Multi-omics technologies in precision medicine

The course covers the current state of knowledge in multi-omics approaches: genomics, transcriptomics, epigenomics, proteomics and metabolomies, providing a basic overview of these technologies, their applications and potential in the scope of precision medicine. The program, which encompasses the theoretical and practical parts of the course, is organized in modules, addressing the following key areas:

T1) Introduction to Omics Approaches

- Introduction to omics technologies: genomics, transcriptomics, epigenomics, proteomics and metabolomics.
- Types and objectives of next-generating sequencing (NGS): whole genome sequencing (WGS), whole exome sequencing (WES).

P1) Public Databases and Gene Information

- Introduction to publicly available omics databases.
- Hands-on session exploring gene information, including tissue-level and gender specificity (GTEx Portal).

T2) Transcriptomics and miRNAs in Therapeutic Research

- Introduction to RNA-seq and miRNA-seq: techniques for studying gene expression.
- Alternative splicing and protein isoforms.
- The role of miRNAs in post-transcriptional regulation and their potential therapeutic applications.

P2) Splicing Profiles and miRNAs

- Hands-on session exploring gene transcripts (GTEx Portal, NCBI, Ensembl, UCSC Genome Browser).
- identification of genes directly targeted by miRNAs (miRWalk, TargetScan, miRBase).

T3) Epigenomics and ChIP-seq: Understanding Gene Regulation

- Introduction to chromatin structure and modifications.
- The role of Chromatin Immunoprecipitation Sequencing (ChIP-seq) and Assay for Transposase-Accessible Chromatin Sequencing (ATAC-seq) in studying epigenetic regulation.

P3) Transcription Factors

- Hands-on session exploring transcription factors (ENCODE, TRRUST, AnimalTFDB v4.0, UCSC Genome Browser).

T4) Proteomics and metabolomics

- Basics of mass spectrometry-based proteomics and -metabolomics.
- The role and importance of post-translational modifications (PTMs) such as phosphorylation, acetylation, methylation, glycosylation, and redox (cysteine based) PTMs.
- Computational Modelling contribution to improve mechanistic understanding of structural and functional effects of PTMs (molecular dynamics).

P4) Proteomics and Protein PTM analysis

- Hands-on session exploring databases and methods used to identify and quantify proteins and protein-PTM (ProteomeXChange, ProteomicsDB, PRIDE).

T5) Multi-Omics analysis and integration to inform therapeutic decisions: implications to precision medicine

- Basic machine learning techniques for analyzing omics data: logistic regression, PCA, K-Means clustering.
- Introduction to more advanced techniques, such as neural network-based machine learning and Sparse regularization methods.
- Integrating Multi-Omics approaches in drug development: identifying druggable targets using integrated omics analyses. Integrating data from genomics, transcriptomics, epigenomics and proteomics for developing advanced therapies.

P5) Case Studies

- Application of multi-omics in personalized therapies for non-communicable diseases.

Preliminary schedule

	Monday	Tuesday	Wednesday	Thursday	Friday
9:00-11:00	**T1** *Welcome session and Course Presentation* Introduction to Omics Approaches	**T2** Transcriptomics and miRNAs in Therapeutic Research	**T3** Epigenomics and ChIP-seq: Understanding Gene Regulation	**T4** Proteomics and metabolomics	**T5** Multi-Omics analysis and integration to inform therapeutic decisions: implications to precision medicine
11:00-11:30	**Coffee break**				
11:30-12:30	**T1** Introduction to Omics Approaches	**T2** Transcriptomics and miRNAs in Therapeutic Research	**T3** Epigenomics and ChIP-seq: Understanding Gene Regulation	**T4** Proteomics and metabolomics	**P5** Case studies
12:30-14:00	**Lunch**				
14:00-16:00	**P1** Public Databases and Gene Information	**P2** Splicing Profiles and miRNAs	**P3** Transcription Factors	**P4** Proteomics and Protein PTM analysis	**Students Presentation**
16:00-17:00	**Tutorial**	**Tutorial**	**Tutorial**	**Tutorial**	**Tutorial**

T – Theoretical classes/ Lectures/ Seminars; P – Practical / Hands-on sessions