



The IFCC Curriculum

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Contents

INTRODUCTION	4
SECTION A: Laboratory Organisation and Management	9
Section A1: Laboratory Principles and Procedures: Learning Objectives	10
Section A2: Senior Laboratory Management: Learning Objectives	10
Section A3: Evidence Based Laboratory Medicine (EBLM): Learning Objectives	11
SECTION B: Analytical Section	12
Section B1: Generic Laboratory Equipment: Learning Objectives	13
Section B2: Basic Techniques: Learning Objectives	13
Section B3: Laboratory Instruments – Routine: Learning Objectives	13
Section B4: Laboratory Instruments – Spectroscopy: Learning Objectives	14
Section B5: Laboratory Instruments – Electrophoresis: Learning Objectives	14
Section B6: Laboratory Instruments – Chromatography: Learning Objectives	14
Section B7: Laboratory Instruments – X-Mass Spectrometry: Learning Objectives	15
Section B8: Laboratory Instruments – Not otherwise classified: Learning Objectives	17
Section B9: Analytes: Learning Objectives	17
Section B10: Laboratory Calculations: Learning Objectives	23
SECTION C: Clinical Section	24
Section C1. Fluid and Electrolyte Disorders: Learning Objectives	25
Section C2. Acid-Base Regulation and Pulmonary Function: Learning Objectives	26
Section C3. Disorders of Kidney and Urinary Tract: Learning Objectives	27
Section C4. Immunology: Learning Objectives	28
Section C5. Diabetes Mellitus: Learning Objectives	30
Section C6. Gastrointestinal and Pancreatic Disease: Learning Objectives	31
Section C7. Hepatobiliary Disease: Learning Objectives	33
Section C8. Lipids and Disorders of Lipoprotein Metabolism: Learning Objectives ...	34
Section C9. Cardiovascular Disorders and Hypertension: Learning Objectives	35
Section C10. Calcium, Magnesium, Parathyroid, Bone Disorders: Learning Objectives	36

Section C11. Iron and Haemoglobin Disorders, including the Porphyrin's: Learning Objectives	37
Section C12. Vitamins and Trace Elements: Learning Objectives	38
Section C13. Pregnancy and Prenatal Diagnosis: Learning Objectives	40
Section C14. General Paediatric Clinical Chemistry: Learning Objectives	41
Section C15. Inborn Errors of Metabolism: Learning Objectives	42
Section C16. Endocrinology: Learning Objectives	43
Section C17. Neurological and Psychiatric Disorders: Learning Objectives	45
Section C18: Biochemical Aspects of Monitoring Malignant Disease: Learning Objectives	46
Section C19: Musculoskeletal Diseases: Learning Objectives	47
Section C20: Therapeutic Drug Monitoring and Toxicology: Learning Objectives	47

INTRODUCTION

The IFCC curriculum is being developed as a guide for its member societies in their development of syllabuses for postgraduate trainees in laboratory medicine, appropriate for use in their own countries.

It is also intended to provide a resource for trainees in planning their private study in preparation for academic and professional qualifications which lead to formal recognition of expertise and status as experts and leaders in the field of laboratory medicine.

The curriculum has been developed in response to a request from some National Societies, by the Committee on Distance Learning (C-DL) and will inform the development of the IFCC e-Academy. The C-DL is grateful to the following National Societies which submitted their own curricula for us to consult in considering format and content:

- Australia and New Zealand
- Canada
- Croatia
- Netherlands
- Romania
- Slovak Republic
- South Korea
- Sweden
- Switzerland

A laboratory medicine expert is expected to have a comprehensive knowledge of the science and medicine on which the specialty is based and to use this knowledge to develop and provide a safe, effective, efficient and high quality service to its users. The curriculum is designed to provide a framework of learning both practical and theoretical components through which this expertise can be achieved.

Learning Skills

IFCC recommends a stepwise approach to the acquisition and application of knowledge by trainees. Bloom's taxonomy defines six categories and cognitive processes.¹, refined in 2001.² Each category is shown with appropriate verbs that may be used to construct learning objectives or assessment questions.

- **Remembering** - retrieving, recognizing, and recalling relevant knowledge
Define, memorise, list, name
- **Understanding** - constructing meaning through interpreting, exemplifying, classifying, summarizing, inferring, comparing, and explaining
Restate, discuss, describe, identify, report, explain, review, recognise
- **Applying** - carrying out or using a procedure through executing, or implementing
Translate, interpret, apply, illustrate, demonstrate, use
- **Analysing** - breaking information into parts to explore understanding and relationships through differentiating, organizing, and attributing
Distinguish, differentiate, appraise, analyse, calculate, compare, contrast
- **Evaluating** - making judgements based on criteria and standards through checking and critiquing
Appraise, evaluate, revise, score, estimate, choose, assess
- **Creating** - putting elements together to form a coherent or functional whole; generating new ideas, products or ways of viewing things
Compose, plan, propose, design, prepare, organise

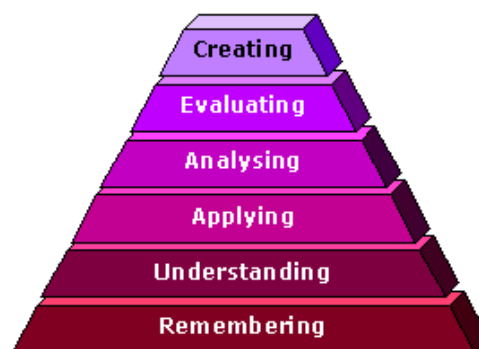


FIGURE I: IN DIAGRAMMATIC FORM, THE PINNACLE OF THE LEARNING PROCESS, CREATING AND EVALUATING ARE KEY FUNCTIONS FOR THOSE IN THE MOST SENIOR PROFESSIONAL ROLES.

¹ Bloom B S (ed.) (1956) Taxonomy of Educational Objectives, the classification of educational goals – Handbook I: Cognitive Domain New York: McKay)

² (Bloom B S (ed.) (1956) Taxonomy of Educational Objectives, the classification of educational goals – Handbook I: Cognitive Domain New York: McKay)

Program Learning Objectives

Many components contribute to safe and effective laboratory investigation of patients and their diseases. These can be summarised in Figure II

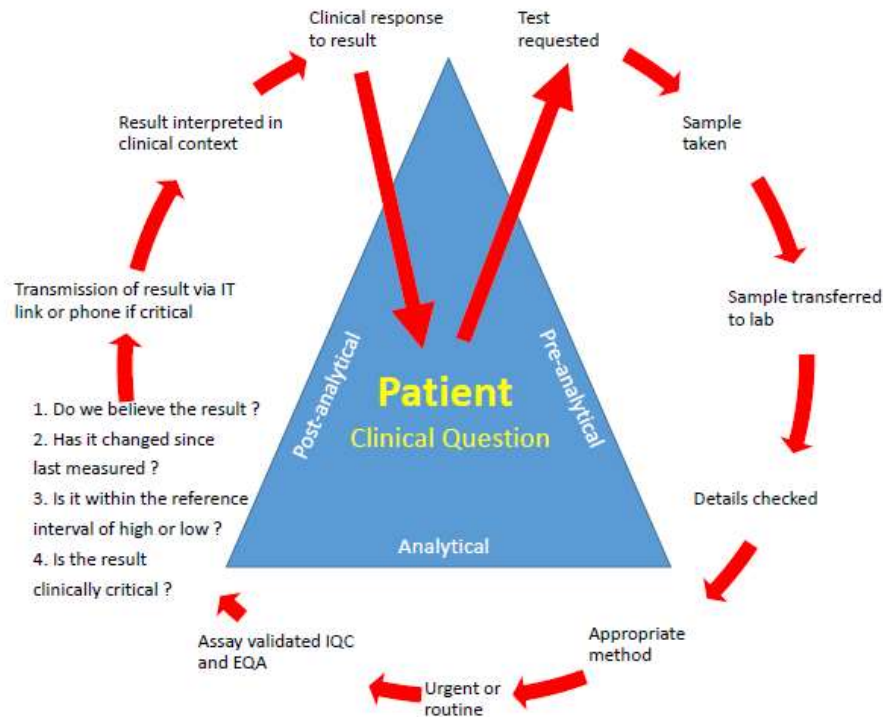


FIGURE II. THE SPECIALIST FUNCTIONS OF A CLINICAL SCIENTIST ARE:

- TO ADVISE ON TESTING PROTOCOLS AND THE APPROPRIATENESS OF TESTING
- TO PRODUCE MEANINGFUL ANALYTICAL RESULTS THAT CAN BE USED WITH CONFIDENCE IN THE DIAGNOSIS AND MANAGEMENT OF PATIENTS WITH DISEASE.
- TO PROVIDE INTERPRETATION OF LABORATORY RESULTS IN THE LIGHT OF CLINICAL FINDINGS IN THE INDIVIDUAL PATIENT.

TO REACH THIS LEVEL OF EXPERTISE THE CLINICAL SCIENTIST MUST HAVE DETAILED KNOWLEDGE OF:

- HUMAN PHYSIOLOGY, BIOCHEMISTRY AND ORGAN FUNCTION
- THE CAUSES, CLINICAL SIGNS AND SYMPTOMS OF DISORDERS OF ORGANS, SYSTEMS, METABOLIC DISEASE AND GENETIC DISEASE
- LABORATORY ANALYSES AND TESTING PROTOCOLS FOR INVESTIGATION OF SUCH DISORDERS
- THE OPTIONS FOR AND PRINCIPLES OF MEASUREMENT OF SPECIFIC ANALYTES
- THE PRE-ANALYTICAL, ANALYTICAL AND POST ANALYTICAL FACTORS THAT MAY INFLUENCE TESTING
- THE LIMITATIONS OF ANALYSES, INCLUDING SPECIFICITY, SENSITIVITY, ACCURACY AND IMPRECISION
- BIOLOGICAL VARIATION, REFERENCE INTERVALS AND CRITICAL TEST RESULTS

Clinical Interpretation

Clinical interpretation of laboratory results is complex and it is important to adopt a systematic approach. There must be procedures in place in the laboratory, to ensure that specimen quality can be guaranteed and that the analytical quality of the result is fit for purpose. The result can then be interpreted with respect to reference intervals, clinically critical limits or significant changes in value and the causes of any abnormal or unexpected laboratory results be considered. It is very useful to have a structured approach to help interpretation of results, particularly those that are unexpected or unfamiliar. Considering the possible underlying pathological processes is an excellent starting point and using an acronym such as the one shown below, provides structure to the thought processes and minimises the risk of missing an important element.

A VITAMIN C DEF

V	vascular	N	neoplastic
I	infective/inflammatory	A	acquired
T	traumatic	C	congenital
A	autoimmune	D	degenerative/developmental
M	metabolic	E	endocrine/environmental
I	iatrogenic/idiopathic	F	functional

Curriculum Structure

The curriculum is designed to represent the three specialties of laboratory medicine; Blood Sciences, Microbiology and Molecular Genetics. Within each of the specialities, clinical and analytical aspects are considered separately and there is further breakdown of the clinical section into subspecialties. These are then subdivided into disease groupings, based on organ system, metabolic disease and genetic disease. Within each of these groupings, individual clinical conditions are specified. Analytical aspects are broken down primarily into technology groupings then further into specific techniques. The whole structure is therefore presented in a hierarchical way. Laboratory Organisation and Management, common to all specialties, is considered separately.

In this version (i.e. version one) of the curriculum, concepts related to Laboratory Organisation and Management and Blood Sciences (Clinical Chemistry and Immunology) have been developed. Future additions to the curriculum will include curricula related to Haematology, Microbiology, and Molecular Genetics.

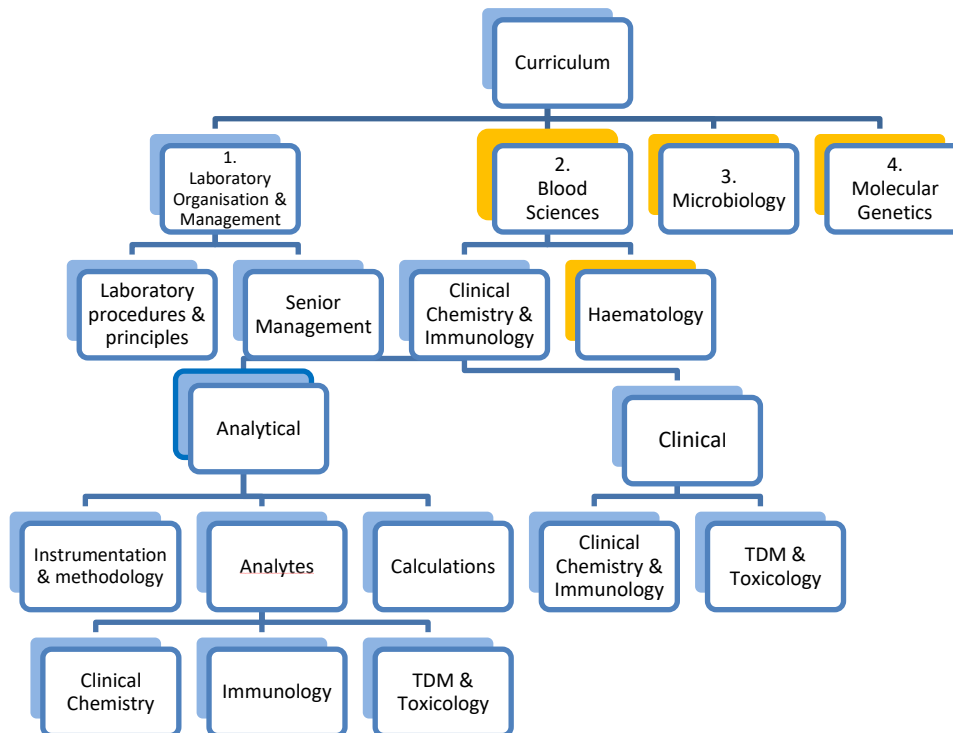


FIGURE III: SUMMARY OF CURRICULUM DESIGN. THE SECTIONS COVERED IN VERSION 1 OF THE CURRICULUM ARE SHOWN IN BLUE. THE YELLOW CELLS INDICATE AREAS OF THE CURRICULUM TO BE DEVELOPED AS PART OF FUTURE VERSIONS.

SECTION A: Laboratory Organisation and Management

Laboratory Organisation and Management skills and concepts are considered in two categories, those which are relevant to all laboratory staff and those which are required by those in senior laboratory roles who have responsibilities for leadership in all aspects of the service.

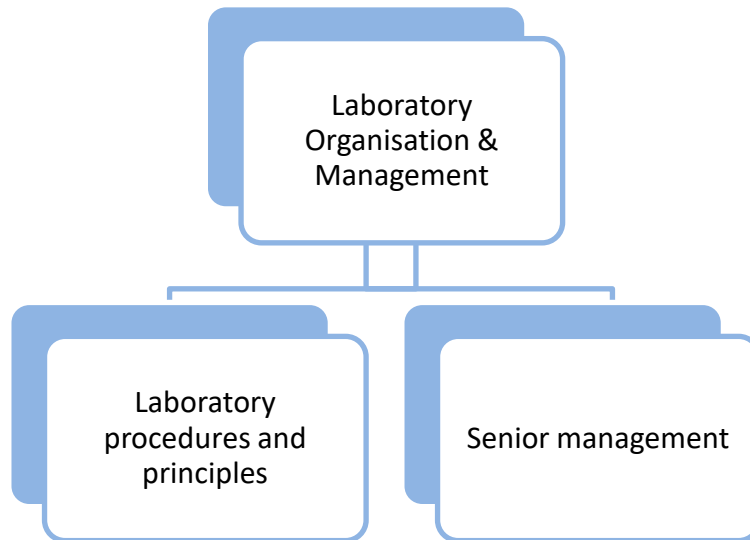


FIGURE A1: HIERARCHICAL STRUCTURE OF LABORATORY ORGANISATION AND MANAGEMENT SECTION OF THE CURRICULUM

Section A1: Laboratory Principles and Procedures: Learning Objectives

Be able to discuss and demonstrate specific skills and competences for laboratory organisation and management

- ✓ Basic instrument and equipment maintenance
- ✓ Basic information communication technology (ICT) skills
- ✓ Basic research skills
- ✓ Basic statistical techniques
- ✓ Biological variation
- ✓ Document control
- ✓ External quality assessment (EQA)
- ✓ Health and safety issues
- ✓ Internal quality control (IQC)
- ✓ Laboratory safety
- ✓ Method evaluation
- ✓ Patient safety
- ✓ Pre-analytical variables
- ✓ Reference intervals (RI)
- ✓ Standard curves
- ✓ Standard operating procedures
- ✓ Temperature monitoring
- ✓ Specimen collection
- ✓ Specimen preparation
- ✓ Waste management
- ✓ Water purity monitoring

Section A2: Senior Laboratory Management: Learning Objectives

Be able to discuss and demonstrate specific skills and competences for laboratory organisation and management at a senior or advanced level

- ✓ Accreditation and ISO15189
- ✓ Advanced communication skills
- ✓ Advanced research skills.
- ✓ Budget management
- ✓ Clinical and professional liaison
- ✓ Evidence-based laboratory medicine
- ✓ Facilitating training and continuing professional development (CPD) for all department staff
- ✓ Initiation of and collaboration in research activities
- ✓ Instrumentation and method selection
- ✓ Laboratory information systems (LIS), hospital information systems (HIS) and interfaces
- ✓ Medico-legal requirement and legislation

- ✓ Personnel management
- ✓ Point of care testing policies and management
- ✓ Professional ethics
- ✓ Requesting and reporting policies
- ✓ System design
- ✓ Total quality management and quality systems
- ✓ Traceability

Section A3: Evidence Based Laboratory Medicine (EBLM): Learning Objectives

Be able to discuss the relevance of evidence based laboratory medicine as applied to your organisation at an advanced level

Core topics

- ✓ Economic Evaluation of Diagnostic Tests.
- ✓ Evaluating the literature: Appraisal instruments; e.g. STEP.
- ✓ Evidence Based Laboratory Medicine (EBLM): definition, how it differs from Evidence Based Medicine (EBM) and why we need it.
- ✓ The EBLM process: Ask, Acquire, Appraise; Act, Audit.
- ✓ Formulation of the Question (PICO; CAPO and other formats).
- ✓ Guideline development, levels of evidence and appraisal. AGREE instrument.
- ✓ Laboratory Medicine and Clinical Outcomes; Applying the Evidence.
- ✓ Meta-analysis
- ✓ The Role of Clinical Audit.
- ✓ Searching the Evidence; PubMed; EMBASE; Cochrane Library.
- ✓ Sources of bias in studies of diagnostic accuracy. STARD criteria.
- ✓ Study design: cross-sectional; cohort and randomized controlled trials (RCTs).
- ✓ Systematic Reviews versus Narrative Reviews.
- ✓ Sources of Guidelines. Cochrane Collaboration.

EBLM: measures of diagnostic performance

- ✓ Sensitivity, Specificity, Predictive Value. Effect of Prevalence.
- ✓ Likelihood Ratios (and their utility), Odds Ratios – Fagan’s nomogram.
- ✓ Receiver Operating Characteristic (ROC) Curve analysis.

Evidence Based Laboratory Medicine and Point of Care Testing (POCT)

- ✓ Outcomes of relevance for laboratory tests, including POCT.
- ✓ Examples of evidence base for POCT including HbA1c, the Emergency Department, self-monitoring of blood glucose and INR testing.
- ✓ POCT troponin testing and rural health; examples from Australia.
- ✓ POCT in the Primary Care environment.

SECTION B: Analytical Section

The Analytical section is sub-divided into 'Instrumentation and Methodology' and 'Analytes' represented as follows for Clinical Chemistry and Immunology. From this section you should aim to be able to discuss the method principle and potential advantages and limitations of instruments and analytical techniques commonly used in Core and Specialist Clinical Laboratories.

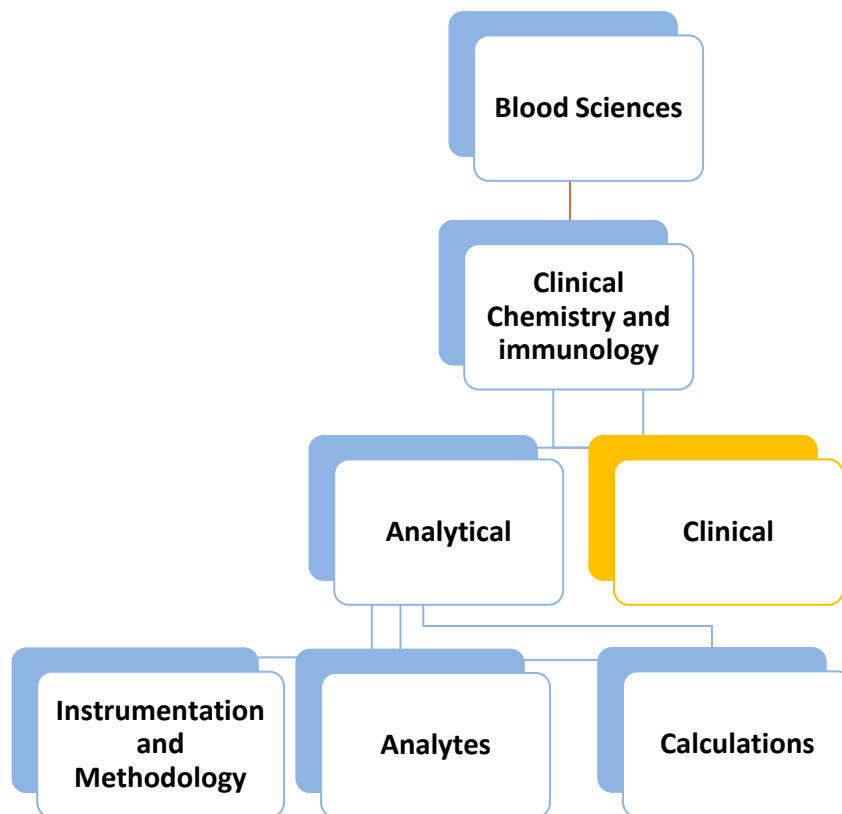


FIGURE B1: HIERARCHICAL STRUCTURE OF BLOOD SCIENCES AS RELATED TO CLINICAL CHEMISTRY AND IMMUNOLOGY SECTION SPECIFICALLY RELATED TO THE ANALYTICAL COMPONENT OF THE CURRICULUM. THE CLINICAL COMPONENT IS SHOWN IN YELLOW TO DEMONSTRATE THE RELATIONSHIP BETWEEN THE ANALYTICAL AND CLINICAL SECTIONS; WHICH IS PRESENTED SEPARATELY IN SECTION C.

Section B1: Generic Laboratory Equipment: Learning Objectives

Be able to discuss the basic principle of use of generic laboratory equipment:

- ✓ Balances
- ✓ Centrifuges
- ✓ Microscopes
- ✓ pH meters
- ✓ Quantities and Units
- ✓ Waterbaths

Section B2: Basic Techniques: Learning Objectives

Be able to discuss the basic techniques as applied in laboratory medicine

- ✓ Buffer preparation
- ✓ Calculations
 - Basic statistics of central tendency
 - Basic statistics of dispersion
 - Addition dilution
 - Serial dilution
- ✓ Centrifugation
- ✓ Dialysis
- ✓ Extraction techniques
 - Liquid-liquid
 - Solid Phase
 - Supported liquid
- ✓ Extractions
- ✓ Filtration
- ✓ Freeze drying
- ✓ Pipetting
- ✓ Ultrafiltration
- ✓ Volumetric measurement
- ✓ Weighing

Section B3: Laboratory Instruments – Routine: Learning Objectives

Be able to discuss the method principle and potential advantages and limitations of instruments and analytical techniques commonly used in a Core Laboratory

- ✓ Absorption, nephelometry and turbidimetry
- ✓ Acid-base measurement
- ✓ Immunoassay and detection systems
- ✓ Ion selective electrodes
- ✓ Main analyser platforms and automation.
- ✓ Osmometry

Section B4: Laboratory Instruments – Spectroscopy: Learning Objectives

Be able to discuss the method principle and potential advantages and limitations of instruments and analytical techniques commonly used in Specialist Clinical Laboratories

- ✓ Luminescence and fluorescence
- ✓ Spectrophotometry
- ✓ Spectrophotometry and ICP-MS
 - Atomic absorption
 - Flame emission photometry

Section B5: Laboratory Instruments – Electrophoresis: Learning Objectives

Be able to discuss the method principle and potential advantages and limitations of instruments and analytical techniques commonly used in Specialist Clinical Laboratories

- ✓ Electrophoresis
 - 2-dimensional
 - Agarose
 - Capillary zone
 - Cellulose acetate
 - Isoelectric focusing (IEF)
 - Immunofixation
 - Isotachopheresis
 - Polyacrylamide

Section B6: Laboratory Instruments – Chromatography: Learning Objectives

Be able to discuss the method principle and potential advantages and limitations of instruments and analytical techniques commonly used in Specialist Clinical Laboratories

- ✓ Chromatography
 - Affinity
 - Column
 - Direct and reverse phase liquid chromatography
 - Gas chromatography
 - Gas vs liquid chromatography
 - High-performance liquid chromatography
 - Ion-exchange
 - High pressure liquid chromatography (HPLC)
 - Partition techniques
 - Planar
 - Principles of chromatography
 - Size exclusion techniques

Section B7: Laboratory Instruments – X-Mass Spectrometry: Learning Objectives

MS - Basic Concepts

Describe the basic principles of mass spectrometry (MS)

Explain the mass to charge ratio and mass spectra

Outline the components of a mass spectrometer, including ionisation sources (electron impact, chemical ionisation, electrospray ionisation), mass filters (quadruple, magnetic), detectors

- ✓ Mass spectrometry
 - Chromatographic separation (see above)
 - Gas Chromatography-MS (GC-MS)
 - Inductively Coupled Plasma MS (ICP-MS)
 - Liquid Chromatography MS (LC-MS)
 - LC-MS-MS
 - Matrix Assisted Laser Desorption/Ionization – Time of Flight (MALDI-TOF)

Discuss the past, current and potential future clinical applications of mass spectrometers, including full scan, selective ion monitoring, multiple reaction monitoring, TOF

Instrumentation

Critically discuss and compare mass spectrometry instruments in terms of their place in clinical testing along with advantage and limitations

- ✓ GC- with single or tandem quadrupoles
- ✓ High- resolution MS
- ✓ ICP-MS
- ✓ LC-MS/MS with single or tandem quadrupoles
- ✓ MALDI-TOF
- ✓ Orbitrap
- ✓ Quadrupole – TOF (Q-TOF)

Principles of Analysis X-MS

Sample Preparation

Critically discuss the approaches to sample preparation in clinical testing along with advantage and limitations of each

- ✓ Derivatisation
- ✓ Dilute and shoot
- ✓ Liquid-liquid extraction (LLE)
- ✓ Protein precipitation
- ✓ Supported liquid extraction (SLE)
- ✓ Solid phase extraction (SPE)

Analytical – chromatography

Discuss the processes of chromatographic separation including the selection of columns and mobile phases

Define the terms isomer and epimer and explain the importance of chromatographic separation

Analytical - quality

Discuss the important considerations to support analytical quality

- ✓ Calibrators including traceability and commutability
- ✓ External Quality Assurance (EQA)
- ✓ Interferences
- ✓ Internal quality control (IQC)
- ✓ Internal standard selection, including non-isotopic, deuterated and carbon 13.
- ✓ Post implementation quality assessment
- ✓ Qualitative scans
- ✓ Quantifiers and qualifier selection
- ✓ Quantitation – calibration curves

Post analytical

Discuss the implementation of mass spectrometry reference intervals

Outline the criteria for accepting an analytical run

Outline the requirements of reporting a result

Setting up a LC-MS/MS assay

Critically discuss the pre implementation quality assessment i.e. method validation required.

Critically discuss the role and selection of mass spectrometry instruments in terms of automation and processes

- ✓ Fully automated solutions
- ✓ Kit-user setting
- ✓ Lab developed tests
- ✓ Near patient testing
- ✓ Identification, optimisation, qualitative assessment, sample preparation to full quantitation

Applications

Discuss the clinical applications of mass spectrometry

- ✓ Creatinine
- ✓ Drug of abuse testing
- ✓ Genomics
- ✓ Glycated haemoglobin
- ✓ Inborn errors of metabolism

- ✓ Metabolomics - Translation from discovery phase to targeted assays and clinical practice
- ✓ Microbiology
- ✓ Non-peptide hormones
- ✓ Peptide hormones
- ✓ Proteomics
- ✓ Therapeutic drug monitoring
- ✓ Toxicology including General unknowns screen – targeted MS/MS or high-resolutions MS
- ✓ Vitamins

Discuss the application of mass spectrometry in a variety of clinical matrices

- ✓ Blood including serum and plasma
- ✓ Dried blood spots
- ✓ Misc e.g. dried urine, dried saliva spots, hair, vitreous humour
- ✓ Saliva
- ✓ Urine

Section B8: Laboratory Instruments – Not otherwise classified: Learning Objectives

Be able to discuss the method principle and potential advantages and limitations of instruments and analytical techniques commonly used in Specialist Clinical Laboratories

- ✓ Cell counters
- ✓ Emerging technologies,
 - Multiplex analysis
 - Nuclear magnetic resonance (NMR) spectroscopy
 - Sensors
- ✓ Enzymology
- ✓ Flow cytometry
- ✓ Isotopic techniques

Section B9: Analytes: Learning Objectives

Be able to identify the clinical relevance of each of these analytes (as applied in Section C)

Be able to discuss the basic methods, including their advantages and limitations, that could be used for the analysis of common analytes measured in laboratory medicine

Be able to discuss the matrix or matrices (including their advantages and limitations) used for measuring a particular analyte

Lung

- ✓ Base Excess
- ✓ Bicarbonate
- ✓ pCO₂
- ✓ pH
- ✓ pO₂

Renal

- ✓ Aluminium
- ✓ Cystatin C
- ✓ Creatinine
- ✓ Potassium
- ✓ Sodium
- ✓ Inulin
- ✓ Urea
- ✓ Uric acid
- ✓ Urine albumin
- ✓ Urine protein
- ✓ Urine creatinine

Liver

- ✓ Albumin
- ✓ Alkaline phosphatase (ALP)
- ✓ Alanine Aminotransferase (ALT)
- ✓ Aspartate Aminotransferase (AST)
- ✓ Bile acids
- ✓ Bilirubin
 - Total
 - Conjugated or Direct
 - Unconjugated or Indirect
 - Fractions
- ✓ Gamma-Glutamyl Transferase (GGT)
- ✓ Insulin like growth factor (IGF)-1
- ✓ Lactate dehydrogenase (LDH)
- ✓ Total protein

Metabolism

- ✓ Ammonia
- ✓ Glucose
- ✓ Lactate
- ✓ HbA1c

Heart - muscle

- ✓ B-type natriuretic peptide (BNP) and Pro-BNP
- ✓ cholesterol
- ✓ Creatine kinase (CK)
- ✓ CK-MB

- ✓ High density lipoprotein (HDL)
- ✓ Low density lipoprotein (LDL)
- ✓ pCO₂
- ✓ triglycerides
- ✓ Troponin I
- ✓ Troponin T

Bone

- ✓ 1,25 di hydroxy vitamin D
- ✓ Calcium
- ✓ Magnesium
- ✓ Phosphate
- ✓ Parathyroid hormone (PTH)
- ✓ Vitamin D

Endocrinology - Pituitary

- ✓ Adrenocorticotrophic hormone (ACTH)
- ✓ Growth hormone (GH)
- ✓ Follicle stimulating hormone (FSH)
- ✓ Luteinizing hormone (LH)
- ✓ Thyroid stimulating hormone (TSH)

Endocrinology - Peripheral

- ✓ 17 hydroxyprogesterone
- ✓ Aldosterone
- ✓ Anti-mullerian hormone (AMH)
- ✓ Cortisol
- ✓ Dehydroepiandrosterone (DHEA)
- ✓ DHEA sulfate (DHEA-S)
- ✓ Estradiol
- ✓ free triiodothyronine (fT3)
- ✓ free thyroxine (fT4)
- ✓ IGF-1
- ✓ IGF Binding protein 3 (BP3)
- ✓ Inhibin
- ✓ Progesterone
- ✓ Steroid hormone profiles
- ✓ Sex hormone binding globulin (SHBG)
- ✓ Testosterone

Dynamic Function Tests

- ✓ Dexamethasone suppression
- ✓ Glucagon stimulation Test
- ✓ Growth hormone releasing hormone (GHRH)-Arginine Test
- ✓ Insulin Tolerance Test
- ✓ Metyrapone Suppression Test

- ✓ Oral Glucose Tolerance Test (OGTT)
- ✓ OGTT for growth hormone (GH) suppression
- ✓ Synacthen stimulation
- ✓ Water deprivation

Gastrointestinal - nutrition

- ✓ Amylase
- ✓ Ceruloplasmin
- ✓ Copper
- ✓ Faecal calprotectin
- ✓ Faecal elastase
- ✓ Ferritin
- ✓ Insulin
- ✓ Intestinal permeability
- ✓ Iodine
- ✓ Lead iron
- ✓ Lipase
- ✓ Phorphyrin screen
- ✓ Selenium
- ✓ Vasoactive intestinal peptide (VIP)
- ✓ Vitamin A - retinol
- ✓ Vitamin B1
- ✓ Vitamin B2
- ✓ Vitamin B3
- ✓ Vitamin B6
- ✓ Vitamin B9 – folate
- ✓ Vitamin B12
- ✓ Vitamin C
- ✓ Vitamin D
- ✓ Vitamin E
- ✓ Vitamin K
- ✓ Transferrin
- ✓ Zinc

Biomarkers of Cancer

- ✓ Alpha foeto protein
- ✓ 5-hydroxyindoleacetic acid (5HIAA)
- ✓ Carbohydrate antigen (CA) 19-9
- ✓ CA125
- ✓ Calcitonin
- ✓ Catecholamines
- ✓ Carcinoembryonic antigen (CEA)
- ✓ Chromogranin A
- ✓ Homovanillic acid (HVA)
- ✓ Prostate specific antigen (PSA)
- ✓ Thyroglobulin

Therapeutic Drug Monitoring and Toxicology

- ✓ Acetaminophen (paracetamol)
- ✓ Carbamazepine
- ✓ Carbon monoxide
- ✓ Cyclosporine
- ✓ Digoxin
- ✓ Ethanol
- ✓ Ethylene glycol
- ✓ Lithium
- ✓ Mycophenolic acid
- ✓ Methanol
- ✓ Methotrexate
- ✓ Phenytoin
- ✓ Salicylate
- ✓ Saliva drug screen
- ✓ Sirolimus
- ✓ Tacrolimus
- ✓ Theophylline
- ✓ Urine drugs of abuse screening

Immunology

- ✓ Albumin
- ✓ Alpha-1-antitrypsin quantification
- ✓ Antibodies associated with neurological diseases (paraneoplastic antibodies)
- ✓ Beta -2 microglobulin
- ✓ C1 esterase inhibitor
- ✓ Total complement activity (CH50)
- ✓ Complement (C) 3 and C4
- ✓ C-reactive protein (CRP)
- ✓ Cryoglobulins
- ✓ Genotyping
- ✓ Full blood count
- ✓ Gliadin autoantibodies
- ✓ Haptoglobin
- ✓ Hepatitis A, B and C serology
- ✓ HIV serology
- ✓ IgE and specific IgE
- ✓ Immunofixation electrophoresis (IFE)
- ✓ Immunoglobulins (IgA, IgG, IgM)
- ✓ IgD
- ✓ IgG subclasses
- ✓ Immunosubtraction
- ✓ Intrinsic factor antibodies
- ✓ Lymphocyte subsets
- ✓ Monoclonal protein quantification

- ✓ Oligoclonal banding (isoelectric focusing)
- ✓ Phenotyping
- ✓ Prealbumin (transthyretin)
- ✓ Rheumatoid factor
- ✓ Serum and urine protein electrophoresis
- ✓ Serum free light chains
- ✓ Serum protein electrophoresis
- ✓ Tissue transglutaminase
- ✓ Total complement activity (CH50)
- ✓ Transglutaminase autoantibodies
- ✓ Transthyretin (prealbumin)
- ✓ Tryptase

Autoantibodies

- ✓ Acetyl choline receptor
- ✓ Adrenal
- ✓ Centromere
- ✓ Cyclic citrullinated peptide
- ✓ Double stranded DNA
- ✓ Endomysium
- ✓ Extractable nuclear antigens
 - 70
 - Jo1
 - La (SSB)
 - RNP
 - Ro (SSA)
 - Scl Sm
- ✓ Glomerular basement membrane
- ✓ Liver
 - Liver kidney microsomal
 - Mitochondrial
 - Smooth muscle
- ✓ Neutrophil cytoplasm (ANCA)
 - Myeloperoxidase
 - Proteinase 3
- ✓ Nuclear components (ANA)
- ✓ Ovary
- ✓ Pancreas
 - Glutamic acid decarboxylase
 - Insulin
 - Islet cell
- ✓ Skin
 - Basement membrane
 - Intercellular cement
- ✓ Thyroid

- Microsomal
- Thyroglobulin
- TSH receptor

Section B10: Laboratory Calculations: Learning Objectives

Be able to discuss the process for calculating common equations relevant to laboratory medicine

- ✓ Addition dilution
- ✓ Anion Gap
- ✓ Bicarbonate
- ✓ Converting between mass and molar units
- ✓ Corrected calcium
- ✓ Corrected sodium
- ✓ Estimated glomerular filtration rate (eGFR)
- ✓ Globulins
- ✓ INR
- ✓ LDL
- ✓ Osmol Gap

Be able to perform basic statical calculations used in the laboratory.

Be able to distinguish the appropriate statistical tests to employ based on the distribution of the data.

- ✓ Bias
- ✓ Biological variation
- ✓ Evaluation of differences between populations
- ✓ Measures of central tendency
- ✓ Measures of dispersion
- ✓ Multiple of Median (MOM)
- ✓ Positive and negative predictive value
- ✓ Reference interval
- ✓ Recovery
- ✓ Sigma
- ✓ Uncertainty of measurement

SECTION C: Clinical Section

In laboratory medicine it is essential for professionals to have a sound understanding of both analytical tools to achieve the best clinical outcomes. It is therefore essential that laboratory professionals have a sound working knowledge of physiology and pathophysiology related to their testing area. This section of the curriculum details the clinical areas related to clinical chemistry and immunology as detailed in Figure C1.

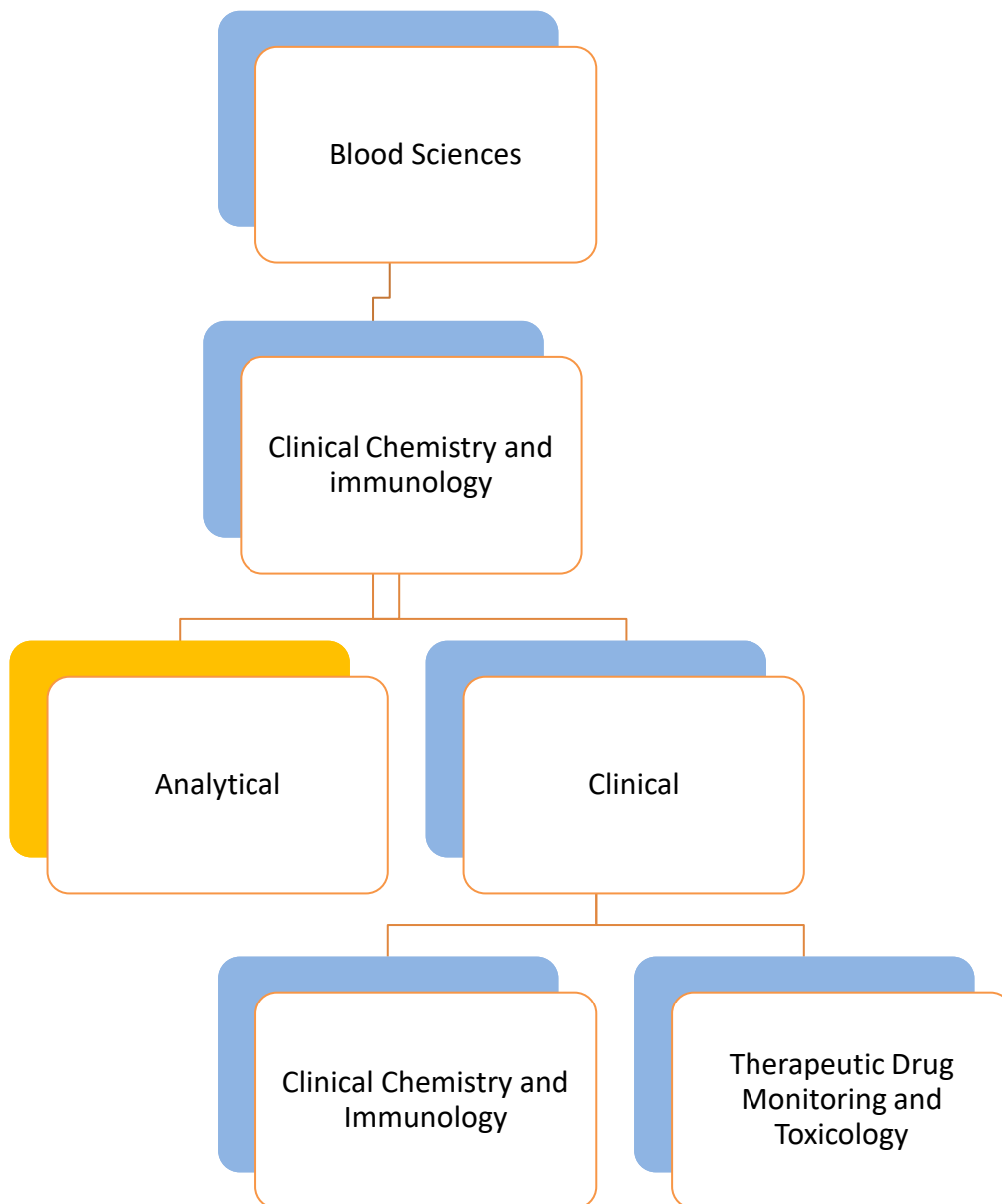


FIGURE C1: HIERARCHICAL STRUCTURE OF BLOOD SCIENCES AS RELATED TO CLINICAL CHEMISTRY AND IMMUNOLOGY SECTION SPECIFICALLY RELATED TO THE CLINICAL COMPONENT OF THE CURRICULUM. THE ANALYTICAL COMPONENT IS SHOWN IN YELLOW TO DEMONSTRATE THE RELATIONSHIP BETWEEN THE ANALYTICAL AND CLINICAL SECTIONS; WHICH WAS PRESENTED SEPARATELY IN SECTION B.

Section C1. Fluid and Electrolyte Disorders: Learning Objectives

Basic Concepts

To understand the principles and control of fluid and electrolyte balance:

- ✓ Clinical assessment of ECF volume
- ✓ Extracellular and intracellular fluid volumes
- ✓ Hormonal control of fluid and electrolyte balance (renin, angiotensin, aldosterone, ADH)
- ✓ Principles of correcting fluid and electrolyte losses

Disorders and disease states

To understand the causes, clinical signs and symptoms of the following features of disorders relating to fluid and electrolyte metabolism.

To describe which laboratory investigations are important in their detection, diagnosis and management

- ✓ Dehydration
- ✓ Diabetes insipidus
- ✓ Extracellular fluid (ECF) volume loss
- ✓ Hypernatremia
- ✓ Hyperkalemia and pseudohyperkalemia
- ✓ Hypokalemia
- ✓ Hyponatremia and pseudo hyponatraemia
- ✓ Shock
- ✓ Syndrome of inappropriate antidiuretic hormone (SIADH)

Specific Laboratory Investigations

To gain an in depth knowledge of the following specific laboratory investigations important to the study of fluid and electrolyte disorders.

To be familiar with analytical methods available for their measurement

To be able to select laboratory investigations and interpret the analytical results in the light of the clinical signs and symptoms in the individual patient

- ✓ Aldosterone
- ✓ Electrolytes (sodium, potassium, chloride)
- ✓ Serum and urine osmolality
- ✓ Renin-angiotensin axis (RTA) assessment
- ✓ Urine and faecal electrolytes

Section C2. Acid-Base Regulation and Pulmonary Function: Learning Objectives

Basic Concepts

To understand the principles and control of acid –base balance and pulmonary function

- ✓ Anion gap
- ✓ Compensation for acidosis and alkalosis
- ✓ Control of respiration
- ✓ Henderson-Hasselbach equation
- ✓ Haemoglobin dissociation curves and limitations of calculated oxygen saturation
- ✓ Osmol gap
- ✓ Systematic approach to investigating acid-base disturbances

Disorders and disease states

To understand the causes, clinical signs and symptoms of the following features of disorders relating to acid-base balance and pulmonary function.

To describe which laboratory investigations are important in their detection, diagnosis and management

- ✓ Alpha 1 antitrypsin (A1AT) deficiency (*see also Section C7, Hepatobiliary disease*)
- ✓ Carbon monoxide poisoning
- ✓ Metabolic acidosis
- ✓ Metabolic alkalosis
- ✓ Pyloric stenosis
- ✓ Renal tubular acidosis (*see also Section 3, Disorders of kidney and urinary tract*)
- ✓ Respiratory acidosis
- ✓ Respiratory alkalosis

Specific Laboratory Investigations

To gain an in depth knowledge of the following specific laboratory investigations important to the study of acid-base balance and pulmonary function.

To be familiar with analytical methods available for their measurement

To be able to select laboratory investigations and interpret the analytical results in the light of the clinical signs and symptoms in the individual patient

- ✓ Alcohols (ethanol, methanol, ethylene glycol, isopropanol)
- ✓ Anion gap
- ✓ Blood gas and hydrogen ion measurements
- ✓ Co-oximetry (carboxyhaemoglobin and methaemoglobin)
- ✓ Calculated blood gas parameters and their limitations
- ✓ Ketones (urine and serum)
- ✓ Lactate
- ✓ Osmolality
- ✓ Osmol gap
- ✓ Salicylate

Section C3. Disorders of Kidney and Urinary Tract: Learning Objectives

Basic concepts

To understand the principles and control of renal function and the urinary tract, including renal stones and purine and pyrimidine metabolism

- ✓ Clearance (creatinine, cystatin C, inulin)
- ✓ Creatinine standardisation
- ✓ Disorders and disease states
- ✓ Estimated glomerular filtration rate (eGFR) calculations
- ✓ Endocrine functions of the kidney
- ✓ Formation of renal calculi
- ✓ Haemodialysis
- ✓ Peritoneal dialysis
- ✓ Proteinuria; glomerular permeability, tubular proteinuria
- ✓ Renal stone formation
- ✓ Steady state renal function
- ✓ Transplant biochemistry

To understand the causes, clinical signs and symptoms of the following features of disorders relating to renal function, the urinary tract and uric acid metabolism

To describe which laboratory investigations are important in their detection, diagnosis and management

- ✓ Acute kidney injury
- ✓ Amyloid
- ✓ Antineutrophil cytoplasmic antibodies (ANCA) associated vasculitis
- ✓ Chronic kidney disease
- ✓ Cryoglobulin associated renal damage
- ✓ Drug-induced renal damage
- ✓ Gout
- ✓ Glomerulonephritis
- ✓ Hyperuricaemia
- ✓ Myeloma associated renal damage
- ✓ Nephritic syndrome
- ✓ Nephrotic syndrome
- ✓ Renal tubular acidosis (*see also Section 2: Acid-base regulation and pulmonary function*)
- ✓ Systemic lupus erythematosus (SLE)
- ✓ Urinary tract infection (UTI)
- ✓ Types of renal stone
- ✓ Uraemia

Specific Laboratory Investigations

To gain an in depth knowledge of the following specific laboratory investigations important to the study of renal function, the urinary tract and uric acid metabolism

To be familiar with analytical methods available for their measurement

To be able to select laboratory investigations and interpret the analytical results in the light of the clinical signs and symptoms in the individual patient

- ✓ Antinuclear antibodies (ANA)
- ✓ ANCA
- ✓ Beta 2 microglobulin
- ✓ Complement C3 and C4
- ✓ Creatinine (serum and urine)
- ✓ Cryoglobulins
- ✓ Cystatin C
- ✓ Erythropoietin
- ✓ Examination and identification of renal calculi
- ✓ Measurement of immunosuppressant drugs (cyclosporine, tacrolimus, sirolimus)
- ✓ Phosphate, calcium and magnesium
- ✓ Renal calculi analysis
- ✓ Serum and urine electrophoresis and immunoglobulins
- ✓ Urea and urea kinetics
- ✓ Uric acid
- ✓ Urine albumin
- ✓ Urine dip stick analysis
- ✓ Urine microscopic analysis
- ✓ Urine oxalate

Section C4. Immunology: Learning Objectives

Basic concepts

To understand the principles, components and control of the immune system

Components of the immune system (Cells, Lymphoid tissue, Soluble components and mediators)

- ✓ Acute phase response
- ✓ Adaptive Immune system
- ✓ Complement
 - Alternative pathway
 - Classical pathway
 - Mannose-binding lectin (MBL) pathway
- ✓ Cytokines
 - Colony stimulating factors and haematopoietic

- Interferons
- Interleukins
- Tumour necrosis factors
- ✓ Hypersensitivity reactions
 - Types I – IV (or V)
- ✓ Immunoglobulins
 - Function
 - Gene rearrangement
 - Structure
- ✓ Innate Immune system
- ✓ Lymphocytes
 - B lymphocytes
 - T lymphocytes

Disorders and disease states

To understand the causes, clinical signs and symptoms of the following features of disorders relating to the immune system

To describe which laboratory investigations are important in their detection, diagnosis and management

- ✓ Allergy and anaphylaxis
- ✓ Autoimmune diseases
 - Endocrine
 - Gastro intestinal (GI) tract
 - Liver
 - Renal
 - Rheumatic and articular
 - Skin
- ✓ Lymphoid malignancy
 - B cell
 - T cell
- ✓ Primary immune deficiency
- ✓ Secondary immune deficiency
- ✓ Transplantation

Specific Laboratory Investigations

To gain an in depth knowledge of the following specific laboratory investigations important to the study of disorders of the immune system

To be familiar with analytical methods available for their measurement

To be able to select laboratory investigations and interpret the analytical results in the light of the clinical signs and symptoms in the individual patient

- ✓ Autoantibodies to
 - Basement membrane, intercellular cement
 - Nuclear (ANA), smooth muscle, mitochondrial

- Neutrophil cytoplasmic (ANCA), glomerular basement membrane, ANA
- Rheumatoid factor, cyclic citrullinated peptides, nuclear, double stranded DNA, extractable nuclear antigens
- Thyroid, pancreas, adrenal, ovary, (testis)
- Tissue transglutaminase, endomysial, intrinsic factor
- ✓ Full blood count
- ✓ HLA typing
- ✓ Immunoglobulin quantification and IgG subclasses
- ✓ Lymphocyte subsets (CD3, 4, 8, 16/56, 19)
- ✓ Monoclonal protein identification and quantification in serum and urine
- ✓ Total and specific IgE
- ✓ Tryptase

Section C5. Diabetes Mellitus: Learning Objectives

Basic concepts

To understand the pathogenesis of diabetic states and the following aspects of the study of diabetes mellitus

- ✓ Aetiology of Type 1, Type 2 and gestational diabetes
- ✓ Complications of diabetes (microvascular, macrovascular)
- ✓ Diabetic ketoacidosis
- ✓ HbA1c standardisation
- ✓ Guidelines for the screening, diagnosis and monitoring of diabetes
- ✓ Non-ketotic hyperosmolar coma
- ✓ Self-monitoring of blood glucose

Disorders and disease states

To understand the causes, clinical signs and symptoms of the following aspects of diabetes mellitus

To describe which laboratory investigations are important in their detection, diagnosis and management

- ✓ Diabetic ketoacidosis
- ✓ Gestational diabetes
- ✓ Hypoglycaemia
- ✓ Metabolic syndrome
- ✓ Non-ketotic hyperosmolar coma
- ✓ Type 1 diabetes
- ✓ Type 2 diabetes

Specific Laboratory Investigations

To gain an in depth knowledge of the following specific laboratory investigations important to the study of diabetes mellitus

To be familiar with analytical methods available for their measurement

To be able to select laboratory investigations and interpret the analytical results in the light of the clinical signs and symptoms in the individual patient

- ✓ Anti-glutamic acid decarboxylase (GAD) antibodies
- ✓ Anti-islet cell and insulin antibodies
- ✓ Blood gas and hydrogen ion measurements
- ✓ C-peptide
- ✓ Fructosamine and other glycated proteins
- ✓ Glucagon
- ✓ Glucose
- ✓ Glucose tolerance tests
- ✓ HbA1c
- ✓ Ketones, (β -hydroxy butyrate)
- ✓ Insulin
- ✓ Microalbumin

Section C6. Gastrointestinal and Pancreatic Disease: Learning Objectives

Basic concepts

To understand the principles and control of gastrointestinal and pancreatic function

- ✓ Acute and chronic pancreatitis
- ✓ Autoimmune bowel disease
- ✓ Bowel cancer screening
- ✓ Causes of gastric ulceration
- ✓ Endocrine and exocrine functions of the pancreas
- ✓ Inflammatory bowel disease
- ✓ Intestinal absorption of proteins, fats and carbohydrates
- ✓ Neuroendocrine Tumours
- ✓ Vitamin B12 absorption

Disorders and disease states

To understand the causes, clinical signs and symptoms of the following features of disorders relating to gastrointestinal and pancreatic function

To describe which laboratory investigations are important in their detection, diagnosis and management

- ✓ Acute and chronic pancreatitis
- ✓ Carcinoid syndrome
- ✓ Coeliac Disease
- ✓ Crohn's Disease
- ✓ Food allergy
- ✓ H. pylori infection
- ✓ Intestinal malabsorption, including vitamins, (*see also Section 5 : trace elements and vitamins*)
- ✓ Neuroendocrine tumours
- ✓ Pyloric stenosis (*See also Section 2, Acid base regulation and pulmonary function*)
- ✓ Pernicious anaemia
- ✓ Zollinger-Ellison syndrome

Specific Laboratory Investigations

To gain an in depth knowledge of the following specific laboratory investigations important to the study of disorders of gastrointestinal and pancreatic function

To be familiar with analytical methods available for their measurement

To be able to select laboratory investigations and interpret the analytical results in the light of the clinical signs and symptoms in the individual patient

- ✓ $^{14}\text{CO}_2$ urea breath test for H. pylori
- ✓ Amylase and macroamylase
- ✓ CA 19-9
- ✓ Carcinoembryonic antigen (CEA)
- ✓ Chromogranin A
- ✓ Elastase
- ✓ Gliadin autoantibodies
- ✓ Faecal calprotectin
- ✓ Faecal occult blood
- ✓ Hydrogen breath test for lactose intolerance
- ✓ IgE and specific IgE
- ✓ Intrinsic factor antibodies
- ✓ Lipase
- ✓ Serotonin and 5 HIAA
- ✓ Transglutaminase autoantibodies
- ✓ Vitamin B12 and folate
- ✓ Xylose absorption test

Section C7. Hepatobiliary Disease: Learning Objectives

Basic concepts

To understand the metabolic functions of the liver and the following aspects of hepatobiliary disease

- ✓ Autoimmune disease
- ✓ Cholestasis
- ✓ Drugs – acute and chronic
- ✓ Genetic – e.g. A1AT deficiency (see also Section 2, Acid-base regulation and pulmonary function)
- ✓ Inflammatory and infective liver disease (hepatitis)
- ✓ Liver cirrhosis
- ✓ Liver function – synthesis, conjugation, detoxification
- ✓ Liver transplantation
- ✓ Liver tumours – primary or secondary
- ✓ Origin, metabolism and transport of bilirubin

Disorders and disease states

To understand the causes, clinical signs and symptoms of the following features of disorders relating to hepatobiliary function

To describe which laboratory investigations are important in their detection, diagnosis and management

- ✓ Acute hepatitis
- ✓ Alcoholic liver disease
- ✓ Allograft rejection
- ✓ Biliary damage and dysfunction
- ✓ Chronic hepatitis
- ✓ Cirrhosis (Including primary biliary cirrhosis)
- ✓ Elevated bilirubin levels: conjugated, unconjugated and total
- ✓ Elevated neonatal bilirubin levels
- ✓ Infectious hepatitis
- ✓ Paracetamol (Acetaminophen) overdose

Specific Laboratory Investigations

To gain an in depth knowledge of the following specific laboratory investigations important to the study of disorders of hepatobiliary function

To be familiar with analytical methods available for their measurement

To be able to select laboratory investigations and interpret the analytical results in the light of the clinical signs and symptoms in the individual patient

- ✓ Albumin (blood and ascites)
- ✓ Alpha-1 antitrypsin concentration and phenotype/genotype
- ✓ Alphafoetoprotein (AFP)

- ✓ Ammonia
- ✓ Bile acids
- ✓ Bilirubin – conjugated, unconjugated, total, transcutaneous
- ✓ Caeruloplasmin
- ✓ Ethanol
- ✓ Ferritin
- ✓ Hepatitis serology
- ✓ Iron
- ✓ Liver enzymes: ALT, AST, ALP, GGT
- ✓ Measurement of immunosuppressant drugs (cyclosporine, tacrolimus, sirolimus)
- ✓ Paracetamol (Acetaminophen)
- ✓ PT-INR

Section C8.

Lipids and Disorders of Lipoprotein Metabolism: Learning Objectives

Basic concepts

To understand the principles and control of lipid metabolism and the following aspects of the study of lipid and lipoprotein disorders

- ✓ Apolipoproteins: functions, receptors (e.g. LDL-R)
- ✓ Cardiovascular disease risk calculation and evaluation, and cost-effectiveness of lipid screening strategies.
- ✓ Fatty acid transport and oxidation
- ✓ Lipid absorption, transport and metabolism
- ✓ Lipoprotein metabolism: endogenous and exogenous pathways

Disorders and disease states

To understand the causes, clinical signs and symptoms of the following features of disorders relating to lipid and lipoprotein disorders

To describe which laboratory investigations are important in their detection, diagnosis and management

- ✓ Atherosclerosis
- ✓ Hypercholesterolaemia
- ✓ Hyperlipidemia
 - Inherited disorders
 - Non-inherited disorders
- ✓ Metabolic syndrome

Specific Laboratory Investigations

To gain an in depth knowledge of the following specific laboratory investigations important to the study of disorders of lipid and lipoprotein metabolism

To be familiar with analytical methods available for their measurement

To be able to select laboratory investigations and interpret the analytical results in the light of the clinical signs and symptoms in the individual patient

- ✓ Apolipoprotein A and B
- ✓ Genotyping of ApoE, LDL receptor and LPL
- ✓ HDL cholesterol
- ✓ High sensitive CRP
- ✓ LDL cholesterol – direct and calculated methods
- ✓ Lipoprotein electrophoresis
- ✓ Lipoprotein ultracentrifugation
- ✓ Lp(a)
- ✓ Non-HDL cholesterol (calculated)
- ✓ Total cholesterol
- ✓ Triglycerides

Section C9. Cardiovascular Disorders and Hypertension: Learning Objectives

Basic concepts

To understand the causes and manifestations of the cardiovascular disease the assessment of individual risk

- ✓ Acute coronary syndrome
- ✓ Cardiac risk assessment
- ✓ Myocardial infarction

Disorders and disease states

To understand the causes, clinical signs and symptoms of the following features of cardiovascular disorders

To describe which laboratory investigations are important in their detection, diagnosis and management

- ✓ Atherosclerosis
- ✓ Cardiac amyloid
- ✓ Congestive heart failure
- ✓ Hypertension
- ✓ Myocardial infarction
- ✓ Stable angina
- ✓ Unstable angina

Specific Laboratory Investigations

To gain an in depth knowledge of the following specific laboratory investigations important to the study of cardiovascular disease and hypertension

To be familiar with analytical methods available for their measurement

To be able to select laboratory investigations and interpret the analytical results in the light of the clinical signs and symptoms in the individual patient

- ✓ Anti-heart muscle antibodies (Dresslers)
- ✓ High-sensitivity CRP
- ✓ Natriuretic peptides
- ✓ Serum and urine electrophoresis and immunoglobulins
- ✓ Troponin and high-sensitivity troponin

Section C10.

Calcium, Magnesium, Parathyroid, Bone Disorders: Learning Objectives

Basic concepts

To understand the control of calcium and phosphate homeostasis including the following specific aspects of the process.

- ✓ Circulating forms of calcium
- ✓ Metabolism of vitamin D
- ✓ Markers of bone resorption and bone formation
- ✓ Primary versus secondary hyper/hypo calcaemia
- ✓ Regulation of calcium and phosphate levels

Disorders and disease states

To understand the causes, clinical signs and symptoms of the following disorders and manifestations of calcium and phosphate metabolism and bone disease

To describe which laboratory investigations are important in their detection, diagnosis and management

- ✓ Hypercalcaemia
- ✓ Hypermagnesaemia
- ✓ Hyperparathyroidism
- ✓ Hyperphosphataemia
- ✓ Hypocalcaemia
- ✓ Hypomagnesaemia
- ✓ Hypoparathyroidism
- ✓ Hypophosphataemia
- ✓ Hypophosphatasia

- ✓ Pseudohypoparathyroidism
- ✓ Osteogenesis imperfecta
- ✓ Osteoporosis
- ✓ Paget's disease

Specific Laboratory Investigations

To gain an in depth knowledge of the following specific laboratory investigations important to the study of calcium and phosphate metabolism and bone disease

To be familiar with analytical methods available for their measurement

To be able to select laboratory investigations and interpret the analytical results in the light of the clinical signs and symptoms in the individual patient

- ✓ 1,25 di-hydroxy vitamin D
- ✓ 25 hydroxy vitamin D
- ✓ C- and N-telopeptides
- ✓ Calcium – total and ionized
- ✓ Magnesium
- ✓ Osteocalcin
- ✓ Phosphate
- ✓ PTH
- ✓ PTHrp
- ✓ Pyridinolines
- ✓ Total and bone-specific ALP

Section C11.

Iron and Haemoglobin Disorders, including the Porphyria's: Learning Objectives

Basic Concepts

To understand the control and metabolism of iron and haem, the mechanisms which lead to iron overload and deficiency, and the implications of these states.

To understand the enzymatic defects of haem synthesis which lead to the porphyrias

- ✓ Haem biosynthesis
- ✓ Haem metabolism
- ✓ Iron absorption, transport and storage
- ✓ Iron deficiency
- ✓ Iron overload

Disorders and disease states

To understand the causes, clinical signs and symptoms of the following aspects and manifestations of disorders of iron and haem metabolism

To describe which laboratory investigations are important in their detection, diagnosis and management

- ✓ Acute and chronic porphyrias and their differential diagnosis
- ✓ Anaemia secondary to malignancy
- ✓ Glucose-6-phosphate dehydrogenase (G6PD) deficiency
- ✓ Haemochromatosis
- ✓ Haemoglobinopathies
- ✓ Intravascular haemolysis
- ✓ Iron deficient anaemia
- ✓ Thalassaemia

Specific Laboratory Investigations

To gain an in depth knowledge of the following specific laboratory investigations important to the study of iron and haem metabolism and the porphyrias

To be familiar with analytical methods available for their measurement

To be able to select laboratory investigations and interpret the analytical results in the light of the clinical signs and symptoms in the individual patient

- ✓ Delta-aminolaevulinic acid (ALA)
- ✓ Ferritin
- ✓ Full blood count
- ✓ G6PD
- ✓ Haptoglobin
- ✓ Haemoglobin and haemoglobin variants
- ✓ Haemopexin
- ✓ Iron
- ✓ Porphobilinogen (PBG)
- ✓ Porphyrins
- ✓ Soluble transferrin receptor
- ✓ Total iron binding capacity
- ✓ Transferrin
- ✓ Transferrin saturation

Section C12. Vitamins and Trace Elements: Learning Objectives

Basic Concepts

To understand the importance of trace elements and vitamins to metabolic processes and wellbeing, the mechanisms of their actions and the consequences of deficiency and overload states.

- ✓ Essential and non-essential metals
- ✓ Fat soluble vitamins; A and carotene, D, E and K

- ✓ Folate metabolism and function
- ✓ Genetic disorders of copper metabolism
- ✓ Genetic disorders of iron metabolism
- ✓ Potential vitamin toxicity
- ✓ Toxic and non-toxic metals
- ✓ Vitamin B12 absorption, metabolism and function
- ✓ Water soluble vitamins; B vitamins and C

Disorders and disease states

To understand the causes, clinical signs and symptoms of the following aspects of disorders of trace element and vitamin metabolism

To describe which laboratory investigations are important in their detection, diagnosis and management

- ✓ Cadmium poisoning
- ✓ Copper deficiency/excess
- ✓ Folate deficiency
- ✓ Iron overload
- ✓ Lead poisoning
- ✓ Mercury poisoning
- ✓ Vitamin B12 deficiency

Specific Laboratory Investigations

To gain an in depth knowledge of the following specific laboratory investigations important to the study of trace elements and vitamins

To be familiar with analytical methods available for their measurement

To be able to select laboratory investigations and interpret the analytical results in the light of the clinical signs and symptoms in the individual patient

- ✓ Cadmium in blood and urine
- ✓ Caeruloplasmin
- ✓ Delta amino laevulinic acid (ALA)
- ✓ Ferritin
- ✓ Folate
- ✓ Homocysteine
- ✓ Intrinsic factor antibody
- ✓ Laboratory assessment of specific B vitamin status
- ✓ Lead in blood and urine
- ✓ Mercury in blood and urine
- ✓ Methylmalonic Acid (MMA)
- ✓ Serum and urinary iron
- ✓ Serum and urinary copper
- ✓ Transferrin
- ✓ Vitamin B12
- ✓ Vitamin D

Section C13. Pregnancy and Prenatal Diagnosis: Learning Objectives

Basic Concepts

To understand the following concepts in relation to the provision of a clinical laboratory service to support pregnancy and the health of the mother and foetus.

- ✓ Biochemical, haematological and endocrine changes during pregnancy
- ✓ Changes in analyte levels throughout pregnancy
 - Multiples of the median
- ✓ Foetal lung maturity
- ✓ hCG doubling time
- ✓ hCG forms
- ✓ Maternal serum screening – purpose, limitations, screen vs. definitive testing
 - First trimester screening
 - Integrated screening
 - Second trimester screening
- ✓ Premature rupture of membranes and pre-term labour
- ✓ Rh isoimmunisation

Disorders and disease states

To understand the causes, clinical signs and symptoms of the following, complications of pregnancy and foetal development.

To describe which laboratory investigations are important in their detection, diagnosis and management

- ✓ Choriocarcinoma
- ✓ Ectopic pregnancy
- ✓ Gestational diabetes
- ✓ Molar pregnancy
- ✓ Obstetric cholestasis
- ✓ Open neural tube defects
- ✓ Pre-eclampsia, HELLP syndrome
- ✓ Rh isoimmunisation
- ✓ Trisomy 21, 18 and 13
- ✓ Trophoblastic disease

Specific Laboratory Investigations

To gain an in depth knowledge of the following specific laboratory investigations important to the study of pregnancy and foetal development

To be familiar with analytical methods available for their measurement

To be able to select laboratory investigations and interpret the analytical results in the light of the clinical signs and symptoms in the individual patient

- ✓ AFP
- ✓ hCG

- ✓ Inhibin A
- ✓ PAPP-A
- ✓ Plasma nucleic acids
- ✓ Serum bile acids
- ✓ Unconjugated estriol

To be able to discuss the clinical rationale for tests using amniotic fluid

- ✓ Acetylcholinesterase
- ✓ AFP
- ✓ Bilirubin – absorbance at 450 nm
- ✓ Karyotype

Section C14. General Paediatric Clinical Chemistry: Learning Objectives

Basic Concepts

To understand the following special considerations in relation to the provision of a general paediatric clinical laboratory service.

- ✓ How to collect heel prick samples
- ✓ Issues with capillary specimens
- ✓ Paediatric reference intervals – dynamic changes with growth, development and puberty
- ✓ Sample volume and collection issues, including sweat collection

Disorders and disease states

To understand the causes, clinical signs and symptoms of the conditions which may present to a general paediatric laboratory.

To describe which laboratory investigations are important in their detection, diagnosis and management

- ✓ Congenital thyroid disease
- ✓ Cystic fibrosis
- ✓ Delayed puberty
- ✓ Diabetes mellitus type 1
- ✓ Disorders of sex development, including congenital adrenal hyperplasia
- ✓ Growth retardation and growth hormone deficiency
- ✓ Hypocalcaemia
- ✓ Inborn errors of metabolism
- ✓ Neonatal hypoglycaemia
- ✓ Neonatal jaundice
- ✓ Neuroblastoma
- ✓ Precocious puberty
- ✓ Respiratory distress

Specific Laboratory Investigations

To gain an in depth knowledge of the following specific laboratory investigations important to the study of disorders presenting in the neonate and in childhood

To be familiar with analytical methods available for their measurement

To be able to select laboratory investigations and interpret the analytical results in the light of the clinical signs and symptoms in the individual patient

For all analyses, sample size is of key importance in method selection

- ✓ Acid base / blood gases
- ✓ Calcium
- ✓ Glucose,
- ✓ Hormone measurement (See Section 16, Endocrinology)
 - Anterior hypothalamic hormones
 - Cortisol
 - Neuropeptides
 - Ovarian hormones
 - Testicular Hormones
 - Thyroid function
 - Other adrenal hormones
- ✓ HVA, dopamine
- ✓ Performance of the sweat test
- ✓ Plasma catecholamines
- ✓ Total and differential bilirubin

Section C15. Inborn Errors of Metabolism: Learning Objectives

Basic Concepts

To understand all aspects of screening for disease including the rationale for screening and the process.

- ✓ Challenges with newborn screening
- ✓ Diseases appropriate for newborn screening – characteristics
- ✓ Newborn screening process

Disorders and disease states

To understand the causes, clinical signs and symptoms of the following inherited conditions

To describe which laboratory investigations are important in their detection, diagnosis and management

- ✓ Congenital hypothyroidism
- ✓ Cystic fibrosis
- ✓ Enzyme deficiencies: biotinidase, galactokinase

- ✓ Fatty acid oxidation disorders: short, medium, long and very long chain
- ✓ Haemoglobinopathies
- ✓ Homocystinuria
- ✓ Lysosomal disease, glycogen storage diseases: lipidoses, hexosaminidases, Fabry's disease
- ✓ Maple syrup urine disease
- ✓ Phenylketonuria
- ✓ Tyrosinaemia

Specific Laboratory Investigations

To gain an in depth knowledge of the following specific laboratory investigations important to the study of inherited metabolic diseases

To be familiar with analytical methods available for their measurement

To be able to select laboratory investigations and interpret the analytical results in the light of the clinical signs and symptoms in the individual patient

- ✓ Acylcarnitines
- ✓ Alpha-1-antitrypsin genotyping
- ✓ Amino acids
- ✓ Haemoglobin electrophoresis
- ✓ Immunoreactive trypsinogen
- ✓ Organic acids
- ✓ Specific enzyme testing (e.g., biotinidase, galactokinase)
- ✓ Sweat chloride and conductivity

Section C16. Endocrinology: Learning Objectives

Basic Concepts

To understand all aspects of hormone action, including feedback inhibition and other controlling mechanisms for hormone release and to acquire a detailed knowledge of the major endocrine organs and systems.

Hypothalamic-pituitary axis

- ✓ Anterior pituitary hormones
- ✓ Communication between pituitary and hypothalamus – anterior vs. posterior
- ✓ Hirsutism and virilisation
- ✓ Hypothalamic hormones
- ✓ Inhibitory hormones
- ✓ Posterior pituitary hormones
- ✓ Primary vs. secondary causes
- ✓ Renin-angiotensinogen-aldosterone pathway
- ✓ Steroid biosynthesis pathway
- ✓ Stimulation tests
- ✓ Suppression tests

Disorders and disease states

To understand the causes, clinical signs and symptoms of the following endocrine disorders

To describe which laboratory investigations are important in their detection, diagnosis and management

- ✓ Acromegaly/gigantism
- ✓ Addison's syndrome
- ✓ Adrenal insufficiency
- ✓ Congenital adrenal hyperplasia
- ✓ Cushing's syndrome and Cushing's disease
- ✓ Female infertility
- ✓ Growth hormone deficiency
- ✓ Hyperaldosteronism
- ✓ Hyperprolactinemia
- ✓ Hyperthyroidism
- ✓ Hypothyroidism
- ✓ Male infertility
- ✓ Pheochromocytoma
- ✓ Polycystic ovarian syndrome
- ✓ Premature ovarian failure
- ✓ Sheehan's syndrome
- ✓ Thyroid cancer

Specific Laboratory Investigations

To gain an in depth knowledge of the following specific laboratory investigations important to the study of endocrine disorders

To be familiar with analytical methods available for their measurement

To be able to select laboratory investigations and interpret the analytical results in the light of the clinical signs and symptoms in the individual patient

- ✓ 17 hydroxyprogesterone
- ✓ ACTH
- ✓ ADH
- ✓ Aldosterone, renin and ratio
- ✓ Androstenedione
- ✓ Angiotensin converting enzyme (ACE)
- ✓ Anti-thyroid peroxidase antibodies
- ✓ Catecholamines (plasma and urine)
- ✓ Cortisol – serum, urine, salivary
- ✓ Dexamethasone suppression test
- ✓ DHEAS
- ✓ Estradiol
- ✓ FSH
- ✓ Growth hormone

- ✓ Growth hormone suppression test (OGTT)
- ✓ Insulin-like growth factor 1 (IGF-1)
- ✓ LH
- ✓ Metanephrines (plasma and urine)
- ✓ Progesterone
- ✓ Prolactin and macroprolactin
- ✓ SHBG
- ✓ Testosterone – total, free, bioavailable
- ✓ Thyroglobulin, anti-thyroglobulin antibodies
- ✓ Thyroid function tests: TSH, Free T3, free T4 Total T3, Total T4
- ✓ TSH receptor antibodies

Section C17. Neurological and Psychiatric Disorders: Learning Objectives

Basic Concepts

To understand the following key concepts relating to neurological processes and disruption of these

- ✓ Blood brain barrier
- ✓ Paraneoplastic syndromes

Disorders and disease states

To understand the causes, clinical signs and symptoms of the following disorders, some of which are primary neurological disorders and some of which have neurological manifestations

To describe which laboratory investigations are important in their detection, diagnosis and management

- ✓ Acute porphyria's
- ✓ Alzheimer's disease
- ✓ Epilepsy
- ✓ Meningitis
- ✓ Multiple sclerosis
- ✓ Myasthenia gravis
- ✓ Paraneoplastic syndrome

Specific Laboratory Investigations

To gain an in depth knowledge of the following specific laboratory investigations important to the study of neurological disorders

To be familiar with analytical methods available for their measurement

To be able to select laboratory investigations and interpret the analytical results in the light of the clinical signs and symptoms in the individual patient

- ✓ Aminolaevulinic acid (ALA)

- ✓ Anti-acetylcholine receptor antibodies
- ✓ Anti-Hu, Anti-Yo antibodies
- ✓ CSF beta-2-transferrin in rhinorrhoea and otorrhoea (fistula)
- ✓ CSF glucose
- ✓ CSF protein
- ✓ Examination of synovial fluid
- ✓ Oligoclonal banding (isoelectric focusing)
- ✓ Paraneoplastic antibodies
- ✓ Porphobilinogen (PBG)
- ✓ Porphyrins (urine, feces, serum)

Section C18:

Biochemical Aspects of Monitoring Malignant Disease: Learning Objectives

Basic Concepts

To understand the following key concepts relating to the choice, use and measurement of tumour markers

- ✓ Characteristics of an ideal tumour marker
- ✓ Uses and limitations of current tumour markers
- ✓ Uses of tumour markers: screening, diagnosis, prognosis, monitoring, recurrence

Specific Laboratory Investigations

To gain an in depth knowledge of the following specific laboratory investigations important in the management of malignant diseases

To be familiar with analytical methods available for their measurement

To be able to select laboratory investigations and interpret the analytical results in the light of the clinical signs and symptoms in the individual patient

- ✓ AFP
- ✓ ALP isoenzymes
- ✓ CA 15-3
- ✓ CA 19-9
- ✓ CA 125
- ✓ Calcitonin
- ✓ CEA
- ✓ hCG
- ✓ HER2/Neu
- ✓ LDH isoenzymes
- ✓ PSA (total and free)
- ✓ PTHrp
- ✓ Thyroglobulin, anti-thyroglobulin antibodies

Section C19: Musculoskeletal Diseases: Learning Objectives

Basic concepts

To understand muscle function and the use and limitations of autoimmune testing in diagnosis

- ✓ Autoimmune testing
- ✓ Muscle function

Disorders and disease states

To understand the causes, clinical signs and symptoms of the following musculoskeletal disorders

To describe which laboratory investigations are important in their detection, diagnosis and management

- ✓ Goodpasture's syndrome
- ✓ Osteoarthritis
- ✓ Rhabdomyolysis
- ✓ Rheumatoid arthritis
- ✓ Systemic lupus erythematosus
- ✓ Vasculitis

Specific Laboratory Investigations

To gain an in depth knowledge of the following specific laboratory investigations important in the management of malignant diseases

To be familiar with analytical methods available for their measurement

To be able to select laboratory investigations and interpret the analytical results in the light of the clinical signs and symptoms in the individual patient

- ✓ Anti-CCP antibodies
- ✓ Anti-ds DNA
- ✓ Anti neutrophilic cytoplasmic antibodies (ANCA)
- ✓ Anti-nuclear antibodies (ANA and specific antibodies SSA, SSB, Sm, RNP)
- ✓ Rheumatoid factor
- ✓ Serum creatine kinase

Section C20: Therapeutic Drug Monitoring and Toxicology: Learning Objectives

Basic Concepts

To understand the following key concepts of pharmacology and the key factors relevant to drug action and measurement.

To understand the mode of action and clinical uses of drugs in the categories listed.

Pharmacokinetics (PK)

- ✓ Absorption
- ✓ Bioavailability
- ✓ Compliance
- ✓ Distribution
- ✓ Excretion
- ✓ Metabolism

Pharmacodynamics (PD)

Pharmacogenetics (PG)

- ✓ Antibiotics
- ✓ Antidepressants
- ✓ Anti-epileptic drugs
- ✓ Anti-psychotic drugs
- ✓ Carbon monoxide poisoning
- ✓ Cardioactive drugs
- ✓ Common drugs of abuse
- ✓ Drugs appropriate for TDM
- ✓ Drug screens vs. confirmatory tests for drugs of abuse
- ✓ Free drugs
- ✓ Immunosuppressants
- ✓ Lithium
- ✓ Methotrexate and rescue
- ✓ Peak vs. trough drug levels
- ✓ Steady state
- ✓ Thiopurines

Disorders and disease states

To understand the causes, clinical signs and symptoms of the following toxic conditions and the treatment regimes which may be used,

To describe which laboratory investigations are important in their diagnosis and management

- ✓ Acetaminophen toxicity
- ✓ Carbon monoxide poisoning
- ✓ Ethanol, alcohol toxicity
- ✓ Organophosphate poisoning
- ✓ Salicylate toxicity

Specific Laboratory Investigations

To gain an in depth knowledge of the following specific laboratory investigations important in for drug monitoring and detection of toxic concentrations of drugs

To be familiar with analytical methods available for their measurement

To be able to select laboratory investigations and interpret the analytical results in the light of the clinical signs and symptoms in the individual patient

- ✓ Acetaminophen
- ✓ Carbon monoxide – carboxyhaemoglobin
- ✓ Cholinesterase and pseudocholinesterase
- ✓ Cyclosporine
- ✓ Ethanol
- ✓ Ethylene glycol
- ✓ Isopropanol
- ✓ Methanol
- ✓ Mycophenolic acid (MPA)
- ✓ Osmolality
- ✓ Point-of-care drug screens
- ✓ Sirolimus
- ✓ Salicylates
- ✓ Tacrolimus