M.Sc. in Diagnostics and Precision Medicine

Dublin City University

Programme Chair

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The M.Sc. in Diagnostics and Precision Medicine is a new blended-learning programme that details how advances in science and technology are revolutionising healthcare and medicine by providing the right person with the right therapy at the right time.

Programme Overview

Recent advances in the understanding of normal and diseased states has led to revolutionary new treatments for conditions such as cancer, inflammatory diseases and inherited diseases. Furthermore, advances in science and technology have resulted in the development of new biomedical assays to (a) diagnose diseases and conditions more accurately (b) classify disease more precisely (c) approach treatment more individually and (d) identify who is at risk of developing a disease or condition. Such advances in diagnostics and therapeutics have ushered in an exciting new era known as Precision Medicine, which refers to prevention and treatment strategies that takes patient variability into account (people’s genes, environment and lifestyles) by providing the right patient with the right medicine at the right time. As an example, the treatment of several cancers have shifted away from the “One-Size-Fits-All” approach of treatment (e.g. chemotherapy) to a more focused and tailored strategy where targeted therapies are matched according to the molecular profile of a patient’s tumour. In this situation, variations in the sequence, structure or expression of that person’s DNA, RNA or protein (i.e. biomarkers) are analysed using clinically-validated diagnostic assays (commonly referred to as Companion Diagnostics) and used to stratify patients so that those who are likely to benefit from these therapies are identified and treated, while who are unlikely to benefit (and may experience unnecessary side effects) can receive alternative treatments. Similarly, molecular diagnostic assays are increasing used to predict the outcome of a patient’s disease (prognosis), and therefore medical treatments can be tailored accordingly.

The M.Sc. in Diagnostics and Precision Medicine provides structured module-based training at postgraduate level on the latest advances in diagnostics and therapeutics and their relevance for Precision Medicine.
The programme is aimed at:

- Life scientists (including newly qualified graduates)
- Professionals from the diagnostics, biopharmaceutical, pharmaceutical and healthcare industries
- Medical Practitioners (including General Practitioners and clinicians-in-training)

Who wish to:

- Develop and broaden their knowledge of how new therapies including targeted therapeutics, cell-based therapies and gene modulation technologies are revolutionising the treatment of diseases such as cancer, inflammatory diseases and inherited diseases
- Understand how the integration of diagnostics and therapeutics are changing the landscape of healthcare and medicine through Precision Medicine
- Pursue a career in the biomedical diagnostics, biomedical science and biopharmaceutical industries
- Develop/consolidate their research skills with a view to undertaking further research (e.g. PhD or MD)
- Develop their critical analysis skills and enhance their professional development
Course Structure and Delivery

The M.Sc. in Diagnostics and Precision Medicine is delivered via blended-learning, where all lectures/modules are delivered fully online and supported by Course Coordinators and academic staff at DCU who provide face-to-face tutorials, monitor student activity/progress and offer one-to-one guidance. Tutorials are run during semester every second Friday afternoon in DCU for students based in Ireland who prefer face-to-face contact. Tutorials are also streamed online so students can attend remotely.

1. The programme has been designed with flexibility in mind by enabling students to:
   - Access course material at a time and a place that is convenient to them (lectures are recorded and available through DCU’s online learning platform)
   - Register Full-time or Part-time (Part-time students must complete all modules within a maximum period of 4 years)
   - Tailor their education and training by offering exit routes at M.Sc. (90 ECTS credits), Diploma (60 ECTS credits) and Certificate (30 ECTS credits)

2. The programme is delivered through blended-learning which is comprised of:
   - Online (recorded) lectures
   - Face-to-face tutorials every second Friday afternoon in DCU during term (tutorials will also be recorded for those who would like to attend remotely)
   - A 12-week research project in DCU (June – August)

3. In addition, three of the modules on the programme will be delivered by our partners at Arizona State University (USA) as part of the International School of Biomedical Diagnostics. Support for these modules will be provided at DCU through tutorials.

4. Student assessment is through Continuous Assessment and primarily consists of submission of online assignments throughout the year. Formal written examinations are not used for assessment of student learning.
The modules offered on the programme are outlined in Table 1

**Table 1: Modules on the M.Sc. in Diagnostics and Precision Medicine programme**

<table>
<thead>
<tr>
<th>Module Title</th>
<th>ECTS Credits</th>
<th>Semester</th>
<th>Assessment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Introduction to Cell Biology and Biotechnology</td>
<td>5</td>
<td>1</td>
<td>100% CA</td>
</tr>
<tr>
<td>Recombinant DNA Technology</td>
<td>5</td>
<td>1</td>
<td>100% CA</td>
</tr>
<tr>
<td>Fundamental and Applied Immunology</td>
<td>5</td>
<td>1</td>
<td>100% CA</td>
</tr>
<tr>
<td>Molecular Diagnostics(^1)</td>
<td>5</td>
<td>1</td>
<td>100% CA</td>
</tr>
<tr>
<td>Precision Medicine 1: Targeted Therapeutics and Diagnostics for Cancer</td>
<td>10</td>
<td>1</td>
<td>100% CA</td>
</tr>
<tr>
<td>Translational Bioinformatics(^1)</td>
<td>5</td>
<td>2</td>
<td>100% CA</td>
</tr>
<tr>
<td>Precision Medicine 2: Targeted Therapeutics and Diagnostics for Inflammatory Diseases and Inherited Diseases</td>
<td>10</td>
<td>2</td>
<td>100% CA</td>
</tr>
<tr>
<td>Applied Biostatistics for Medicine and Informatics(^1)</td>
<td>5</td>
<td>2</td>
<td>100% CA</td>
</tr>
<tr>
<td>Professional Skills for Scientists</td>
<td>5</td>
<td>2</td>
<td>100% CA</td>
</tr>
<tr>
<td>Laboratory practical skills in Biomedical Diagnostics and Therapeutics</td>
<td>5</td>
<td>2</td>
<td>100% CA</td>
</tr>
<tr>
<td>Literature Review, Research Project and Presentation</td>
<td>30</td>
<td>Autumn</td>
<td>100% CA</td>
</tr>
</tbody>
</table>

CA = Continuous Assessment

\(^1\)Delivered by Arizona State University as part of the International School of Biomedical Diagnostics

**Summary of modules on the programme (please refer to the full modules at the end of this document for more details)**

1. Students will initially gain a thorough understanding of fundamental subjects such as cell biology and the manipulation of cells to produce functional products, including therapeutic medicines, in the module entitled ‘Introduction to Cell Biology and Biotechnology’.

2. Students will subsequently learn how biological drugs produced by the Biotechnology industry can be manipulated for enhanced therapeutic purposes in the module entitled ‘Recombinant DNA Technology’.

3. In the module entitled ‘Fundamental and Applied Immunology’, students will gain an appreciation of the complexity of the immune system in protection of the host from pathogenic microorganisms and how antibodies produced during an immune response are
now widely employed as targeted therapeutics for the treatment of cancer, inflammatory disease and infectious disease.

4. Three modules on the programme will be delivered by our partners at Arizona State University as part of the International School of Biomedical Diagnostics (https://chs.asu.edu/programs/schools/international-school-biomedical-diagnostics). These modules are entitled ‘Molecular Diagnostics’, ‘Translational Bioinformatics’ and ‘Applied Biostatistics in Medicine and Informatics’. In these modules students will understand the importance of molecular diagnostic assays in Precision Medicine and healthcare, the role of bioinformatics (computational biology) in biomedical science, and the role of statistical analysis of scientific data, respectively.

5. In two modules entitled ‘Precision Medicine 1’ and ‘Precision Medicine 2’, students will understand how biomedical diagnostics and targeted therapeutics have revolutionised medical practice by delivering the right medicine to the right patient at the right time for diseases including cancer, inflammatory diseases and inherited diseases.

6. The ‘Professional Skills for Scientists’ module develops many of the soft-skills to enhance professional development, including Science Communication, Innovation and Entrepreneurship, Ethics, Research Integrity, Networking and Career Development.

7. In the module entitled ‘Laboratory techniques in Biomedical Diagnostics and Therapeutics’ students learn about the key techniques used in diagnostic assays and fundamental cellular assays employed to monitor therapeutic drugs.

8. Finally, a major component of the M.Sc. will involve a 12-week research project in DCU on a novel research topic related to biomedical science in the module ‘Literature Review, Research Project and Presentation’ (30 ECTS credits). Alternatively, if the student is currently employed full-time in a relevant industry (diagnostics or biopharmaceutical industry), a 12-week design project in the person’s place of work may be permitted, subject to agreement by the programme management team at DCU and the student’s employers.
Course requirements for award at the level of M.Sc., Graduate Diploma and Graduate Certificate are indicated in Table 2.

Table 2: Requirements for level of award at MSc, Graduate Diploma and Graduate Certificate

<table>
<thead>
<tr>
<th>Level of award</th>
<th>ECTS credits</th>
<th>Modules</th>
</tr>
</thead>
<tbody>
<tr>
<td>MSc in Diagnostics and Precision Medicine</td>
<td>90 ECTS credits</td>
<td>All modules listed in Table 1</td>
</tr>
<tr>
<td>Graduate Diploma in Diagnostics and Precision Medicine</td>
<td>60 ECTS credits</td>
<td>All modules listed in Table 1 except for the module ‘Research project, Literature review and Presentation’</td>
</tr>
<tr>
<td>Graduate Certificate in Diagnostics and Precision Medicine</td>
<td>30 ECTS credits</td>
<td>Students must take 2 core modules (15 ECTS credits)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Molecular Diagnostics</td>
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<tr>
<td></td>
<td></td>
<td>- Precision Medicine 1</td>
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<td></td>
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<td></td>
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<tr>
<td></td>
<td></td>
<td>Then select optional modules from the following list to make 30 ECTS credits:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Introduction to Cell Biology and Biotechnology (5 ECTS credits)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Recombinant DNA Technology (5 ECTS credits)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Fundamental and Applied Immunology (5 ECTS credits)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Translational Bioinformatics (5 ECTS credits)</td>
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<tr>
<td></td>
<td></td>
<td>- Laboratory practical skills in Biomedical Diagnostics and Therapeutics (5 ECTS credits)</td>
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<tr>
<td></td>
<td></td>
<td>- Precision Medicine 2 (10 ECTS credits)</td>
</tr>
</tbody>
</table>
**Entry Requirements**

To qualify for the M.Sc. in Diagnostics and Precision Medicine programme students will be expected to have a Second Class Honours degree (2.1) or equivalent in a life science, pharmaceutical or chemistry discipline.

In addition, candidates who hold a primary degree, with a Second-Class grade (H2.2) in a relevant discipline and with industrial experience will be considered.

Medical graduates must have a MB, BCh, BAO or equivalent from a recognised medical school.

Non-native speakers of the English language must satisfy the University of their competency in the English language. See [www.dcu.ie/registry/english.shtml](http://www.dcu.ie/registry/english.shtml) for further details of the English competency test.
Programme Learning outcomes

On successful completion of this programme, the learner will be able to demonstrate:

PO1 Knowledge - Breadth: An understanding of the theory, concepts and knowledge pertaining to biomedical diagnostics and therapeutics, in particular how they are increasingly used to tailor medical treatments according to the characteristics of the individual patient.

PO2 Knowledge – Kind: Fundamental knowledge of core disciplines including molecular and cellular biology, genetics, immunology and molecular diagnostics; Application of this knowledge to understand the molecular basis of disease, to understand how targeted therapeutics are developed and manipulated by recombinant DNA technology for medical applications, to understand the critical importance of biomedical diagnostics and therapeutics in precision medicine and healthcare delivery, to address the critical need to develop new diagnostics assays and therapeutic drugs for the treatment of diseases; Development of new knowledge and critical thinking by engaging in research and development in a laboratory-based environment.

PO3 Skill – Range: A capacity to apply the above named core disciplines in the design and production of biomedical diagnostic assays and biopharmaceutical products; cross-disciplinary and quantitative analysis of biomedical diagnostic assays and therapeutics drugs; problem-solving and incorporating critical thinking and decision-making into a variety of diagnostic/biopharmaceutical applications and environments.

PO4 Skill – Selectivity: An ability to access and critically evaluate the scientific literature on a given topic or area of biomedical diagnostics, therapeutics or both; an ability to develop and refine research hypotheses in these areas; an ability to design and conduct studies/experiments relating to biomedical diagnostics and therapeutics and to scientifically evaluate and interpret experimental data and results; an ability to select and apply appropriate means for the design of new, improved or alternative processes or protocols that address scientific challenges in biomedical diagnostics and therapeutics.
PO5 Competence – Context: Competence to critically evaluate the most effective tools and techniques for the development next-generation biomedical diagnostic assays and therapeutic drugs for the diagnosis and treatment of disease; competence to formulate appropriate solutions and to provide alternative strategies to address challenges pertaining to biomedical diagnostics and therapeutics.

PO6 Competence – Role: Competence to work both independently and as part of a team where leadership and teamwork are actively developed and encouraged; an ability to lead and manage teams within the diagnostics and biopharmaceutical industry or within research institutes in academic centres; an ability to communicate results and ideas clearly and effectively.

PO7 Competence – Learning to Learn: Learning to self-evaluate through an awareness to develop critical skills relating to professional development; an appreciation of the need to update and deepen key skills pertaining to new methods, tools and technologies employed in diagnostics and therapeutics (including R&D and production of products); an awareness to keep up to date with industrial and academic training initiatives.

PO8 Competence – Insight: Competence to understand the importance of ethics, ethical standards and integrity for the R&D of diagnostic assays and therapeutic products; an understanding of the importance of the role of scientists in society and the need to communicate results and progress clearly and effectively to his/her peers and to members of the public.
Module Learning Outcomes
Module 1: Introduction to Cell Biology and Biotechnology

Module Aims: Students will come from a broad range of disciplines on entering the M.Sc. in Diagnostics and Precision Medicine programme. This module is designed to ensure that students will quickly achieve the necessary background and understanding of fundamental topics in cellular and molecular biology. The module will also introduce students to the biotechnology/biopharmaceutical industry and explain how advances in cellular and molecular biology have been exploited to produce useful products, particularly therapeutic medicines.

Learning Outcomes:

Upon completion of this module, you will be able to
LO1. Compare and contrast eukaryotic cells and prokaryotic cells in terms of their structure, organisation and intracellular organelles.
LO2. Explain the scientific principles underpinning cellular and molecular biology in eukaryotic and prokaryotic organisms.
LO3. Explain the scientific principles underpinning signal transduction pathways in mammalian cells.
LO4. Discuss how advances in cellular and molecular biology has been exploited by the Biotechnology industry to produce useful products from living organisms.
LO5. Use the scientific literature to source relevant information on current topics in cellular and molecular biology, signal transduction and biotechnology.
Module 2: Recombinant DNA Technology

Module aims: This module will give the student an understanding of how recombinant DNA technologies are used to manipulate both cloned genes and host producer cells so that biopharmaceuticals of authentic structure can be safely and stably produced using appropriate cell-based systems.

Learning Outcomes:
Upon completion of this module, you will be able to

LO1. Discuss protein engineering, giving examples of how and where recombinant genes have been manipulated leading to the generation of recombinant proteins with modified properties.

LO2. Describe examples of rDNA expression systems that ensure high-level production of soluble, purifiable and authentic recombinant proteins.

LO3. Explain gene knockdown technology and discuss its applications in producer cell engineering and gene therapy.

LO4. Describe the principles of Genome Engineering and DNA integration technologies and discuss their applications in the context of engineering host cells to stably produce high-levels of recombinant proteins.
Module 3 Fundamental and Applied Immunology

Module aims: The purpose of this module is to provide a detailed understanding of the innate and adaptive immune systems in protecting the host against pathogens and microorganisms. Students will subsequently learn how the immune system can be manipulated for disease recognition, particularly in relation to vaccine production. The module will also provide a comprehensive overview of the production, manipulation and purification of antibodies for diagnostic, biomedical and therapeutic applications.

Learning Outcomes:
Upon completion of this module, you will be able to
LO1. Compare and contrast the cells and components of the innate and adaptive immune systems.
LO2. Describe how the immune system and immune responses have been exploited for the development of vaccines.
LO3. Describe in detail the methods used to produce antibodies and antibody fragments in the laboratory.
LO4. Identify applications of antibodies and antibody fragments for research, diagnostic and therapeutic applications.
LO5. Describe several different types of immunoassays and select the most appropriate immunoassay to detect/quantify a particular antigen.
LO6. Discuss how antibody-based therapy can be used to treat human disease.
Module 4: Molecular Diagnostics (ASU)
Module Aims: The module is intended to provide a broad survey of molecular diagnostics. It will cover a number of topics including genomics, proteomics, diagnostic platforms and applications, and the underlying key technologies used in molecular diagnostics. The course will also provide insights on where the field of molecular diagnostics is heading and what the key challenges are.

Learning Outcomes:
Upon completion of this module, you will be able to
LO1: Identify and describe the drivers of molecular diagnostics which include nucleic acid and protein structures, disease treatment and management, and healthcare economics.
LO2: Develop an understanding of major molecular diagnostic technologies and their application to diagnostics.
LO3: Select the most appropriate molecular diagnostic assay to address a challenge relating to diagnosis of a particular disease or condition.
LO4: Identify approaches towards trouble-shooting a serious problem during development of a molecular diagnostic assay.
Module 5: Precision Medicine 1: Targeted Therapeutics and Diagnostics for Cancer

Module Aims: Precision Medicine 1 will focus on how advances in our understanding of cancer biology, together with advances in molecular diagnostics and targeted therapeutics, have revolutionised the treatment and outcome of cancer by tailoring treatments to the individual patient. Students will initially develop an understanding of the molecular, cellular and environmental basis of cancer. They will subsequently learn how through Precision Medicine, the treatment of several cancers has shifted away from the “One-Size-Fits-All” approach of treatment to a focused and tailored strategy based on the molecular profile of a patient’s tumour. The module will also focus on the critical importance of predictive diagnostic assays (Companion Diagnostics, Complimentary Diagnostics and Laboratory-Developed Tests) and prognostic diagnostic assays in Precision Medicine, as well as emerging role of diagnostics in the drug development process. Students will therefore develop an understanding of the theory and practice of Precision Medicine in oncology and how this knowledge has been translated into improved outcomes for cancer patients.

Learning Outcomes:
Upon completion of this module, you will be able to
LO1: Describe the genetic, molecular, cellular and environmental basis of cancer.
LO2: Discuss, using specific examples, the milestones that led to the development of targeted therapeutics and diagnostics for the treatment of several cancers, including target identification/evaluation in pre-clinical models and the pivotal human clinical trials that led to their regulatory approval.
LO3: Evaluate the critical role of biomarkers in cancer screening, diagnosis, stratification of patients for therapy, monitoring of response to therapy and patient prognosis.
LO4: Describe the different types of in-vitro diagnostic assays that are used in Precision Medicine (including Companion Diagnostics, Complimentary Diagnostics and Laboratory-Developed Tests) and be able to distinguish between them.
LO5: Explain how diagnostics have been integrated into the drug development process (drug-diagnostic co-development), and by highlighting several case studies, the challenges in implementing this co-development.
LO6: Identify the critical issues remaining to identify, classify and treat cancer more effectively and more efficiently.
Module 6: Precision Medicine 2: Targeted Therapeutics and Diagnostics for Inflammatory Diseases and Inherited Diseases

Module Aims: In this module students will learn how targeted therapeutics have revolutionised the treatment of inflammatory/autoimmune diseases such as Rheumatoid Arthritis, Multiple Sclerosis, Psoriasis and Inflammatory Bowel Disease. In contrast to Precision Medicine for Cancer where predictive diagnostic assays are used to determine the likelihood of response to targeted therapy, such assays are lacking for the treatment of patients with inflammatory disease. Hence, students will be able identify the critical need for development of diagnostic assays to predict the likelihood of response to therapy in the context of inflammatory disease by providing an up to date synopsis of the latest developments in this field of Precision Medicine. The module will also cover exciting new therapies that have recently been approved for inherited conditions such as Cystic Fibrosis and Duchenne Muscular Dystrophy, as well as gene modulation technologies including gene therapy, RNA interference and CRISPR technology.

Learning Outcomes:

Upon completion of this module, you will be able to

LO1: Describe the molecular basis of inflammation and how unregulated/non-resolving inflammation can lead to inflammatory diseases.
LO2: Describe the mechanism of action of targeted therapies for the treatment of inflammatory diseases such as Rheumatoid Arthritis, Multiple Sclerosis, Psoriasis and Inflammatory Bowel Disease.
LO3: Address the critical need to develop diagnostic assays to predict who is likely to benefit from these targeted therapies and who is unlikely to benefit.
LO4: Explain the pattern of inheritance of diseases such as Cystic Fibrosis and Duchenne Muscular Dystrophy and how the development of targeted therapies has led to better outcomes for subgroups of patients with these disorders.
LO5: Identify the mechanisms of gene delivery to human cells and how this has been exploited for gene therapy.
LO6: Explain the molecular mechanism of RNA interference and CRISPR-mediated gene silencing/modification and their potential applications for Precision Medicine.
Module 7: Translational Bioinformatics (ASU)
This course will provide an introduction to bioinformatics methods and applications used in the field of translational medicine research, focusing on analytics that translate high-throughput molecular data into biomedical knowledge.

Learning Outcomes:
Upon completion of this module, you will be able to
LO1: Identify and describe the major areas of translational informatics.
LO2: Critically appraise existing applications and methods in these area.
LO3: Use bioinformatics databases and tools to search, manage and analyse molecular data.
LO4: Describe likely future applications and probable growth areas.
Module 8: Applied Biostatistics in Medicine and Informatics (ASU)
This course covers the basics for statistical methods used most often to analyse quantitative data collected in medical and biomedical informatics studies, including clinical trials and epidemiologic studies. The course also introduces some of the most important issues encountered in the analysis of 'omic data. Emphasis is placed on assessing data quality, understanding how to select an overall approach to analysis, and presenting and interpreting the results of statistical analysis. Students will learn to use R to effectively display and analyze data collected in biomedical research studies.
Upon completion of this course, students will: 1) recognize the importance of data quality and how to ensure data quality before undertaking analysis; 2) conduct statistical analysis of data from an array of designs used commonly in biomedical studies; 3) interpret statistical analysis of biomedical data from a variety of study designs.

Learning Outcomes:
Upon completion of this module, you will be able to
LO1: Demonstrate the ability to recognize problems with data quality before undertaking analysis.
LO2: For an array of designs used commonly in biomedical studies, demonstrate the ability to conduct an analysis of the data using R and interpret the results.
LO3: Demonstrate the ability to conduct a power analysis and estimate sample size requirements for planned studies.
Module 9: Laboratory Practical Skills in Biomedical Diagnostics and Therapeutics

Module Aims: The purpose of this module is to prepare the students in evaluating and critiquing data generated from advanced laboratory techniques that are relevant to the Diagnostics and Biopharma industries. The students will develop a good understanding of the theory and practice of each technique and will complete a comprehensive laboratory report outlining the background, experimental design, results and discussion for each data set.

Learning outcomes:
1. Evaluate and critique data from an experiment to determine the concentration of an analyte using HPLC.
2. Evaluate and critique data from an experiment to examine a chemotherapeutic agent on cancer cell growth:
3. Evaluate and critique data from an experiment to identify a biomarker of disease using qPCR analysis of gene expression in a cell-derived mRNA sample).
4. Evaluate and critique data generating from examining the immune suppressive properties of an anti-inflammatory drug candidates.
5. Evaluate and critique data from flow cytometry data related to practicals 1 and 2.

Module Content

Practical 1: Evaluate and critique research data from an experiment to determine the concentration of an analyte using HPLC: The student will watch a video and read a selection of papers to understand the basic chromatographic principles of bioanalysis using high performance liquid chromatography (HPLC, UHPLC) and explain the critical functional components of a HPLC system. Provide the technical information to run a HPLC analysis to determine the concentration/purity of an analyte (e.g. a drug or metabolite) in a biological sample or other preparation. Understand how HPLC parameters (e.g. mobile phase composition, flow rate, sample preparation) can be practically optimized to improve sample separation and quantitation. Data will be provided and the student will complete a lab report that will

Practical 2: Evaluate and critique data from an experiment to identify a biomarker of disease using qPCR analysis of gene expression in a cell-derived mRNA sample).

Practical 3: Evaluate and critique data from an experiment to examine a chemotherapeutic agent on cancer cell growth: Work aseptically with a human colon cancer cell line and a macrophage cell line. Prepare cell culture media. Perform a direct cell count and distinguish between viable and dead cells. Describe the technical aspects that are important for animal cell culture. Set up 96-well microtitre plates to measure the impact of a chemotherapeutic agent on cell viability, cytotoxicity and cell proliferation. Design, execute and interpret experiments in cancer cell biology, including cell cycle/apoptosis analysis and the detection of disease biomarkers. Evaluate and critique research data from
cancer biology experiments involving Flow Cytometry, IHC, Western blots, gene knockdown, transgene expression, RTqPCR, and gene promoter analysis including Chromatin Immunoprecipitation.

**Practical 4: Evaluate and critique data immune suppressive properties of a novel drug candidate:** Work aseptically with macrophage cell line and a macrophage cell line. Prepare cell culture media. Perform a direct cell count and distinguish between viable and dead cells. Describe the technical aspects that are important for animal cell culture. Set up cell culture plates using a macrophage cell line to measure the impact novel immune therapeutics on inflammatory repose. Perform a range of immunological techniques such as Enzyme-linked immunosorbent assay to measure cytokine release. Design, execute and interpret experiments in immunology measuring changes in cell surface expression of co-stimulatory molecules and intracellular expression of cytokines. Evaluate and critique research data from immunology experiments involving the detection of inflammatory biomarkers.

**Practical 5:** Evaluate and critique data from flow cytometry data related to practicals 3 and 4.
Module 10: Professional Skills for Scientists

Module aims: In this module students will develop a wide range of critical and transferrable skills for a successful career in Biomedical Sciences, Diagnostics and Biopharma. These topics include Career Planning, Research Integrity, Intellectual Property and Patent Searching, Science Communication (Writing for Science and Presentation skills), Innovation and Entrepreneurship for Scientists, and Ethics in Scientific Research.

Learning Outcomes:

Upon completion of this module, you will be able to:

LO1. Identify strategies that will enable you to plan your professional career.

LO2. Understand the principles of communicating science through science writing, oral presentations and poster presentations.

LO3. Critically analyse a fundamentally important publication in the field of diagnostics or therapeutics and write an opinion piece article designed for an expert audience and a lay audience.

LO4. Develop creative thinking skills, in particular in the area of entrepreneurship and innovation.

LO5. Undertake a patent search and describe how research can be commercialised and protected via intellectual property.

LO6. Understand the importance of research integrity in scientific research.

LO7. Identify common types of ethical dilemmas in biomedical research and diagnostics.
Module 11: Literature review, Research Project and Presentation

Module aims: In this module, students will participate in a three-month research placement within the School of Biotechnology or in other Institutes in DCU. Alternatively, if you are working in a relevant Industry you may undertake your research project in your place of work. This module will help students develop the research skills needed to adopt a problem-solving approach to scientific research in biomedical diagnostics and therapeutics. Guidance will be provided in the basic methodology of scientific research and in summarising, elaborating and explaining research results. Students will also gain a number of transferable skills, including communication, interpersonal and organisational skills. Students will provide the structure of their own literature review/project plan and this should clearly identify the context of the proposed research, and status of the field, together with realistic time scale for completion. Students will complete a dissertation that will include a full scientific report of their project. Also, students will give an oral presentation of their project to all Principle Investigators and mentors involved in the project.

Learning Outcomes:
Upon completion of this module, you will be able to:
LO1. Locate the source information and literature necessary for your research thesis and literature review.
LO2. Apply the methods and procedures of scientific research and development on a novel topic pertaining to diagnostics or therapeutics.
LO3. Identify logical approaches to experimental design, analytical measurement, and data analysis.
LO4. Prepare a research thesis that provides a summary and critical analysis of the scientific research that was carried out in this project.
LO5. Deliver an oral presentation of your research topic.