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HPCSA
Health Professions Council of South Africa

## SYLLABUS

# HAEMATOLOGY

## MEDICAL TECHNOLOGISTS (MT) and MEDICAL LABORATORY SCIENTISTS (MLS)

**PBMT Approved in July 2022 for training implementation from Jan 2023.**
**For exams starting in March 2024**

## CONTENTS

## 1. INTRODUCTION

The objective of this syllabus is to provide the intern/student Medical Technologists & Medical Laboratory Scientists with a guideline on the essential aspects that must be covered in order to adequately prepare intern/student Medical Technologists for the Health Professions Council of South Africa Professional Board of Medical Technology examination (intern medical technologists) and final exit examination by University of Technology (UoT) (student medical laboratory scientists). The candidates are expected to be able to correlate their practical knowledge and laboratory testing with the clinical condition and other disciplines.

The examination will be based on the contents of this syllabus and related theoretical knowledge gained during study at the University of Technology.

HPCSA regulations require that accredited training laboratories perform a minimum of 80% of the tests contained in this syllabus. Laboratories are required to ensure that Interns receive appropriate training in the tests contained within the syllabus but which are not routinely performed at the training site.

It is expected from them that they cover all the practicals included in this instruction manual. Their promoters must ensure that they are competent in all the prescribed laboratory procedures.

The student must be able to provide an in depth practical and theoretical knowledge of screening, quantitative and qualitative analytical process used in the testing of specimens in haematology and an adequate understanding of the interpretation, clinical significance and troubleshooting of the final results.

Students must have a comprehensive knowledge of the pathogenesis and biology of all haematological diseases including malignancy, anaemia and haemostatic disorders. In addition, candidates are expected to be able to correlate their practical knowledge and laboratory testing with the clinical condition and other disciplines.

**RANGE:**

- Peripheral blood and bone marrow.
- Body fluids for specific testing such as:
    - Urine for haemosiderin and eosinophils
    - Sputum & urine for eosinophils
    - Cerebral spinal fluid (CSF), bronchial washes, pleural fluids, vitreous fluids, for cytospin and flow cytometry.

**Specific Outcomes**

At the end of the training period the candidate will sit for an HPCSA's Professional Board of Medical Technology examination consisting of two, three-hour papers. Both papers will be broadly based on the entire field of Haematology as covered in this syllabus up to and including the final year. Medical Laboratory Scientists will sit for a Final Exit Examination administered by the UoT where the student is enrolled.

The students will be required to draw from all knowledge gained to date in order to answer these papers. The emphasis will however be on problem solving and the application of knowledge of concepts expected of a fully competent Medical Technologist & Medical Laboratory Scientist. Specific details of methods, times and quantities and clinical interpretation will not be asked. Students are expected to know principles as well as interpretation and troubleshooting of results and have sufficient understanding for expected clinical presentation.

## 2. STATUTORY REGULATIONS AND ETHICS

### Objective

Provide the intern/ student with information on the regulations and ethical principles which underpin the practice of Medical Laboratory Technology.

### Specified outcomes

On completion of this section the intern/student should be able to:

- Demonstrate knowledge of the structure and function of the Health Professions Council of South Africa. (HPCSA)
- Demonstrate knowledge of the structure and function of the Professional Board for Medical Technology (PBMT).
- Discuss the regulations relating to the scope of practice for Medical Technologists & Medical Laboratory Scientists.
- Describe the legal and ethical standards related to the professional practice of Medical Technology.
- Demonstrate knowledge of the requirements for the acquisition of continual education units (CEUs).
- Demonstrate knowledge on the practice / ethos of how confidentiality in the workplace is achieved and maintained.
- Demonstrate knowledge of No. 61 of 2003: National Health Act, 2004.

## 3. TOTAL QUALITY MANAGEMENT SYSTEM

### 3.1 LABORATORY SAFETY

#### Objective

Provide knowledge of all safety procedures that must be applied in the workplace and an understanding of the relevant legislation relating to laboratory safety procedures.

#### Specified outcomes

On completion of this section the intern/student should be able to:

- Explain and apply the fundamental concepts of the relevant legislation pertaining to laboratory safety.
  **RANGE:** *Occupational Health and Safety Act*
  *Hazardous Substances Act*
  *Compensation for Occupational Injuries and Diseases Act*
- Demonstrate knowledge of the procedures to follow in the event of laboratory accident or emergency.
  **RANGE:** *Chemical or bio-hazardous spill*
  *Fire, Flood, Bomb threat*
- Describe the correct procedures for the storage, handling and disposal of laboratory waste.

- Describe the application of laboratory safety procedures to the collection, transport, storage and analysis of biological specimens including the International Air Transport Association (IATA) regulations.
  **RANGE:** *Biological specimens*
  *Human tissue*
  *Solid and liquid bio-hazardous waste*
  *Radioactive waste*
  *Sharps*
- Describe the basic principles for the storage, handling and disposal of chemicals, poisons, flammable substances, gases and infectious material.
- Describe procedures to follow for the prevention, control and management of laboratory acquired infections including general housekeeping and decontamination of equipment.
- Describe the purpose and basic content of the material safety data sheets (MSDS).
- Demonstrate knowledge of the protocols to follow in the event of injuries on duty including needle-stick injury.
- Define the role of the designated safety personnel.
  **RANGE:** *Fire marshal, Safety representative, First aid officer*
- Recognize the international safety symbols used in the medical laboratory environment.
  **RANGE**: *Prohibition Signs, Mandatory Signs, Warning Signs, Safe Condition Signs and Fire Equipment Signs.*
- Demonstrate the knowledge of all safety and emergency equipment.
  **RANGE:** *Safety goggles, Eyewash stations, Lab coats, Protective gloves, Fire extinguishers, Chemical fume hoods, First aid kits, Fire Blankets*

## 3.2 SPECIMENS / PRE-ANALYTICAL REQUIREMENTS

### Objective

Provide an understanding of the optimal specimen requirements for the maintenance of the integrity and suitability for ***all types*** of laboratory analyses with particular reference to the tests specified throughout this syllabus.

### Specified Outcomes

On completion of this section the intern/student should be able to:

- Demonstrate knowledge of any required patient preparation for the collection of specimens for individual tests.
- Collect specimens as defined within current statutory requirements and limitations.
- Describe the optimal specimen requirements for the individual tests.
- Identify and describe related factors that may affect results generated from the analysis of specimens for the individual tests.
- Describe the conditions under which the specimens must be transported to the laboratory
- Display knowledge of the optimal storage conditions should testing be delayed and the stability of the specimen for the individual testing process.
- Where applicable, capture the data and patient demographics that are required for the registration of the specimens at the laboratory accurately.
- Explain the principle of continuous identification and tracking of the specimen, aliquots and documentation.
- Identify criteria for rejection and describe the process for the rejection of unsuitable specimens.
- Conduct the pre-analytical preparation required for specimen type and test requested.

## 3.3 LABORATORY EQUIPMENT

### Objective

Explain the correct use, principle of operation, maintenance of laboratory equipment and the appropriate troubleshooting procedures to apply where and when indicated.

### Specified outcomes – applicable to all equipment/instruments and analysers

On completion of this section the intern/student should be able to:

- Describe the principle of operation where applicable to discipline specific instrumentation.
- Operate all equipment optimally in accordance with the manufacturers recommended operating procedures.
- Demonstrate basic computer skills (e.g. MS Office/Excel)
- Apply the correct safety precautions during the operation and maintenance of equipment.
- Demonstrate full knowledge of, and apply, the correct maintenance, service and calibration requirements within scope, of / for the specific instrumentation.
- Differentiate between calibration, validation and verification.
- Demonstrate an understanding of the approach to the validation and/or verification of new equipment, reagents and testing kits (Qualitative and Quantitative).
- Conduct applicable decontamination procedures.
  **RANGE**: *General cleaning, disinfection and sterilisation.*
- Apply the appropriate functional checks to ensure optimal operation of equipment/ instruments and analysers
- Describe and implement troubleshooting procedures when optimal operation is not demonstrated by the instrument on-board functional checks.
- Demonstrate full knowledge of the maintenance procedures, all equipment records and documentation required for good laboratory practice.
  **RANGE:**
  - All glassware – volumetric and graduated
  - Pipettes – glass, automated, air displacement and disposable, pro-pipettes, rubber teats, pipette aids,
  - Balances - top pan and fine analytical chemical,
  - Stirrers, hotplates,
  - pH meters,
  - Rotators, shakers, rollers (flat bed and vortex),
  - Microscopes (light, phase contrasts, inverted and fluorescent),
  - Water baths,
  - Stop watches/timers,
  - Spectrophotometers,
  - Thermometers – min/max, electronic and mercury,
  - Incubators (Haematology related 37°C).
  - Staining instruments and automated analysers are included in this range – knowledge of the makes and models in use in the current workplace.
  - Fridges
  - Freezers
  - Bio-hazardous safety cabinets – Class I and II
  - Fume cupboards
  - Centrifuges (safety, temperature controlled, ultra)

Laboratory instrumentation and automated analysers are included in this range – knowledge of the principles of instruments in use in the current workplace is required.

## 3.4 LABORATORY REAGENTS

### Objective

Provide details of the correct preparation, storage and disposal of laboratory reagents.

### Specified outcomes

On completion of this section the intern/student should be able to:

- Differentiate between controls and calibrators.
- Demonstrate knowledge of the objective, use and retention of package inserts/ instructions for use (IFU's).
- Prepare, store, and safely dispose of laboratory reagents including working reagents
- Define terms and solutions used in the laboratory:

  **RANGE:** *Physiologically normal saline*
  *Buffer*
  *Stock solutions*
  *Working solutions*
  *Working reagents*
  *Reagent kits*

## 3.5 STOCK CONTROL

### Objective

Outline the processes involved in good materials stock management**.**

### Specified outcomes

On completion of this section the intern/student should be able to:

- Demonstrate knowledge of the basic principles to apply when managing merchandise stock.
- Demonstrate an understanding of the receipt of stock including the required records regarding condition of goods, expiry dates and lot numbers.
- Demonstrate an understanding of stock rotation with particular reference to expiry dates.
- Describe the correct storage conditions for all stock.
- Differentiate between open vial stability and expiry date.
- Demonstrate knowledge of workplace policy with regard to the use of expired reagents, controls and calibrators.

## 3.6 QUALITY ASSURANCE / ACCREDITATION

### Objective

Expose the intern/student to all aspects of quality assurance / accreditation.

### Specified outcomes

On completion of this section the intern/student should be able to:

- Discuss quality assurance and quality control in the correct context.
- Define and apply the appropriate processes of quality assurance in the pre-analytical, analytical and post analytical areas of specimen handling.
- Identify the need for releasing, communicating, and reporting of urgent/ critical/ panic value laboratory results, following prescribed protocols.
- Discuss the correct protocol to be followed when erroneous laboratory reports are released and amended reports are issued.
- Demonstrate general knowledge on Accreditation system and process, related to International Organisation for Standardisation (ISO 15189).
- Demonstrate general knowledge on the use, performance and evaluation of RISK assessments.
- Define and explain all quality assurance terminology.
  **RANGE:** *Non-conformance*
  *Corrective action*
  *Preventive action*
  *Root cause analysis*
  *Continual improvement of quality assurance and quality control processes*
  *Audits – Internal & External (Onsite, virtual, desktop, horizontal, vertical, witnessing)*

## 3.7 QUALITY CONTROL

### Objective

Expose the intern/student to all aspects of quality control.

### Specified outcomes

On completion of this section the intern/student should be able to:

- Describe and apply the appropriate quality control processes which must be performed and applied to all the analyses as well as equipment and reagents in this syllabus.
- Explain the principles of internal and external quality control procedures in the context of the tests performed.
- Understand and interpret LJ and SDI graphs.
- Apply a sound knowledge of all the principles, procedures and interpretation of all related internal and external, ***quantitative*** quality control data.
- Apply a sound knowledge of all the principles, procedures and interpretation of all related internal and external, ***qualitative*** quality control data
- Describe the potential causes and apply appropriate troubleshooting procedures in the event of failed Internal and external, quantitative and qualitative quality control.
- Define all terminology used in the assessment of quality control results.
  **RANGE:** *Westgard rules, shift, trend, outlier, positive and negative bias, specificity, sensitivity, systematic error, random error, delta difference, reference range, linearity, reportable range, Uncertainty of measurement, Accuracy, Precision, Biological variance.*

## 3.8 METHOD VALIDATION

### Objective

Expose the intern/student to all aspects of method validation.

### Specified outcomes

On completion of this section the student should be able to:

- Differentiate between validation and verifications in terms of relevant ISO standards (ISO 15189).
- Demonstrate an understanding of the approach to the validation and/or verification of new equipment, reagents and testing kits (Qualitative and Quantitative)
- Differentiate between the terms sensitivity and specificity used in the validation/ verification of qualitative test kits.
- Differentiate and explain the different statistical analysis terms in the below range. (No calculations)
- **RANGE:** *Bias (proportional and constant),*
  *Total Error percentage (TE%),*
  *Biological variation,*
  *T-Test,*
  *Slope,*
  *Intercept,*
  *R-value,*
  *Upper and Lower limit of acceptance,*
  *reference range / normal range; analytical range / reportable range;*
  *linearity,*
  *specificity;*
  *sensitivity,*
  *within run and between run precision studies,*
  *correlation*

## 3.9 PERSONNEL

### Objective

Provide knowledge of basic requirements for personnel in terms of relevant ISO standards (ISO 15189).

### Specified outcomes

On completion of this section the intern/student should be able to:

- Describe the personal documents and records which are required for all laboratory personnel which falls within the scope of practice of Medical Technologists & Medical Laboratory Scientists.
- Demonstrate an understanding of the terms of 'training', 'competency' and 'ongoing competency' in terms of the training of all laboratory personnel which falls within the scope of practice of Medical Technologists & Medical Laboratory Scientists.
  **RANGE**: *Personnel qualifications documentation, job descriptions, personal introduction to the organisational environment program, training provision, competence assessment per person, reviews of staff performance, continuing education and professional development, and personal records of relevant skills.*

## 3.10 DOCUMENTATION

### Objective

Provide knowledge of basic requirements of documentation in terms of relevant ISO standards (ISO 15189).

### Specified outcomes

On completion of this section the intern/student should be able to:

- Demonstrate knowledge of document control requirements in terms of relevant ISO standards.
- Demonstrate knowledge of the required content of SOP's including the minimum content of the cover page.
- Identify the minimum required content of a laboratory report according to ISO standards.
- Demonstrate knowledge on editable and final / non-editable types of records.
- Know the process on how to render documents obsolete.
- Demonstrate knowledge on the retention and disposal in terms if relevant ISO.
- Demonstrate knowledge on document control and regular review of prescribed documentation.
- Differentiate between a record and document.

  **RANGE:** *Policies*
  *Procedures (SOPs)*
  *Working instructions*
  *Raw data*
  *Equipment records*
  *Quality control records*
  *Personnel records*
  *Package inserts/ IFU's*

# 4. LABORATORY RELATED MATHEMATICS

## Objective

Provide the intern/student with instruction on the application of the correct mathematical formulae to relevant calculations.

## Specified outcomes

On completion of this section the intern/student should be able to:

- Demonstrate proficiency in the calculations required for the preparation of solutions.
  **RANGE**: *Physiological saline,*
  *Percentage solutions*
- Demonstrate the proficiency in the use of the correct formula used in the calculation of their patients' haematological results:
  **RANGE:**
  Red Cell Parameters (HCT (*L/L*) and PCV (%), MCV, MCH, MCHC and RDW),
  Mentzer Index,
  absolute and relative differential white cell counts,
  correction for the presence of nucleated red cell parameters,
  percentage haemolysis,
  mean corpuscular fragility,
  percentage parasitaemia,
  International Normalised Ratio (INR),
  absolutereticulocyte count (ARC),
  reticulocyte percentage,
  corrected reticulocyte count (CRC),
  reticulocyte maturity index / reticulocyte production index (RMI/RPI)
- Demonstrate proficiency in the calculations required for the preparation of solutions or patients' samples: Normal solutions, percentage solutions, molar solutions, titrations/dilutions, serial and doubling dilutions.
- Apply SG and purity in the preparation of molar/ molal solutions.
- Calculate parameters used in the assessment of quality control results: SD, SDI, CV, mean, median, reference range.

**Note: SI Units applicable.**
*(Exception: Traditional unit for Haemoglobin and MCHC is g/dL)*

## 5. MOLECULAR BIOLOGY

### Objective

Provide intern/student with a comprehensive knowledge of molecular biology as applied to techniques throughout the Medical Laboratory Technology disciplines.

### Specified outcomes

At the end of this training the intern/student will be able to:

- Describe workflow dynamics in a molecular biology laboratory.
- Demonstrate and apply knowledge of the methods used for the prevention of contamination in a molecular laboratory. (i.e. blood vs bone marrow, DNA vs RNA, 24hours vs 96hour sample, ice vs requirement).
- Demonstrate a fundamental knowledge of the function of DNA in terms of structure, replication, transcription and translocation.
- Describe the principles of DNA and RNA extraction.
- Discuss the principle of the polymerase chain reaction (PCR) and the steps involved.
  **RANGE:** *Denaturation*
  *Annealing*
  *Extension*
- List the components of a PCR master mix and explain the purpose and action of each component.
- Discuss the role of primers used within a PCR laboratory.
- Demonstrate knowledge of the quality controls used in the assay procedure.
- Identify the potential causes of false positive and negative results.
- Identify potential causes of interference in the PCR process.
- Understand the principles and testing limitations of real-time PCR using dyes such as SYBR® Green, hybridization probes and hydrolysis probes.
- A basic understanding of the PCR graph and Ct values (how the Ct values are used in quantitative and semi-quantitative PCR's)
- Understand the difference between conventional PCR and real-time PCR.
- Understand the principle and purpose of reverse transcription PCR (cDNA synthesis)
- Understand the difference between multiplex and single plex PCR's.
- Demonstrate basic practical knowledge of the techniques utilized for the automated extraction, amplification and detection.
- Prepare specimens for analysis according to documented laboratory procedures.
- Explain the principle and basic introductory level information of agarose gel electrophoresis.
- Describe the application of molecular based testing for the following haematological diseases and the role of each relevant molecular marker in disease pathogenesis:
  **RANGE:** *BCR/ABL in CML, PML/RARA in APL,*
  *FLT3 and NPM1 mutations in AML,*
  *Mutations associated with myeloproliferative neoplasms (i.e. JAK2 & MPL mutations)*
  *Mutations associated with Thrombophilia (i.e. Factor V Leiden).*
- Understand the application and relevance of up to and including the following:
  **RANGE:** *BCR/ABL kinase, PML/RARA, FLT3, Factor V Leiden, NPM1, MTHFR, CEBPA, STRs and any other relevant mutations within the context of haematological diseases.*

## 5.1 CYTOGENETICS and FISH

### Objectives

To provide the students with a comprehensive knowledge of cytogenetic techniques and FISH as applied to haematological disease and malignancy.

### Specific outcomes

At the end of this training the intern should have an understanding of:

- **Karyotyping of Haematology Samples (Cytogenetics):**
  - Sample types used
  - Setting up
  - Sample processing
- **Fluorescence in situ hybridization (FISH)**
  - Pre-treatment according to sample type
  - Reporting and interpretation.
- The use of cytogenetic karyotyping and FISH as diagnostic tools for haematological neoplasm's along with other relevant applications such as morphology, cytochemical staining and flow cytometry.

**RANGE:**

All cytogenetic abnormalities that are relevant to Haematological neoplasm's, including AML, ALL, Chronic Lymphoproliferative and Myeloproliferative Neoplasms that are included in the syllabus.

## 5.2 FLOW CYTOMETRY / IMMUNOPHENOTYPING

### Objectives

To provide all students with a comprehensive knowledge of Flow Cytometry as it is applied to haematological disease.

### Specific Outcomes

At the end of this training session the intern will be able to:

- Display an understanding of the operation of a flow cytometer: light source, fluidics, optics scatter plots.
- Will be able to identify specific antigen markers associated with haematological associated disorders as required in this syllabus (haematological neoplasms).
- Understand updated methods of gating techniques used in immunophenotyping.
- Will have an in-depth knowledge of CD4 analysis, pertaining to gating techniques by MultiTest type analysis and PLG, including reflex testing for CrAg FLA.
- Perform CD34+ enumeration, with an understanding of gating techniques such as the International Society for Hematotherapy and Graft Engineering (ISHAGE) and other commercially available kits.
- Understanding of markers used in the identification of PNH.
- Understand any other relevant immunophenotypic technique used in the diagnosis and monitoring of haematological disease.

# 6. HAEMATOLOGY

## 6.1 ROUTINE INVESTIGATIONS

### 6.1.1 Full Blood Count

**Objectives**

To provide an in-depth knowledge of the concept behind the automated analysers in medical laboratories, their parameter array and expected ranges so that they can sufficiently interpretindividual results and make an informed decision on further required action.

**Specific outcomes**

At the end of this section the intern/ student should be able to:

- Process specimens with the use of an automated full blood count analyser (and stainer where required), using recognised standard operating procedures (SOP's).
- Have a sound knowledge of the principles required in operating Haematology analysers with regard to full blood count and automated differential count as listed in the range 6.1.1 Full Blood Count. Utilize the correct units for reporting the results of the parameters and cell lines.
- Demonstrate knowledge of the interpretation of the histograms and scatter plots generated by the auto-analyser in use at the workplace. (i.e. population distribution, sizing etc*). For examination purpose: Taking into account the variety of instruments placed, a broad general understanding of concepts that are familiar to most light scatter, impedance and staining.*
- Describe the relevant changes in the FBC results which could be expected in the clinical conditions identified in this syllabus.
- Demonstrate knowledge of the reference ranges for all the parameters and cell lines in the range.
- Reveal satisfactory knowledge of troubleshooting and resolving method failures and inadequacies resulting in abnormally obtained results *(ie errors, factors and specimen characteristics which may cause false low/high and abnormal FBC, histogram and scatterplot results).*
- Follow the correct processes in the handling of critical/life threatening results.
- Correlate laboratory results with physiological and pathological conditions. Thus, offering an insightful interpretation of anomalous parameters.
- In addition, knowledge of both external and internal quality control programmes, interpretation of Levy Jennings charts, reference ranges and calibration procedures for analysers is required.

**RANGE:**

- Leukocytes - White Blood Cell/White Cell Count (WBC/WCC) and their parameters: neutrophils, lymphocytes, monocytes, eosinophils basophils and any additional instrument count flags and corrected White Cell Count.
- Haemoglobin (HB/HGB) and its related parameters: Red Blood Cells (RBC), Haematocrit/Packed Cell Volume [HCT (L/L) and PCV (%)], Mean Cell Volume (MCV), Mean Cell Haemoglobin (MCH), Mean Cell Haemoglobin Concentration (MCHC), Red Cell Distribution Width (RDW).
- Platelets and its related parameters: Platelet Distribution Width (PDW), Platelet Volume (PDW) and Mean Platelet Volume (MPV).
- Reticulocytes and its related parameters: Reticulocyte Percentage, Absolute Reticulocyte Count, Low, medium and high reticulocyte fluorescence. Reticulocyte Production Index (RPI).

### 6.1.2 Bone Marrow samples

**Specific Outcome**

On completion of this section, the student should have an in-depth knowledge of the following:

- How to make a bone marrow aspirate wedge preparation.
- Prepare aspirates for cytogenetic and molecular studies.
- Other slide preparations required from bone marrow aspirates, such as: crush and imprints.
- Safety precautions required for all procedures in the bone marrow room.

***Note:*** *In addition, refer to section 4. Haematology Related Mathematics and 3.6 & 3.7 Laboratory Quality Management System.*

## 6.2 MISCELLANEOUS TESTS

**Objectives**

The objective is to ensure that the student is equipped to perform all related tests, with an understanding of the principle's methodology interpretation and troubleshooting.

**Specified outcomes**

At the end of this training the student should be able to:

- Have a sound knowledge on test performance and relevant staining techniques within the range in accordance with laboratory procedures which will include morphological assessment of normal and abnormal cells (relative and absolute values), microscopic assessment of erythrocytes and platelets to be included. As Seen in *6.3 Morphology*.
- Describe and apply the appropriate technical precautions during the testing process.
- Collection and handling of blood samples including knowledge of anticoagulants and their effects on both morphology and test results.
- Utilise the correct units for reporting the results of the tests.
- Describe the principles of the test processes.
- Reveal satisfactory knowledge of troubleshooting and resolving method failures and inadequacies resulting in abnormally obtained results.
- Have an in-depth knowledge of technical limitations and factors affecting the final results.
- Demonstrate an in-depth knowledge of the interpretation and clinical significance of the final result of the test required.

**RANGE:**

*Erythrocyte Sedimentation Rate (ESR) manual and automated;*
*Manual Reticulocyte preparation;*
*Buffy Layer Preparation;*
*Cytospin Preparation;*
*Spinner Preparation;*
*Wedge Preparation;*
*Malaria Thick and Thin Preparation and any other relevant tests.*

## 6.3 MORPHOLOGY

**Objective**

The objective is to provide an in-depth knowledge of peripheral blood, bone marrow and related body fluid morphological features (normal and abnormal). The student will cover all areas of morphological analysis, and interpretation for the diagnosis of haematological conditions.

**Specified Outcomes**

At the end of this section the student must be able to recognise and interpret peripheral blood, bone marrow pictures in correlation with the knowledge of cytochemical stains (6.6), Cytogenetics (5.1) Immunophenotyping / Flow Cytometry (5.2), and molecular techniques/Molecular Biology, including PCR (5), and any other relevant investigations used to confirm a diagnosis.

**RANGE:**

- **Normal morphology**

- **Anaemia:**

  - Iron deficiency and other microcytic hypochromic anaemias (eg Lead poisoning)
  - Sideroblastic anaemia
  - Megaloblastic anaemia and macrocytic anaemia
  - Haemolytic anaemia: Red cell membrane defects, enzyme defects, haemoglobinopathies, Thalassaemia, PNH, Immune haemolysis
  - Haemolysis due to drugs and chemicals.
  - Symptomatic Anaemia including: Anaemia of Chronic disorders, haemorrhage, normocytic anaemia
  - Microangiopathic / Macroangiopathic fragmentation haemolytic anaemias.
  - Aplasia/ hypoplastic anaemia/ pancytopaenia
  - Anaemia of pregnancy
  - Methhaemoglobinaemia

- **White cell disorders:**

  - Disorders of the neutrophil
  - Pathological variations in white cell values
  - Neutropaenia and agranulocytosis
  - Leukaemoid reactions
  - Leucoerythroblastic reactions and Leucoerythroblastic pictures

- **Myeloproliferative disorders:**

  - Essential Thrombocythaemia
  - Chronic Myeloid leukaemia
  - Polycythaemia
  - Myelofibrosis
  - All myeloproliferative disorders identified by the WHO classification.

- **Lymphoproliferative disorders:**

    - Chronic Lymphocytic leukaemia and all other lymphoproliferative disorders. Knowledge of all the subtypes within the WHO is required.
    - Classification of all Lymphomas.
    - Myeloma and related plasma cell disorders.
    - Infectious mononucleosis and other viral disorders
    - Reactive lymphocytosis

- **Lipid storage diseases and histiocytosis**

- **Acute leukaemia's**

    - Recognition of all subtypes including knowledge of all available classifications

- **Platelet disorders:**

    Recognition and knowledge of both quantitative and qualitative disorders:

    - Immune thrombocytopaenia
    - Bernard Soulier Syndrome
    - May Hegglin Anomaly
    - Thrombophilia
    - Glanzmann's Thrombasthenia
    - Any other relevant disorders

- **Inclusion bodies in both white cells and red cells**

- **Blood Parasites:**

    - Malaria
    - Trypanosomes
    - Leishmania
    - Microfilaria
    - Spirochaetes and Borrelia (consider taxonomy listing)
    - Babesiosis
    - Histoplasmosis
    - Borrelia

- **Myelodysplastic Syndromes:**

    - WHO Classification of myelodysplastic syndromes

- **Miscellaneous:**

    - Hyper and Hypo splenism
    - Haemolytic Uraemia Syndrome and renal disorders
    - Malignancy
    - Collagen diseases
    - Haematological effects of HIV on cell morphology.

## 6.4 COAGULATION

**Objective**

The objective is to provide an in-depth knowledge of haemostasis and its related disorders. The student will cover normal and abnormal features of coagulation.

**Specific outcomes**

At the end of section, the intern should have acquired theoretical and practical knowledge with regard to haemostasis. They must demonstrate an in-depth knowledge of principles, interpretation of all necessary tests and results, including trouble shooting in the investigation of the following:

**RANGE:**

- Disorders of both the extrinsic and extrinsic coagulation pathways
- Disorders of the fibrinolytic, coagulation and kinin (theory only) systems
- Thrombosis and anticoagulant therapy
- Vascular disorders
- Factor Inhibitors
- Disseminated intravascular coagulation
- Platelet disorders
- Von Willebrand disease
- Lupus anticoagulant
- Hypercoagulability states
- Haemophilia
- PCR related tests:
    - Factor V Leiden
    - Prothrombin G20210A
    - MTHFR
- Lupus Anticoagulants

## 6.5 HAEMOLYTICS

**Objective**

The objective is to provide an in-depth knowledge of haemolysis and its related disorders.

**Specific Outcome**

At the end of section, the intern must be able to perform and interpret all the necessary tests needed to investigate the following haemolytic disorders. In addition, an in-depth knowledge of general concepts in the diagnosis of haemolytic anaemia is required.

**RANGE:**

- Hereditary haemolytic anaemia due to red cell membrane defects
- Hereditary spherocytosis: Erythrocyte membrane skeleton (EMS proteins)
- Enzyme deficiencies
- Drug induced haemolytic anaemia due to G6PD deficiency
- The non-spherocytic congenital haemolytic anaemias
- Haemoglobinopathies
- Immune haemolytic anaemias
- Haemolytic anaemia due to drugs and chemicals
- Thalassaemias
- Intravascular Haemolysis
- HPFH

## 6.6 STAINS

**Specific Outcome**

At the end of this section the intern must be familiar with the principles, interpretation and troubleshooting of the following laboratory procedures:

- Preparation of thin and thick smears
- Preparation of Giemsa stains and all other staining techniques used in routine haematology.
- Full blood counts
- Bone Marrow smears
- Reticulocyte counts
- Concentration techniques: Buffy layers

**RANGE:**

- Romanowsky Stains
- Reticulocyte Stain
- Perl's Prussian Blue
- Staining for Heinz bodies & Hb H inclusion
- **Special stains** (Theoretical knowledge only):
    - Sudan Black
    - Myeloperoxidase
    - Periodic Acid Schiffs
    - Non – Specific Esterases
    - Chloroacetate Esterase Stain
    - Leucocyte/neutrophil alkaline phosphatase
    - Acid Phosphatase (with and without tartrate)

## 6.7 IMMUNOHAEMATOLOGY

**Objective**

Is to provide an in-depth knowledge of routine haematology related immunohaematology.

**Specific Outcome**

At the end of this section the intern must be familiar with the principles and interpretation of the following laboratory procedures:

**RANGE:**

- Blood groups and their pattern of inheritance.
- Direct antiglobulin test (DAT) and Indirect antiglobulin test (IAT) (*Coomb's test*)
- Forward and reverse Blood grouping and Rh.
- Specific antibody identification and titration of clinically relevant antibodies.
- Blood group related phenotyping.

## 6.8 SPECIFIC TESTS

**Objective**

To have in depth working understanding of all tests routinely performed in a haematology department.

**Specific Outcome**

At the end of this section the intern must be familiar with the principles, interpretation and troubleshooting of the following laboratory procedures:

**RANGE:**

Prothrombin Time (PT)
International Ratio (INR)
Activated Partial Thromboplastin Time (APTT)
Fibrinogen
Fibrinolytic studies: D-Dimer
Factor deficiency identification (Factor assays and correction studies)
Factor inhibitors screening and assays
Bleeding times
PFA100/200
Procedures for the detection of thrombophilia (Antithrombin III, Protein C and S)
Quantitative and qualitative platelet studies (platelet aggregation)
Osmotic Fragility
G6PD screen and assay
PK assay (theory only)
Hb A2
Haemoglobin Electrophoresis (Acid and Alkali)
HPLC
Kleihauer test
Test for sickle cells: Sodium metabisulphite, *E.coli* and $O_2$ reduction
Haemoglobin F (Elution method)
Detection of Haemoglobin H
Isopropanol test for unstable haemoglobin
Cold Agglutinin Titre
Direct antiglobulin test (DAT) and Indirect antiglobulin test (IAT)
Donath Landsteiner
Serum and Urine muramidase (Theory Only)
Urinary haemosiderin
Plasma viscosity
Blood Groups. Basic Blood Transfusion

## 7. CLINICAL APPLICATIONS

We are not clinicians, and clinical symptoms and presentation will not be specifically asked in the examination. It is however, important to know the clinical presentation of all the diseases related to the haematological tests as set by the syllabus. These clinical symptoms are given as a guide to interpretation. The student is required to know specific symptoms and complications due to treatment related haematology such as the effect of heparin and warfarin on the coagulation system.

## 8. REFERENCE MATERIAL


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## 9. NOMENCLATURE / ACRONYMS

**APTT** – Activated Partial Thromboplastin Time
**CEBPA**- Enhancer–binding protein alpha
**CEUs** – Continual Education Units
**CSF** – Cerebrospinal fluid
**CV** – Coefficient Variant
**DIC** – Disseminated Intravascular Coagulation
**DNA** – Deoxyribonuclease
**ESR** – Erythrocyte Sedimentation Rate
**FAB** – French American British
**FBC** – Full Blood Count
**FISH** – Fluorescent in situ Hybridization
**G6PD** – Glucose-6-Phosphate Dehydrogenase
**GLP** – Good Laboratory Practice
**Hb/HGB** - Haemoglobin
**HCT** - Haematocrit
**HPCSA** – Health Professions Council of South Africa
**HPLC –** High Performance liquid Chromatography
**INR** – International Standard Ratio
**LIS** – Laboratory Information System
**MCH** – Mean Cell Haemoglobin
**MCHC** – Mean Cell Haemoglobin Concentration
**MCV** – Mean Cell Volume
**MPV** – Mean Platelet Volume
**MTHFR** – Methylene tetrahydrofolate reductase
**NPM1** – Nucleophosmin
**PCR** – Polymerase Chain Reaction
**PCV** – Packed Cell Volume
**PDW** – Platelet Distribution Width
**PK** – Pyruvate Kinase
**PNH** – Paroxysmal Nocturnal Haemoglobinuria
**PT** – Prothrombin Time
**RBC** – Red Blood Cell
**RCC** – Red Cell Count
**RDW** – Red Cell Distribution Width
**RMI** – Reticulocyte Maturation Index
**RNA** - Deoxyribonuclease
**RPI** – Reticulocyte Production Index
**SD** – Standard Deviation
**SOP** – Standard Operating Procedure
**STRs** – Short Tandem Repeat
**TREC –** T Cell Receptor Excision Circles
**TERT –** Telomerase Reverse Transcriptase
**WBC** – White Blood Count
**WCC** – White Cell Count
**WHO** –World Health Organisation

***APPENDICES***