

# 1 Course Program

- Principles of Forensic Toxicology
- Doping principles
- Case review interpretation
- Research and laboratory Management
- Laboratory Techniques in Forensic Toxicology and doping control
- Advanced Instrumentation

# 2 Programme Learning Outcomes

The Forensic toxicology programme provides opportunities for students to develop and demonstrate knowledge and understanding, skills, qualities and other attributes in the area of forensic toxicology and doping control.

## 2.1 Knowledge and Understanding

On successful completion of Course in Forensic Toxicology, students are expected to develop an in-depth, integrated and critical understanding of:

- The role of Forensic Toxicology in the medico-legal investigation of death, poisoning and drug use.
- The role of Doping Control at international and national levels and medico-legal implications
- Principles techniques of toxicological investigation and their application to different sample and analyte types for psychotropic drugs and doping agents.
- Principles of interpretation of toxicological evidence
- The application of practical techniques to a unique research project.

## 2.2 Skills and Other Attributes

### ***Subject- specific/practical skills***

On successful completion of this programme participants will be able to demonstrate:

- The ability to provide expert testimony in a court of law;
- The ability to operate instrumentation required for Forensic Toxicological Analysis (including GC-MS, LC-MS, LC-MS/MS, HRMS)
- Competency in the development and validation of methodology for forensic toxicological analysis and doping control within an accredited laboratory;
- The ability to execute original research;

- Competency in research skills, including critical analysis of the literature and statistical analysis of data;
- The ability to plan and execute a project;

### ***Intellectual skills***

ON successful completion of this programme, participants within the field of forensic toxicology will be able to demonstrate:

- Knowledge and understanding of essential facts, concepts, principles and theories;
- Application of knowledge and understanding to the solution of qualitative and quantitative problems;
- The ability to implement and maintain quality management systems and good (best) practice;
- Skills in presenting material and arguments clearly and correctly in writing and orally to a range of audiences;
- Computational and data processing skills;
- The ability to plan and assess original research.

### ***Transferable/key skills***

On successful completion of this programme participants will be able to demonstrate:

- Ability to communicate forensic information effectively in style appropriate to a variety of different audiences using different media;
- Responsibility for one's own work in independent tasks and as part of a team effort;
- Ability to apply problem solving skills;
- Numeracy skills required for successful experimental design and data interpretation;
- Advanced use of computers for data analysis, retrieval of information and composition of reports;
- Ability to communicate research results as posters or in oral presentation;
- Effective interpersonal skills with particular reference to educational, cultural and religious diversity;
- Ability to manage time appropriately, to prioritise tasks and meet deadlines;
- Study skills for continued professional development.

## **3 Principles in Forensic Toxicology**

### **Course Outline**

Forensic Toxicology essentially combines the specialist areas of analytical chemistry and biochemistry. IN general, a forensic toxicologist detects and identifies foreign chemicals (toxins) in the body. In order to accurately interpret toxicological findings, it is essential that the toxicologist has an understanding of the pharmacology of that substances and the pathological effects it has on the body. In this context, Forensic Toxicology can be divided into two categories, post-mortem toxicology and human performance toxicology.

The fundamentals of these two fields and evaluation of the appropriate matrices for analysis are pivotal in understanding toxicological development of a detailed knowledge of the types of toxic substances and matrices encountered in Forensic Toxicology. Students will also gain theoretical knowledge of the essential pharmacology skills contain seminars focussing on development of generic transferrable skills.

As preparation for the summative literature review, students will undertake a formative literature review (1000 words). This will be assessed and returned prior to submission of the summative assessment.

## Aims of the course

The course will provide the student with the essential information to allow development of critical understanding of the role of a Forensic Toxicologist. The main aims of the course are to:

- Give a detailed overview of the role of the Forensic Toxicologist in the context of post-mortem and human performance toxicology.
- Provide comprehensive details of the biology of matrices encountered in a Forensic Toxicology laboratory.
- Examine the wide variety of toxic substances encountered and their effects on performance.
- Provide thorough details on the application of pharmacokinetics (ADME) and pharmacodynamics to Forensic Toxicology.

## Intended Learning Outcomes

On successful completion of this course students are expected to be able to:

- Demonstrate a detailed knowledge of a various types of biological matrices which may be utilised by a Forensic Toxicologist and the types of casework handled in a Forensic Toxicology laboratory.
- Explain in detail the major types of poison encountered in a modern Forensic Toxicology laboratory.
- Competently discuss toxicological pathology and post-mortem findings in cases of poisoning.
- Illustrate proficiency in the use of pharmacokinetics and pharmacodynamics for a range of poisons.

## Lecture Content

### ***Overview of toxicology in Forensic Science***

- Definitions, what is toxicology, importance in Forensics.
- Important drugs, drug statistics.
- Misuse of Drugs Act.

### ***Casework types and matrices***

- Cases types: including post-mortem, performance testing, workplace testing, DFC, custody cases, etc.
- Matrices: including blood, urine, oral fluid, hair and nails.

### ***Role of the Forensic toxicologist***

- Introduction to medicine.
- Types of casework.
- Overview of PM procedure and issues around sampling.
- Post-mortem changes.

### ***Pathology of Drugs of abuse***

- Action of drugs of abuse and doping agents.

### ***Pharmacology and pharmacokinetics of drugs of abuse***

- Terminologies, usefulness and limitations.
- Dose response, therapeutic safety
- Absorption, Distribution, Metabolism and Excretion (ADME)
- Pharmacokinetic: half-life, volume of distribution, metabolism, elimination.
- Pharmacodynamic: membrane transfer, receptors, agonists and antagonists, role of the liver-enzymes, enterohepatic circulation.

## **4 Doping principles**

### **Course Outline**

Doping is nowadays a global problem, that not only interests elite athletes involved in international sporting events worldwide, but also recreational athletes and young population in search of physical and psychological maximum performance.

For the past half century, International sports federations, led by the International Olympic Committee, have attempted to stop the spread of this problem, with little effect. It was expected that, with educational programs, testing, and supportive medical treatment, this substance-abusing behavior would decrease. Unfortunately, up to now this has not been the case.

The course will explain the principles of World Anti Doping Agency (WADA), its ethical code, the list of prohibited substances and methods, pharmacotoxicology of doping agent, how a control is organized, how an antidoping accredited laboratory is organized, quali-quantitative analysis of each class of doping agents makers.

### **Aims of the course**

The course will provide the student with the essential information to allow development of critical understanding of doping control system and Wada code. The main aims of the course are to:

- Give a detailed overview of the entire organization of doping from sample collection to sample analysis
- Provide comprehensive details of each class of doping agents and method reported in the “prohibited list” yearly released by WADA.

- Examine the pharmacotoxicology of doping agents of toxic substances and their effects on performance.

## Intended Learning Outcomes

On successful completion of this course students are expected to be able to:

- Demonstrate a detailed knowledge of a various classes of doping agents and the organization of antidoping laboratory
- Competently discuss on action of different classes of doping agents on physical performance.
- Illustrate proficiency in the use of pharmacokinetics and pharmacodynamics of doping agents.

## Lecture Content

- Doping in sport
- WADA legislation all over the world, WADA organization
- World Anti-Doping Agency – Update
- Pharmacotoxicology of prohibited substances in the WADA list as detailed: S0:Non-approved substances S1:Anabolic steroids, S2: Peptide hormones
- S2: Growth factors, related substances, and mimetics
- S3, S4, S5: Beta-2 agonists, hormones and metabolic modulators, diuretics and masking agents
- S6 and S7: Stimulants & Narcotics
- S8 AND S9:Cannabinoids & Glucocorticoids
- M1, M2 and M3:Chemical and physical manipulation, gene doping
- Medicalization of the athlete
- Enhancement and Doping in Sports
- Organization of an antidoping laboratory and analysis of doping agents of different classes
- Challenges in Sports Drug Testing: Control organization
- Validation of analytical methods and external quality control programmes in doping control
- Case studies

## 5 Case Review Interpretation

### Course Outline

An essential role of any Forensic Toxicologist is to evaluate results from toxicological analysis and interpret these in light of relevant case details. As an expert witness, the Forensic Toxicologist must have confidence in their analytical results in order to report them to the courts. This course will build on the knowledge and skills from semester one courses and complements the research and laboratory management course in semester two. Using real case studies, students will develop their skills in reviewing cases from sample receipt

through to reporting and enhance their laboratory skills using simulated cases. Training will be given in the production of reports suitable for the various types of casework encountered and in the presentation of results in a court of law. Assessment is through practical reports and a final moot court session where the students will defend their analysis in a court setting.

## Aims of the Course

The main aims of the course are to:

- Provide a detailed overview of the process involved in case review for Forensic Toxicology.
- Enhance laboratory skills to allow for autonomy of laboratory work.
- Develop systematic skills in evaluating and interpreting the results of Forensic Toxicology in conjunction with detailed case information.
- Provide the necessary skills to effectively present expert witness testimony in a court of law.

## Intended Learning Outcomes

On successful completion of this course students are expected to be able to:

- Accurately evaluate case samples and background information and carry out toxicological analyses independently.
- Critically evaluate Forensic Toxicology analytical results for a range of analyses types.
- Competently interpret Toxicological results in light of full case histories and utilises this knowledge to produce reports at a standard acceptable to the courts.
- Expertly deliver toxicological results in a court of law setting.

## Lecture Content

This course consists of three main topics. Students will be given detailed instruction and have hands-on experience of the process involved in case review. This will include cases where analytical results are produced in-house and cases where an opinion is required on work carried out elsewhere. Students will also gain detailed insight into the issues encountered which must be taken into consideration when interpreting toxicological results. The final element of the course concerns provision of training for appearing in a court of law to give Expert Witness Testimony.

## Seminar/Tutorial sessions

Seminars and tutorials will be based on a series of case review information from real casework and will form part of the lecture series. Case information will be handed out prior to class discussion.

## Practical sessions

The purpose of the practical sessions is to carry out a full toxicological analysis on samples submitted for a post-mortem case. Case details will be handed out in the first week. Each student will work on a separate case.

# 6 Research and Laboratory Management

## Course Outline

- The purpose of this course is twofold. Students will receive instruction in good laboratory practice including laboratory management, quality assurance and quality control. In addition, the course will allow students to prepare for their project. Management and quality training will ensure that students to prepare for their project. Management and quality training will ensure that students gain the skills necessary to design, develop and implement effective and efficient systems within the Forensic Toxicology environment. Students will develop an in-depth knowledge of the process for implementation of the international standard ISO/IEC 17025 into a Forensic Toxicology Laboratory and will gain key skills required for conducting and evaluating system audits. The project preparation will be carried out with advice from the potential supervisor; instruction on how to use relevant sources of published information; carrying out with advice from the potential supervisor; instruction on how to use relevant sources of published information; carrying out a literature survey on the subject of the planned project; and the writing of a literature review and project plan. Students will gain instruction in hazard assessment and ethical issues as appropriate.

## Aims of the course

The main aims of the course are to:

- Equip the students with a practical understanding of the research process, such that they can design the research project.
- Equip students with the necessary skills required for design, development and implementation of methods and services within a Forensic Toxicology context.
- Equip students with a detailed understanding of the requirements of the international quality standard ISO/IEC 17025 in the context of Forensic Toxicology Laboratory.

## Intended Learning Outcomes

On successful completion of this course students are expected to be able to:

- Choose and define the scope of an appropriate area for structured investigation /design/ development.

- Identify, select and justify the use of appropriate techniques, methods and development strategies, incorporating an ethical dimension where appropriate.
- Critically assess and summarise the literature in a specific field.
- Demonstrate detailed Knowledge of the processes required within a QUALITY Management System.

## 7 Laboratory techniques in Forensic Toxicology and doping control

### Course Outline

This course will provide students with a detailed theoretical and practical knowledge of the techniques employed within a modern laboratory for sample handling, screening and confirmation of analytes of interest. These are essential skills required by Forensic Toxicology and Doping Control laboratories equipped with state-of-art instrumentation, from high throughput analysers to specialist hyphenated chromatographic spectrometers. In order to effectively troubleshoot or improve current methodologies it is essential as an analyst, laboratory manager or forensic toxicologist to have a fundamental understanding of both the theoretical and practical aspects of the techniques employed within the laboratory.

Students will also develop an appreciation of the importance of good laboratory practice and keeping contemporaneous notes, instrument maintenance logs and record keeping.

### Aims of the course

The main aims of the course are to:

- Equip students with the necessary skills to competently handle and manipulate biological matrices for the analysis of various toxins.
- Provide students with detailed theoretical and practical knowledge of chromatographic and spectroscopic techniques used for screening and confirmation in Forensic Toxicology and doping control.
- Provide students with the skills to effectively select the correct technique for use with selected matrices, toxins and case scenarios.

### Intended Learning Outcomes

On successful completion of the course students are expected to be able to:

- Show competence in the use of instrumentation used for screening and confirmation within Forensic Toxicology and Doping Control laboratory.
- Exhibit proficiency in the handling and manipulation of the scope of samples by Forensic Toxicologists in the laboratory.



- Produce and critically evaluate analytical data obtained from a variety of methods used routinely in Forensic Toxicology and doping control.

## Laboratory Sessions

The laboratories are located within The Section of Legal Medicine at Università Politecnica delle Marche. Students should arrive approximately 10 minutes before the start of each laboratory session.

In some session, students will be assigned to groups and will rotate around the different experiments within the laboratory session.

## Lecture/Seminar session

The lecture/seminar session will take place within the Università Politecnica delle Marche. Student should arrive approximately 5 to 10 minutes before the start of session prior to the arrival of member of staff.

## Lecture & Seminar & Tutorial Detail

### ***Introduction to Analytical Measurement***

- Pipetting, weighing, preparation of solution and analytical standards
- Uncertainty of measurement

### ***Sample collection, Handling and Pre-treatment***

- Collection protocols and handling liquid and solid matrices
- Preservatives, stability and volatility

### ***Sample preparation, QA & QC and E-Learning***

- Theory of Liquid-Liquid Extraction (LLE), Solid phase extraction (SPE), Solid phase micro-extraction (SPME), Supercritical fluid chromatography (SFC) / Supercritical fluid extraction (SFE) and importance of pKa
- Introduction to QA & QC and COSHH within an Analytical Laboratory
- Introduction to CHROMacademy

### ***Chromatography and Immunoassay***

- Theory including TLC, GC and HPLC
- Theory and application of immunoassays (ELISA, FPIA, RIA, EMIT)

### ***Detectors***

- UV-Vis, DAD, fluorescence
- FID, NPD, ECD

- Introduction to mass spectrometry

### **Quantitation**

- Calibration and linearity, use of the internal standards and correlation coefficients
- Signal-to-Noise, limits of detection and quantification, confidence limits
- Introduction to method validation and replicate analyses

## **8 Advanced Instrumentation**

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### **Course outline**

This course expands on the knowledge gained in course “Laboratory Techniques in Forensic Toxicology”. Modern Forensic Toxicology laboratories worldwide provide a service that demands the highest standards and competency to ensure reliable and legally defensible test results for presentation in court. A growing number of laboratories are seeking accreditation to the international standard ISO/IEC 17025 in recognition of the importance of implementing quality systems to ensure the effective control of testing services they provide.

This course will provide students with the opportunity to develop the theoretical and practical skills required for developing and validating new methodologies within a forensic toxicology laboratory accredited to ISO/IEC 17025. Building on the core skills developed in previous courses, students will develop a critical understanding of the theory and practice of interpreting mass spectral data will gain the necessary skills to troubleshoot and carryout routine maintenances of GC and LC-MS instrumentation.

### **Aims of the course**

The main aims of the course are to:

- Expand on instrumentation knowledge to include hyphenated GC and LC techniques, including interpretation of mass spectral data.
- Provide the students with the necessary skills to effectively troubleshoot methodologies and carry out routine maintenance on key equipment including GC and LC-MS, LC-MS/MS, HRMS
- Allow students to carry out method development and validation to a level accepted in an accredited laboratory

### **Intended Learning Outcomes**

On successful completion of this course, students are expected to be able to:

- Interpret mass spectral data from both GC and LC instrumentation for complex toxicological extracts.
- Competently troubleshoot issues arising during routine toxicological testing.
- Proficiently carry out routine maintenance of GC- and LC-MS, LC-MS/MS, HRMS systems.

### Practical sessions

The purpose of the practical sessions is to familiarise you with the instrumentation used in GC-MS and LC-MS LC-MS/MS, HRMS regarding maintenance, troubleshooting, and analysis.