrete their substances (enzymes) into ducts, that carry the secretions into body cavities, into the lumen of an organ, or to the outer surface of the body. Exocrine glands include sudoriferous (sweat), sebaceous (oil), mucous, and digestive glands.

Endocrine gland:

Endocrine glands secrete their substances (Hormone) into the interstitial fluid surrounding the secretory cells rather than into ducts, so it is also called as ductless glands. From the interstitial fluid, hormones diffuse into blood capillaries and blood carries them to target cells throughout the body.

Glands of endocrine system:

Pineal gland, hypothalamus and pituitary gland, parathyroid and thyroid gland, thymus gland, adrenal gland, pancreas, ovaries in female and testes in male.

Pituitary gland:

Pituitary gland or hypophysis is a small endocrine gland located in a depression called ‘Sella turcica’ present in the sphenoid bone at the base of skull. It is connected with the hypothalamus by the pituitary stalk or hypophyseal stalk. Pituitary gland is divided into two divisions.

Anterior pituitary or adenohypophysis:

It secretes many hormones and regulates the other endocrine gland's function, so it is also known as master gland. Adenohypophysis consists of two portions, pars distalis and pars intermedia. The pars distalis region of pituitary, commonly called anterior pituitary, produces following hormones.

Growth/somatotropic hormone (GH/STH):

Responsible for the general growth of the body. Over-secretion of GH stimulates abnormal growth of the body leading to Gigantism and low secretion of GH results in stunted growth resulting in pituitary Dwarfism.

Thyroid stimulating hormone (TSH):

Stimulates the synthesis and secretion of thyroid hormones from the thyroid gland.

Adrenocorticotropic hormone (ACTH):

Stimulates the synthesis and secretion of steroid hormones called glucocorticoids from the adrenal cortex.

Prolactin (PRL):

It regulates the growth of the mammary glands and formation of milk in them. It causes development of breast & milk secretion.

Follicle stimulating hormone (FSH) and luteinizing hormone (LH):

LH and FSH stimulate gonadal activity and hence are called gonadotrophins. In males, LH stimulates the synthesis and secretion of hormones called androgens (Testosterone) from Testes. In males, FSH and androgens regulate spermatogenesis. In females, LH induces ovulation of fully mature follicles (graafian follicles) and maintains the corpus luteum, formed from the graafian follicles after ovulation. FSH stimulates growth and development of the ovarian follicles in females.

Posterior pituitary or neurohypophysis:

It is also known as pars nervosa, and it release following two hormones.

Oxytocin:

It acts on the smooth muscles of our body and stimulates their contraction. In females, it stimulates contraction of uterus at the time of childbirth, and milk ejection from the mammary gland.

Vasopressin:

Vasopressin acts mainly at the kidneys to enhance the reabsorption of water and electrolytes by the distal tubules, thereby reducing water loss through urine. Hence, it is also known as the anti-diuretic hormone (ADH).

Thyroid gland:

It is situated at the roof of the neck on either side of the trachea at the level of 5^{th}, 6^{th}, 7^{th} cervical and 1^{st} thoracic vertebrae. It has two lobes, and both the lobes are interconnected with a thin flap of connective tissue called isthmus. The thyroid gland is composed of follicles and stromal tissues. Each thyroid follicle is composed of follicular cells, enclosing a cavity. These follicular cells synthesize two hormones, tetra-iodothyronine or thyroxine (T4) and tri-iodothyronine (T3). In between the follicles, the parafollicular cells are which secretes calcitonin. Thyroid hormones control the metabolism of carbohydrates, proteins, and fats. Maintenance of water and electrolyte balance is also influenced by thyroid hormones. Thyroid gland also secretes a protein hormone called thyrocalcitonin (TCT) which regulates the blood calcium levels.

Parathyroid gland:

There are four parathyroid glands present on the back side of the thyroid gland, one pair each in the two lobes of the thyroid gland. It secretes a peptide hormone called parathyroid hormone (PTH)/parathormone. The secretion of PTH is regulated by the circulating levels of calcium ions.

Functions of parathyroid hormone:

Parathyroid hormone (PTH) increases the Ca^{2+} levels in the blood. PTH acts on bones and stimulates the process of bone resorption (dissolution/ demineralisation). PTH also stimulates reabsorption of Ca^{2+} by the renal tubules and increases Ca^{2+} absorption from the digested food. It is, thus, clear that PTH is a hypercalcaemic hormone, i.e., it increases the blood Ca^{2+} levels.

Adrenal gland:

Our body has one pair of adrenal glands, one at the anterior part of each kidney. The gland is composed of two types of tissues. The centrally located tissue is called the adrenal medulla, and outside this lies the adrenal cortex.

Adrenal medulla:

Adrenal medullary hormones are the amines derived from catechol and so these hormones are called catecholamines and these are, Adrenaline or epinephrine, Noradrenaline or norepinephrine, and Dopamine. Adrenaline and noradrenaline are rapidly secreted in response to stress of any kind and during emergency situations and are called emergency hormones or hormones of Fight or Flight.

Adrenal cortex:

The adrenal cortex can be divided into three layers, called zona reticularis (inner layer), zona fasciculata (middle layer) and zona glomerulosa (outer layer). The adrenal cortex secretes many hormones, commonly called as corticoids.

The corticoids, which are involved in carbohydrate metabolism are called glucocorticoids. In our body, cortisol is the main glucocorticoid.

Corticoids, which regulate the balance of water and electrolytes in our body are called mineralocorticoids. Aldosterone is the main mineralocorticoid in our body.

Aldosterone acts mainly at the renal tubules and stimulates the reabsorption of Na^{+} and water and excretion of K^{+} and phosphate ions. Thus, aldosterone helps in the maintenance of electrolytes, body fluid volume, osmotic pressure, and blood pressure.

Pancreas:

Pancreas is a composite gland which acts as both exocrine and endocrine gland. The endocrine pancreas consists of 'Islets of Langerhans'. There are about 1 to 2 million Islets of Langerhans in a normal human pancreas representing only 1 to 2 per cent of the pancreatic tissue. The three main types of cells in the Islet of Langerhans are called α-cells, β-cells and δ-cells. The α-cells secrete a hormone called glucagon, β-cells secrete insulin, and δ-cells secretes somatotropin.

Glucagon stimulates glycogenolysis resulting in an increased blood sugar (hyperglycaemia).

Insulin acts mainly on hepatocytes and adipocytes and enhances cellular glucose uptake and utilisation, resulting in decreased blood glucose levels (hypoglycaemia).

Somatotropin is a polypeptide hormone acts as an inhibitor of glucagon and insulin secretion.

Ovary:

It is the primary female sex organ which produces one ovum during each menstrual cycle. In addition, ovary also produces two groups of steroid hormones called oestrogen and progesterone. Ovary is composed of ovarian follicles and stromal tissues. The oestrogen is synthesized and secreted mainly by the ovarian follicles. After ovulation, the ruptured follicle is converted to a structure called corpus luteum, which secretes mainly progesterone.

Testes:

It performs dual functions as a primary sex organ as well as an endocrine gland. The Testes is the male reproductive gland that is responsible for producing sperm and making Androgens (Testosterone), primarily. Testosterone is a hormone secreted by the Leydig cells of the testes. Androgens regulate the development, maturation, and functions of the male accessory sex organs like epididymis, vas deferens, seminal vesicles, prostate gland, urethra etc. These hormones stimulate muscular growth, growth of facial and axillary hair, aggressiveness, low pitch of voice etc.

5. Requirements

Charts, models, and specimens of human endocrine system.

6. Procedure

a. Put on gloves to handle specimens and models to maintain cleanliness and hygiene.
b. Read and review the theoretical aspects of the endocrine systems before observing the specimens or models.
c. Observe the specimens or models of the organs of endocrine system while correlating their positions with their anatomical locations in the human body.

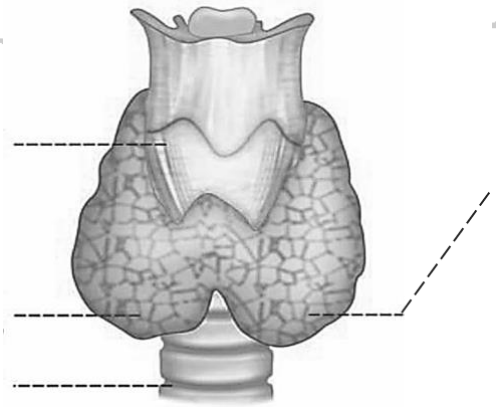
7. Precautions to be taken

a. Do not touch the specimens or models with bare hands. Always wear gloves to prevent contamination and maintain hygiene.
b. Handle models or specimens with care and gentleness to avoid damage or breakage. Use both hands when necessary to support and stabilize items.
c. After completing the experiment or study session, clean the specimens following appropriate protocols and guidelines.

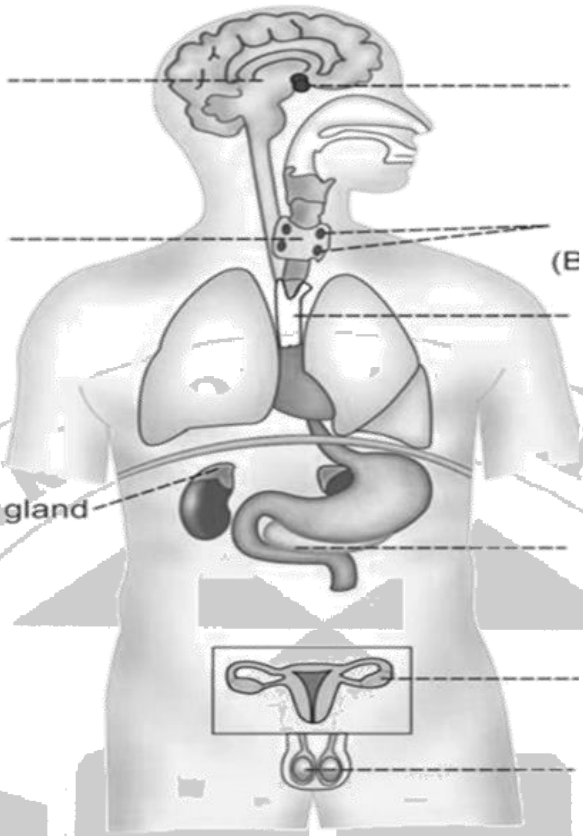
8. Observation

Label the different areas shown with the lines in the following Figs.

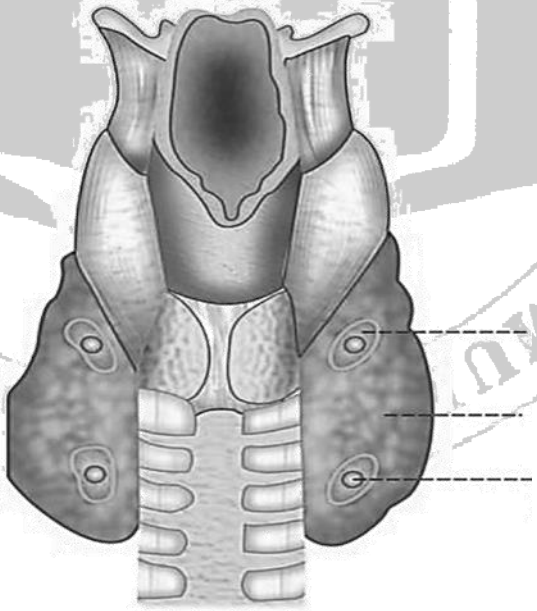
a.



b.



c.



9. Result

10. References

a. Waugh, A., Grant, A. (2023). Ross & Wilson Anatomy and Physiology in health and illness (14th ed.).
b. Tortora, G. J., & Derrickson, B. (2014). Principles of Anatomy and Physiology (14th ed.). Hoboken, N.J.: John Wiley.

11. Practical Related Questions

a. Give any four differences between endocrine and exocrine gland.
b. Draw the table showing different types of endocrine gland, their location, hormones release and function.
c. Why is pituitary gland called as master gland?
d. Why is pancreas called endo and exocrine gland?
e. What are the functions of thyroid hormone?

(Space for writing answers)

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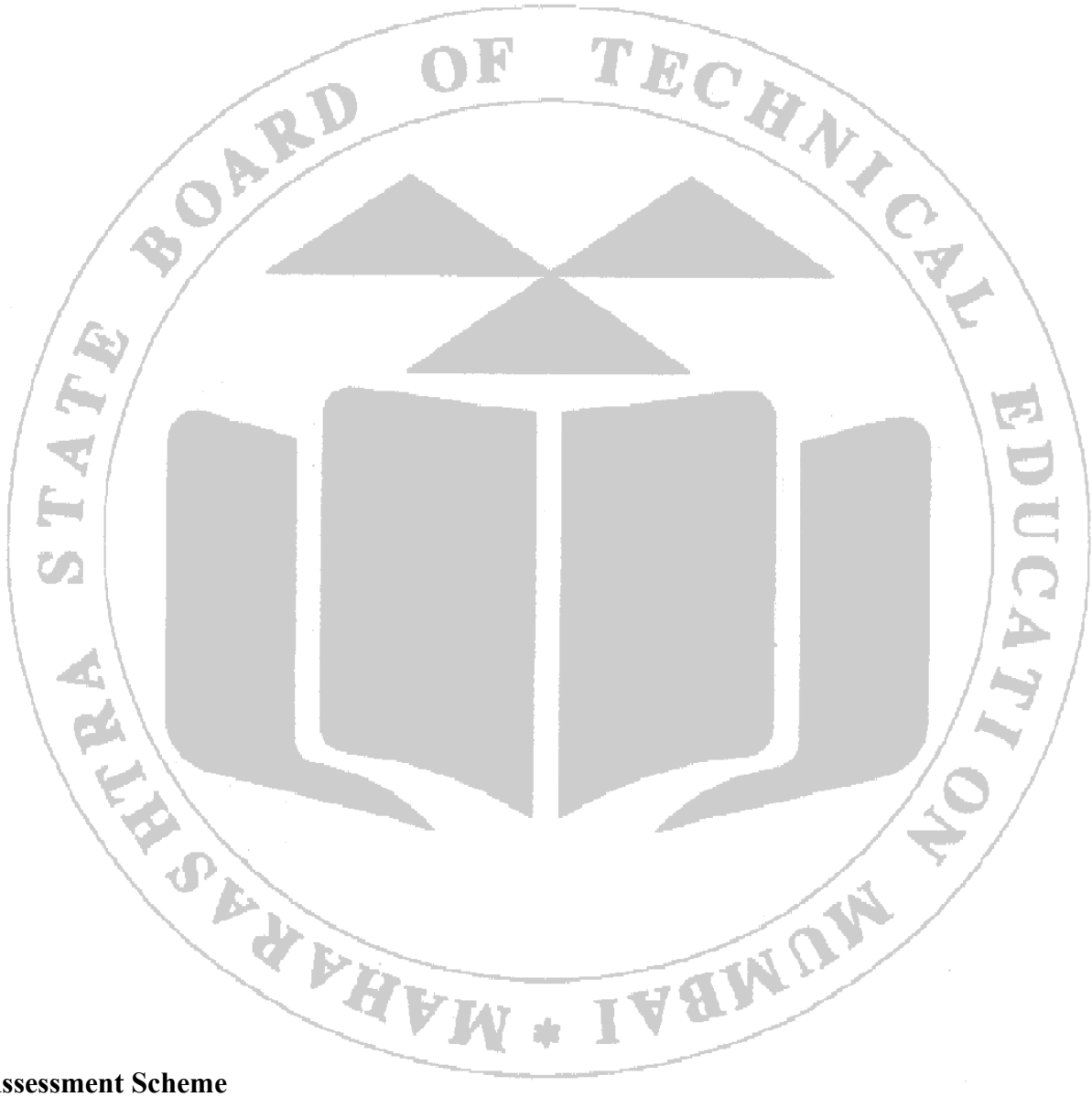


12. Assessment Scheme

Particular	Understanding the basic concept (Intellectual skill)	Activities (Intellectual and motor skills)	Cleanliness & Handling (Affective domain)	Viva-voce / Answers Written	Total	Signature of teacher
Marks Obtained						
Max Marks	**02**	**05**	**01**	**02**	**10**	

Experiment No. 25
Study of Male and Female Reproductive Systems

1. Aim
To study the human male and female reproductive systems using charts, models, and specimens.

2. Practical Significance
The male reproductive system includes external and internal organs responsible for producing, supporting, transporting, and delivering viable sperm for reproduction. Conversely, the primary role of the female reproductive system is to generate eggs (ova) and create the optimal environment for fertilization and the development of a baby. In this experiment, students will gain a visual understanding of the anatomy and physiology of both the male and female reproductive systems.

3. Practical Outcomes (PrOs)
After completion of this practical, the students will be able to:

PrO	Practical Outcomes	Mapped CO	BTL
1	Identify the various anatomical parts of male and female reproductive system.	CO4	1
2	Draw and label the structures of male and female reproductive system.	CO4	2
3	Locate the parts of male and female reproductive system.	CO4	1
4	Collaborate and communicate with fellow students.	CO4	5

4. Relevant Theoretical Background

Reproduction refers to the production of offspring by organized bodies. The offspring is produced as a new individual organism from the parents. There are two forms of reproduction, sexual and asexual.

In sexual reproduction, male and female gametes are formed to produce an offspring. These gametes are either formed by the same individual or by different individuals of the opposite sex. Sexual reproduction is the process in which new organisms are created, by combining the genetic information from two individuals of different sexes. The genetic information carried on chromosomes within the nucleus of specialized sex cells called gametes. Humans and many multicellular organisms exhibit a sexual mode of reproduction.

Asexual reproduction refers to the type of reproduction in which only a single organism gives rise to a new individual. Asexual reproduction does not involve the fusion of gametes, and therefore, the offspring produced are genetically identical to the parent. The organisms produced by asexual reproduction are less diverse in nature. This type of reproduction is practiced widely by unicellular organisms.

Male Reproductive System

The male reproductive system is divided into external genital organs (scrotum, urethra, and penis), internal genital organs (testes, epididymis, vas deferens, spermatic cords, and ejaculatory ducts), and accessory sex glands (seminal vesicles, prostate, and bulbourethral glands).

External genital organs

Scrotum: Scrotum is a thin external sac of skin that is divided into two compartments; each compartment contains one testis, one epididymis and the testicular end of spermatic cord. The skin

of scrotum is thin, wrinkled, and loose. The skin contains many sebaceous glands and sweat glands, as well as some hairs.

The muscle of scrotum either contract or relax in response to cold or warmth to maintain an optimal temperature for formation of spermatozoa.

Urethra: It is a tube-like structure which travels through the penis and about 19-20 cm long. Male urethra is the common passageway for the flow of urine and semen.

Penis: It is cylindrical in shape and consists of root and body (shaft). The root of penis is the point at which it connects to abdominal wall. The body of the penis is composed of three cylindrical masses of erectile tissue. The erectile tissue is supported by fibrous tissue and covered with skin and has a rich blood supply. The tip of penis is expanded into a triangular structure known as glans penis.

The penis delivers sperm and is involved in urination.

Internal genital organs

Testes: These are the oval bodies, about 5 cm long, 2.5 cm diameter, 3 cm thick and weighs about 10-15 g. Generally, the left testis hangs slightly lower than the right one in the scrotum by spermatic cord. Each testis contains 200-300 lobules and within each lobule, there are 1-4 convoluted loops called seminiferous tubules. Seminiferous tubules contain two types of cells, spermatogenic cells (sperm forming cells) and cells of Sertoli (provide nourishment and attachment for developing sperms). In the spaces between adjacent tubules, there are group of cells called Leydig (interstitial) cells which secrete male hormone testosterone.

The testes produce spermatozoa through spermatogenesis. They also secrete the male hormone testosterone, which controls the development, growth, and maintenance of male sex organs and secondary sexual characteristics.

Epididymis: Sperms are transported out of testes into the comma-shaped tube called epididymis. The epididymis is the site of sperm maturation. It helps to propel sperm into the vas deferens during sexual excitement through peristaltic contractions of smooth muscles. Additionally, the epididymis stores sperm, which can remain viable here for several months.

Vas deferens: Within the tail of epididymis, the ductus epididymis becomes less convoluted, and its diameter increases. Beyond this point, the duct is known as vas deferens or ductus deferens. It is about 45 cm (18 in.) long.

The vas deferens conveys sperm from the epididymis to the urethra during sexual excitement via peristaltic contractions of its muscular coat. Like the epididymis, the vas deferens also stores sperm for several months.

Spermatic cords: These are two in number, one leading from each testis. They suspend testes in scrotum.

Ejaculatory ducts: These are two short tubes, about 2 cm long, formed by the union of the duct from a seminal vesicle and a vas deferens.

They eject sperms and seminal fluid into urethra just before the release of semen from the urethra to the exterior.

Accessory sex glands

The accessory sex glands secrete most of the liquid portion of semen.

Seminal vesicles (Seminal glands): The paired seminal vesicles are convoluted pouchlike structures, about 5 cm (2 in.) in length, lying posterior to the base of the urinary bladder and anterior to the rectum. Through the seminal vesicle ducts, they secrete an alkaline, viscous fluid that contains fructose (a monosaccharide sugar), prostaglandins, and clotting proteins.

The alkaline nature of the seminal fluid helps to neutralize the acidic environment of the male urethra and female reproductive tract, which would otherwise deactivate and kill sperm. The fructose in the seminal fluid is used by sperm for ATP production.

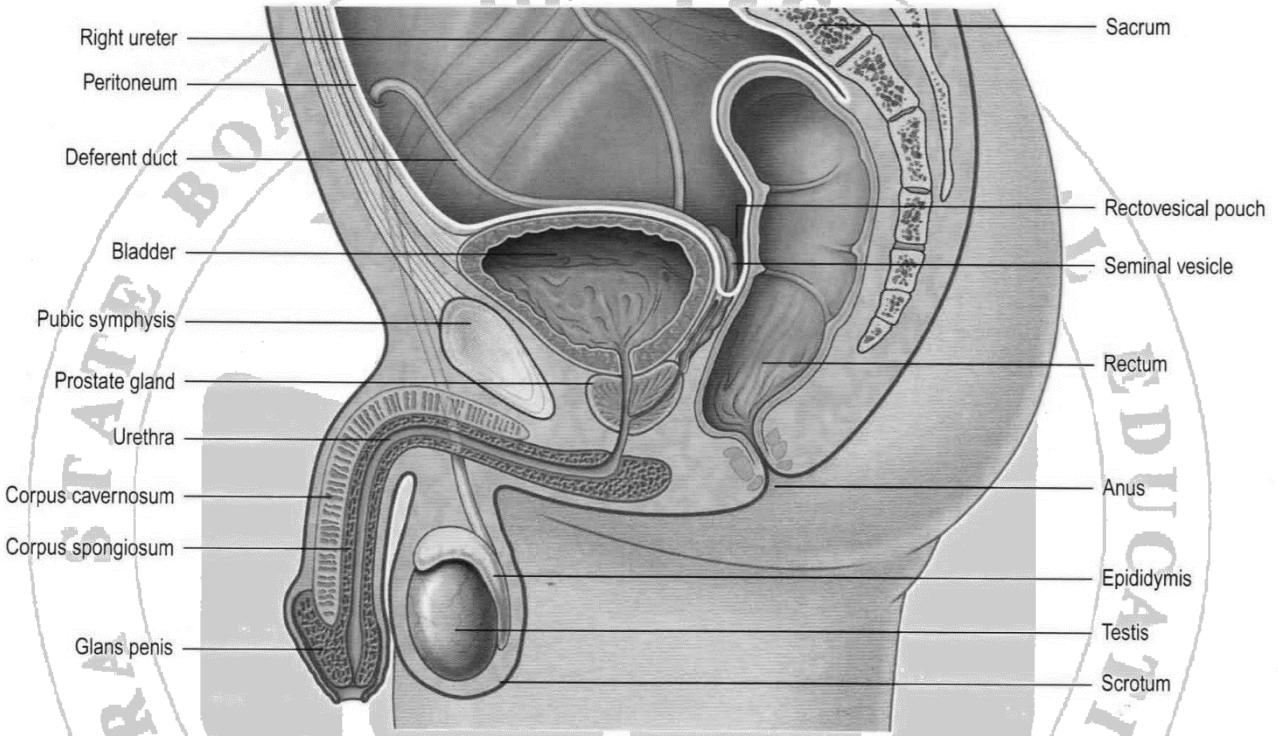


Fig 25.1: Human Male Reproductive System

Prostate gland: The prostate is a single, doughnut-shaped gland about the size of a golf ball. It is located inferiorly to the urinary bladder in the pelvic cavity. The size of the prostate gland increases up to the age of about 30 years and remain constant up to the age of 45 years.

The prostate secretes a milky, slightly acidic fluid (pH about 6.5) that contains several substances such as citric acid, several proteolytic enzymes, acid phosphatase, and seminal plasmin. This prostatic fluid helps sperm remain motile and viable.

Cowper's gland (Bulbourethral gland): The paired Cowper's glands are about the size of peas. They are located inferior to the prostate on either side of the membranous urethra.

During sexual arousal, these glands secrete an alkaline fluid into the urethra that protects the passing sperm by neutralizing acids from urine in the urethra. They also secrete mucus that lubricates the end of the penis.

Ejaculation: Ejaculation, a sympathetic reflex, is the process of powerful release of semen from the urethra to the exterior during orgasm. As part of the reflex, the smooth muscle sphincter at the base

of the urinary bladder closes, preventing urine from being expelled during ejaculation, and semen from entering the urinary bladder.

Functions of the male reproductive system

a. Production, maturation, and storage of spermatozoa.
b. Delivery of sperms in semen into the female reproductive tract.

Female Reproductive System

The female reproductive system is divided into external genitalia (labia majora, labia minora, clitoris, vestibule, hymen, and vestibular glands) and internal genitalia (vagina, uterus, two uterine tubes and two ovaries).

External genitalia (vulva)

Labia majora (outer lips): These are the two large longitudinal folds forming the boundaries of vulva. At puberty, hairs glow on the mons pubis and on lateral surfaces of the labia majora. They contain an abundance of adipose tissue, sebaceous (oil) glands, and sweat glands.

Primary function is to protect the vaginal and urethral openings as well as the clitoris. They also play a role in sexual arousal and pleasure.

Labia minora (inner lips): These are two delicate folds of skin located within the labia majora, containing numerous sebaceous and eccrine sweat glands. Unlike the labia majora, the labia minora are devoid of pubic hair and fat.

They help to protect the delicate structures within the vulva, such as the clitoris and vaginal opening, from friction and irritation. They also contain numerous nerve endings, contributing to sexual pleasure and sensation.

Clitoris: The clitoris is a small, sensitive organ located near the top of a vulva. It contains sensory nerve endings and erectile tissue. The clitoris is homologous to the glans penis in males.

The primary function of the clitoris is to provide sexual pleasure due to the abundance of sensory nerve endings and erectile tissue it contains.

Vestibule: The region between the labia minora is the vestibule. Within the vestibule are the hymen, the vaginal orifice, the external urethral orifice, and the openings of the ducts of several glands.

Hymen: The hymen is a delicate mucous membrane that has a central opening to facilitate the drainage of menstrual flow. It can be stretched or torn due to sexual intercourse, inserting a tampon, or during childbirth.

Vestibular glands: The vestibular glands are located on each side near the vaginal opening and are approximately the size of a pea. They produce and secrete mucus to keep the vulva moist.

Internal genitalia

Vagina: The vagina is a muscular and elastic tube that connects the cervix to the external body. It functions as the receptacle for the penis during sexual intercourse and facilitates the delivery of sperm to the fallopian tubes and uterus. Additionally, the vagina acts as a birth canal by expanding to allow the delivery of the fetus during childbirth.

Uterus (womb): The uterus is a hollow, muscular, pear-shaped organ located in the pelvic cavity between the urinary bladder and the rectum. It measures about 7.5 cm long, 5 cm wide, and its walls

are approximately 2.5 cm thick, weighing between 30 and 40 grams. The parts of the uterus include the fundus (dome-shaped upper part), body (main portion), and cervix (neck of the uterus). The walls of the uterus are composed of three layers of tissue: the perimetrium (outer layer), the myometrium (middle layer composed of smooth muscle), and the endometrium (inner lining that undergoes changes during the menstrual cycle and where implantation of a fertilized egg occurs).

After puberty, the uterus undergoes a regular menstrual cycle under the influence of female sex hormones, which prepare it to receive, nourish, and protect a fertilized ovum. The walls of the uterus contain elastic tissue that stretches to accommodate the growing fetus during pregnancy.

The uterus plays a crucial role in menstruation and in bearing a child by providing a site for the fertilized ovum to implant, protecting it during development, and eventually facilitating childbirth.

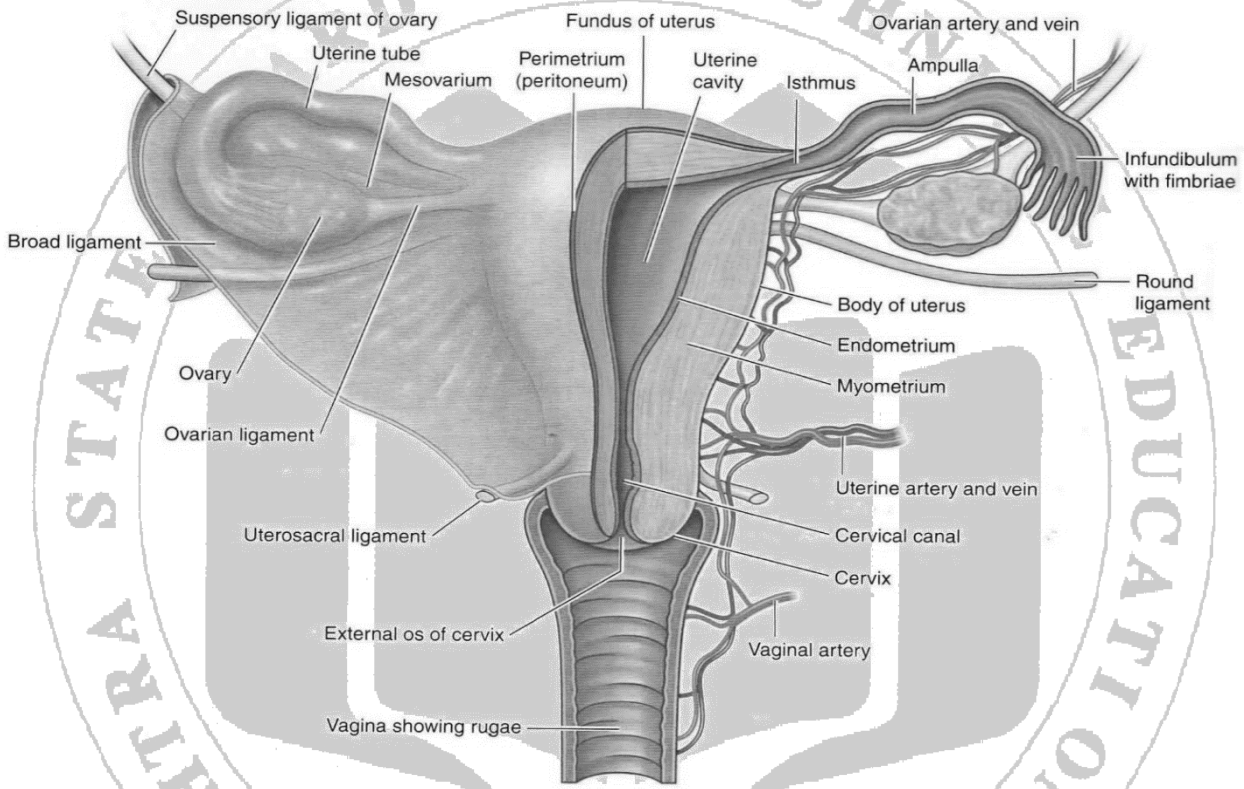


Fig 25.2: Human Female Reproductive System

Uterine (fallopian) tubes: The fallopian tubes are a pair of muscular, funnel-shaped structures extending from the upper corners of the uterus toward the ovaries and about 10 cm long. They are equipped with small projections called fimbriae that sweep over the ovaries to capture released eggs and transport them into the tube. Each fallopian tube is lined with cilia, which help move the egg toward the uterus. The tube is divided into three sections: the ampulla, isthmus, and infundibulum.

Ovaries: Ovaries are the female reproductive organs responsible for producing eggs (ova) and hormones like estrogen and progesterone. Each woman typically has two ovaries, located on either side of the uterus in the pelvic cavity. On average, an adult human ovary typically measures approximately 3 to 5 cm in length, 2 to 3 cm in width, and 1 to 2 cm in thickness. The ovaries release mature eggs during ovulation, which travel through the fallopian tubes towards the uterus. Additionally, the ovaries produce hormones that regulate the menstrual cycle and play a role in pregnancy and overall reproductive health.

5. Requirements

Charts, models, and specimens of human male and female reproductive systems.

6. Procedure

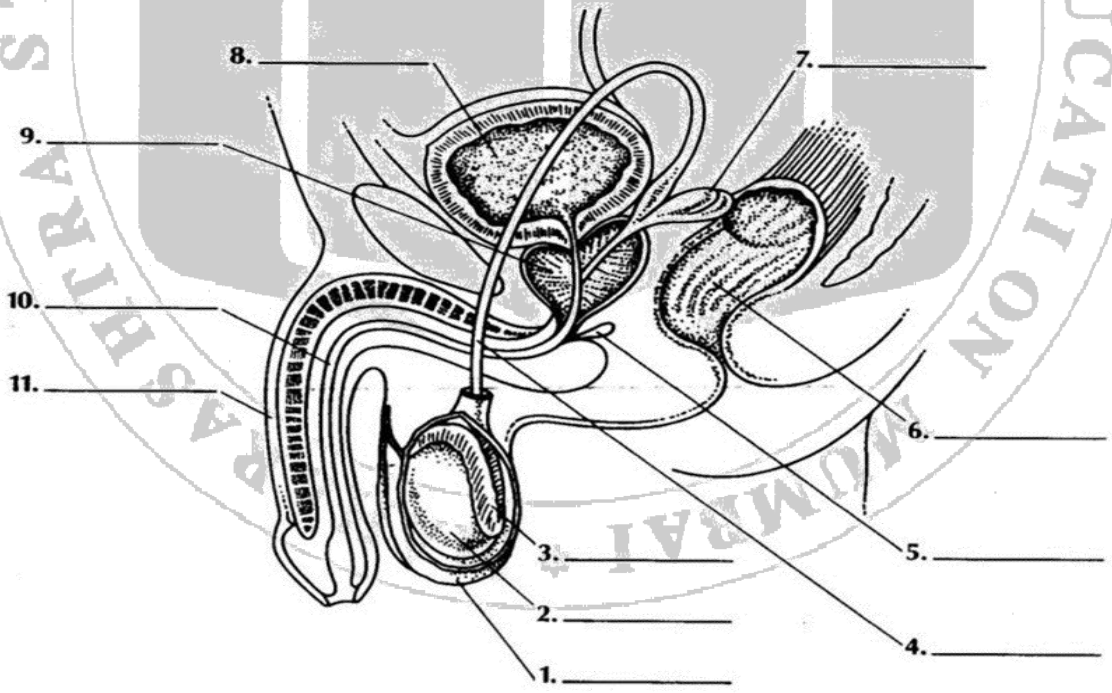
a. Put on gloves to handle specimens and models to maintain cleanliness and hygiene.
b. Read and review the theoretical aspects of the male and female reproductive systems before observing the specimens or models.
c. Observe the specimens or models of the male and female reproductive organs while correlating their positions with their anatomical locations in the human body.
d. Use side-by-side comparison of charts or models to identify and analyze the similarities and differences between the male and female reproductive systems, focusing on structural anatomy and physiological functions.

7. Precautions to be taken

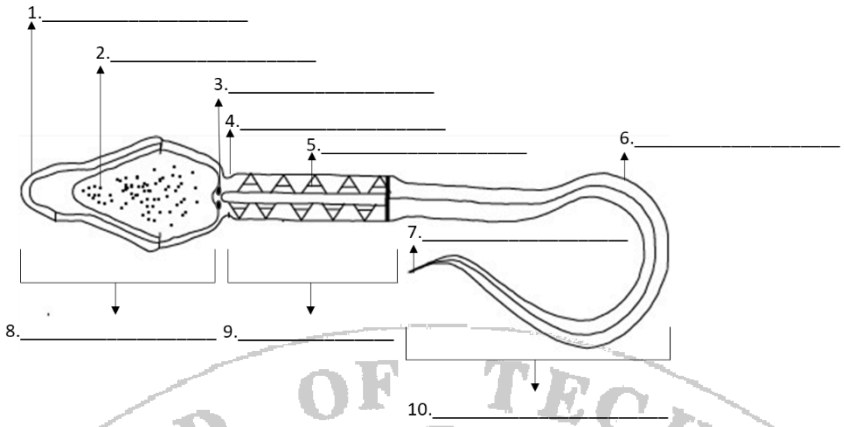
a. Do not touch the specimens or models with bare hands. Always wear gloves to prevent contamination and maintain hygiene.
b. Handle models or specimens with care and gentleness to avoid damage or breakage. Use both hands when necessary to support and stabilize items.
c. After completing the experiment or study session, clean the specimens following appropriate protocols and guidelines.

8. Observations

A. Observe the parts of human male reproductive system from the chart/model and label the following Fig.

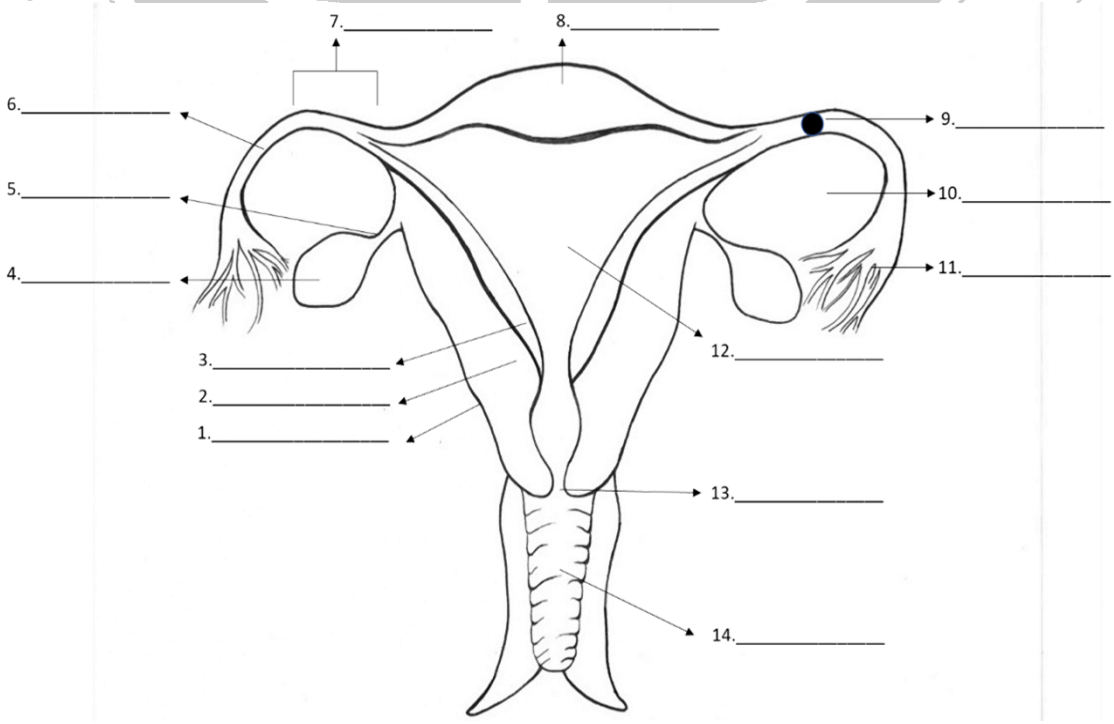


B. Observe the parts of spermatozoa in the following Fig.



C. Draw and label the diagram of L.S. of Testis.

D. Observe the parts of human female reproductive system from the chart/model and label the following Fig.



E. Draw a table showing list of hormones secreted by testis and ovary with their effects.

9. Result

_____

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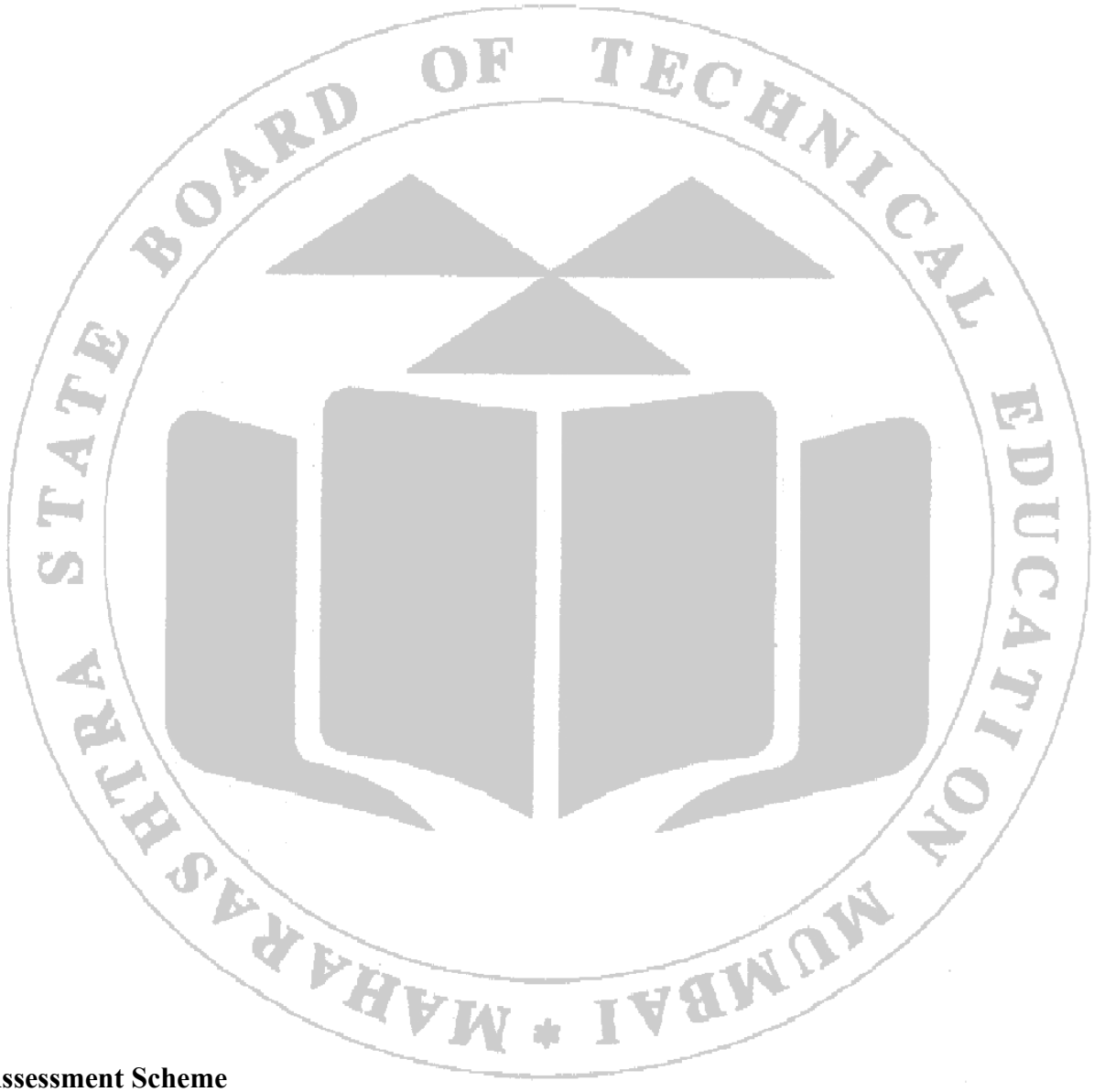
10. References

a. Tortora, G. J., & Derrickson, B. (2014). Principles of Anatomy and Physiology (14th ed.). Hoboken, N.J.: John Wiley.
b. Waugh, A., Grant, A. (2023). Ross & Wilson Anatomy and Physiology in health and illness (14th ed.).
c. https://www.byjus.com
d. https://www.britannica.com

11. Practical Related Questions

a. Define reproduction and spermatogenesis.
b. What is puberty? Mention the changes that occur in male and female during puberty.
c. What is menstrual cycle? Describe the stages of menstrual cycle.
d. What are the functions of scrotum and clitoris?

(Space for writing answers)



12. Assessment Scheme

Particular	Understanding the basic concept (Intellectual skill)	Activities (Intellectual and motor skills)	Cleanliness & Handling (Affective domain)	Viva-voce / Answers Written	Total	Signature of teacher
Marks Obtained						
Max Marks	**02**	**05**	**01**	**02**	**10**	

GUIDELINES FOR CONDUCTION OF SESSIONAL PRACTICAL EXAMINATION

Course: Human Anatomy and Physiology Practical (HPP) **Course Code:** 20054

Class: F. Y. D. Pharm. **Max. Marks:** 80

Time: 03 Hrs.

Q. 1. Synopsis or Spotting **10 Marks**

For the synopsis, 5 questions of 2 marks each can be asked based on basic knowledge.

For spotting, 10 spots can be arranged, with ½ mark for identification of each given spot and 0.5 mark for its description.

Q. 2 Experiments **50 Marks**

a) Major Experiments **30 Marks**

Experiments can include determining WBC count, RBC count, differential leukocyte count (DLC), hemoglobin (Hb) levels and oxygen-carrying capacity.

b) Minor Experiments **20 Marks**

Experiments can include the determination of blood group, bleeding time, clotting time, blood pressure, pulse rate/heart rate, body temperature, respiratory rate, and BMI.

Q. 3 Viva-Voce **10 Marks**

The viva should be conducted on both theory and practical-based questions.

Q. 4 Manual **10 Marks**

**As per new syllabus ER-2020, there will be no consideration of assignment and field visit marks for Human Anatomy and Physiology practical. Sessional out 80 marks directly converted to out of 20 marks.*

GUIDELINES FOR CONDUCTION OF ANNUAL PRACTICAL EXAMINATION

Course: Human Anatomy and Physiology Practical (HPP) **Course Code:** 20054

Class: F. Y. D. Pharm. **Max. Marks:** 80

Time: 03 Hrs.

Q. 1. Synopsis **10 Marks**

For the synopsis, 5 questions of 2 marks each can be asked based on basic knowledge.

Q. 2 Experiments **60 Marks**

a) Major Experiments **30 Marks**

Experiments can include determining WBC count, RBC count, differential leukocyte count (DLC), hemoglobin (Hb) levels and oxygen-carrying capacity.

b) Minor Experiments **20 Marks**

Experiments can include the determination of blood group, bleeding time, clotting time, blood pressure, pulse rate/heart rate, body temperature, respiratory rate, and BMI.

c) Spotting **10 Marks**

For spotting, 10 spots can be arranged, with 1 mark for identification of each given spot and 1 mark for its description. Various bones, instruments and apparatus, models, and specimens of different experiments, histological slides etc can be placed.

Q. 3 Viva-Voce **10 Marks**

The viva should be conducted on both theory and practical-based questions.