MANIFESTO OF STUDIES A.Y. 2015-2016

1st YEAR - MANDATORY COURSES -				
Course	**Teacher**	**Hours**	**Synopsis**	**Evaluation procedure**
Laboratory Safety Course	Prof. Mancini I. Prof. Provenzani A.	12	General Laboratory Procedures, Equipment Use, and Safety Considerations. The course consists of lectures and hands-on activities and provides training in chemical manipulation, laboratory activity, biology hazard, fire, and radiation safety.	Biology part: written exam. Chemical part: written exam
Laboratory Techniques	Various	12		Written report by the teacher

2nd YEAR - MANDATORY COURSE -				
Course	**Teacher**	**Hours**	**Synopsis**	**Evaluation procedure**
Scientific Publishing & Communication	Dr. Dahm R.	12	The proposed course aims to convey the basic skills needed to publish and communicate scientific results. It combines lectures, which will explain the basic principles of good writing practice and presentation skills, with practical parts during which the students will apply their newly acquired knowledge. The target audiences of the course are PhD students, but the course will also be open to select Master's students and junior postdoctoral scientists.	
OPTIONAL COURSES				
Course	**Teacher**	**Hours**	**Synopsis**	**Evaluation procedure**
Scientific English* Extra credits	CLA –Centro Linguistico d'Ateneo	24 (18 in class)		

Preclinical research and clinical development programs of drugs	Prof. Borlak J.	12	The main objective of this course is to provide an overview of biomedical research strategies and clinical development programs in the drug/ biotech industry. The students will be made familiar with some basic experimental concepts as well as legal requirements for the development of novel drugs. Emphasis is given to the knowledge gain from genome biology and complex data analysis arising from high throughput technologies. *1.* Introduction into basic concepts in preclinical drug research and development *2.* Methods in experimental drug research and clinical development with emphasis on microarray , mass spec, high throughput cell biology assays and in vivo imaging modalities *3.* Genetic models of disease with emphasis on cancer biology and validation of such disease models for the development of novel anticancer drugs *4.* The molecular basis for drug metabolism and disposition including case studies *5.* The molecular basis for drug induced toxicities including case studies *6.* Basic concepts in pharmacogenetics and pharmacogenomics and its application to individualised drug therapies *7.* The application of genomic sciences for improved and individualized drug therapies *8*. Round table discussion with students – and 2 to 3 short presentations from students on selected topics of the course objective.	Group exam of n=4 students; students are requested to prepare a 20 min presentation followed by in-class discussion; upon request students can be examined individually.
Statistics	Prof. Agostinelli C.	12	TBD	
Bioinformatics	Prof. Blanzieri E. Dr. Passerini A.	12	Design of microarray experiments. Normalization of microarray data. Loess. Significance of Analysis of microarray data, t-test, SAM, Cluster Algorithms. Kmeans. Hierachical Clustering. Distances used in clustering. Use of R for microarray data analysis. Probabilistic graphical models: probabilistic inference, structure and parameter learning. Hidden Markov Models for biological sequence analysis: Pair-HMMs, Profile HMMs.	Probabilistic graphical models: Bayesian network project.
Business Planning for biotech leaders	Dr. Milani S.	12	The course prepares PhD students to become potential leaders gaining an understanding of the fundamentals of organizational effectiveness-management finance, entrepreneurship and project management Course topics include: 1. Income statement Introduction for biotech projects 2. Balance Sheet Introduction for biotech projects 3. Free cash flow Introduction for biotech projects 4. How venture capitalists evaluate biotech projects 5. How to write a business plan for private/venture funding The course goes beyond the traditional debate over costs and grants as it will examine the critical processes required to develop and deliver biotech projects/products into biotech global market. The students will also work on a biotech project business plan by evaluating alternative financial/sustainability approaches.	

Molecular Spectroscopic Techniques	Prof. Guella G.	12	The lessons include principles and applications of molecular spectroscopy for the elucidation of bioorganic structures and binding phenomena. Main emphasis will be on modern applications of Nuclear Magnetic Resonance and Mass Spectrometry in biochemical contexts but fundamentals of electronic and vibrational spectroscopy will be also presented. *Molecular spectroscopy***.** *Mass Spectrometry* *Principles of Nuclear Magnetic Resonance (NMR).*	Individual reports and discussion on assigned topic & participation.
RNA Molecular Biology and Biotechnology	Prof. Denti M. Dr. Stefani G. Dr. Biagioli M.	18	The course aims to familiarize the students with cutting-edge new discoveries in the field of RNA biology, and we expect the students to be familiar with the major topics of RNA-based regulation by the conclusion of the course. Topics will include: RNA secondary and tertiary structure; small and large ribozymes, riboswitches, RNA interference (RNA splicing modulating therapies). The course also covers Piwi-interacting RNA (piRNA), the largest class of small non-coding RNA molecules expressed in animal cells and their role in epigenetic and post-transcriptional gene silencing of retrotransposons and other genetic elements. Another topic will be Long ncRNAs (lncRNAs) that comprise a rapidly expanding class of non-coding transcripts with emerging roles in protein synthesis and chromatin regulation. We discuss the implications for noncoding RNAs (Linc, SINEUPs) in transcriptional, translational regulation, the formation of specialized chromatin domains in various epigenetic processes as dosage compensation, RNA interference-mediated heterochromatin assembly and gene silencing and programmed DNA elimination. Finally, the course will cover Circ-RNAs biogenesis, back-splicing events, genomic features,expression and stability, as well as their possible function in health and disease.	Presentation of cutting-edge papers, suggested by the teacher and presented by a 30 min journal club by the student.
Stem cell Biology	Prof. Conti L.	12	The course aim is to introduce the students to the biological properties of different stem cell populations and the molecular pathways that control their stemness and developmental potency. Students will discover how stem cell biology is revolutionizing the biomedical field with its fundamental contributions to regenerative medicine and biopharmaceutical industries. Main emphasis will be on recent literature and applications.	Group discussion on assigned topic & participation.
Introduction to metagenomics	Dr. Segata N.	12	The course will present the state-of-the-art metagenomic approaches for studying the microbial communities (microbiomes) populating the human body and the environment, and will describe the main recent microbial ecology findings, with a focus on those related to human diseases. On the methodological viewpoint, we will present metagenomic tools based on microarray chips, 16S rRNA sequencing surveys, and shotgun high-throughput sequencing from both the experimental and technological viewpoints. An overview of the challenges and solutions for computationally analyzing metagenomic data will be presented including methods for taxonomic characterization, functional profiling, genome assembly, phylogenetic inference of microbiomes. Advanced sequencing-based approaches for pathogen detection and characterization will also be presented. Recent findings about the	Presentation and critical discussion of a paper (during the last 2-hours lecture)

			relation between human associated microbial communities and complex diseases will be discussed as well as the mechanisms of vertical microbiome transmission (e.g. from mother to neonate) and gut microbial colonization.	
Chemical modifications and organic synthesis of biomolecules	Prof. Mancini I.	12	The course will focus on the core principles of synthetic strategy and methodology, with the discussion of recently published topics in the field and the possibility to verify some practical aspects in the laboratory. Strategies in total synthesis: linear and convergent sequence, conversion of functional groups, protective groups, carbon-carbon reactions, application of organometallic reagents; workup and isolation of the products. New methodologies: solvent role and choice, solid supported synthesis, microwave irradiation and other eco-friendly techniques. Asymmetric synthesis: stereoselectivity and introduction of new desired elements of chirality. Asymmetric and bio- catalysis using enzymes and chiral natural molecules. Examples of natural product synthesis. Design and synthesis in modern drug discovery: combinatorial and biomimetic approaches. Synthesis of supra-molecular systems, also with the involvement of proteins and DNA.	Presentation and discussion of an assigned paper
Synthetic Biology	Prof. Mansy S.	12	The course will explore different aspects of the new field of synthetic biology. Topics ranging from top-down and bottom-up perspectives, BioBricks (parts, devices, and chassis), genetic circuits, bioengineering, minimal genomes, minimal cells, orthogonal systems, as well as combinatorial and directed evolution methods will be covered. Students will learn how synthetic biology is changing the biotechnology industry, e.g. in the pharmaceutical and biofuels industries, and how work on synthetic biology is helping to reveal how the chemical and physical complexities of a cell give rise to the emergent behavior of life.	Oral exam & participation
Advancements in understanding neuronal degeneration	Dr. Basso M Dr. Pennuto M.	12	The course will provide an overview of the most common neurodegenerative diseases along with the illustration of the most promising diagnostic and therapeutic approaches so far reported	Oral exam
Data Exploration	Dr. Franceschi P.	12	Being able to explore, visualize and interpret complex data is becoming more and more important in biology. With "omic" technologies it is now possible to measure thousands of variables on hundreds of samples, but "big" data can be also produced by many other platforms used to characterize biological samples. The course will focus on data exploration and visualization, introducing some of the bioinformatical and biostatistical tools/concepts which can be used to explore a multidimensional dataset (PCA, Clustering, Linear Modeling, ...). The aim is to highlight the advantages and limitations of each approach. During the course the different aspects will be illustrated by live R/Python sessions on publicly available datasets. The students will be also encouraged to bring their own data to discuss and (possibly) analyse them.	Individual/Group reports and discussion on assigned topics

Beyond the central dogma: epigenetics, non-coding RNA, protein post-translational modifications and human disease.	Prof. Ferrari S. Prof. Marra G. Dr. Biagioli M.	18	This course will explore three aspects of molecular biology (epigenetics, noncoding RNA, and protein post-translational modifications) that complement and extend the basic knowledge of the upward causation of life (i.e., DNA->mRNA->Protein). First part: What is epigenetics? A general overview of nucleosome structure, histone modification, histone variants, DNA methylation and their regulatory role in Methylation of CpG residues in DNA is one epigenetic mechanism regulating transcription. The establishment of DNA methylation is termed de novo methylation and occurs during early development and gametogenesis. Analysis of cytosine methylation, hydroxymethylation and other cytosine modification, discussion of their functional role and implication for disease. How do cells interpret DNA methylation patterns? The readers of methylated DNA are methyl-binding proteins that interact with other proteins to alter transcription rates. genomic organization and transcription. Altered DNA methylation, implications for cancer Second part: General introduction on post-translational modifications of histone tails. Writers, Readers and Erasers of the histone modification and their implication in pluripotency and differentiation. How do cells interpret histone marks? Polycomb group proteins SETD2-dependent trimethylation of histone H3K36 and their role in transcription silencing and alternative pre-mRNA splicing in mammalian cells. Implication for neuronal pathologies and cancer. Chromatin organization within the nucleus is dynamic and non-random. During interphase, chromatin domains establish three-dimensional organization. This organization drives the transcriptional profile of the cell. We discuss the use of high-throughput sequencing technique to map the 3 dimensional chromatin structure, termed Hi-C, to assess subnuclear positioning of tissue-specific promoters during cellular differentiation and cancer. Third part: Reversible post-translational modifications (PTMs) generate protein variants displaying distinct biological properties and, as such, they are a major determinant of network complexity. In the third part of the course, students will become familiar with PTMs whose hierarchical, synergistic or antagonistic combination defines a code that translates into well-defined outputs. Starting from the historically most studied PTM, namely phosphorylation, students will be guided through the discovery of PTMs that put us now in the position of explaining processes as distant as the immune response, the DNA damage response, cell proliferation and cell cycle regulation. For each PTM, special emphasis will be put on pharmacological approaches that aim at targeting pathway components in the therapy of cancer.	Written test consisting of a mixture of short essay-type questions and multiple-choice questions.

Applied Statistics for High-Throughput Biology	Dr. Waldron Levi	24	This course will provide biologists and bioinformaticians with practical statistical and data analysis skills to perform rigorous analysis of high-throughput biological data. The course assumes some familiarity with genomics and with R programming, but does not assume prior statistical training. It covers the statistical concepts necessary to design experiments and analyze high-dimensional data generated by genomic technologies, including: exploratory data analysis, hypothesis testing, linear modeling, principal components analysis, unsupervised clustering, predictive model training and validation, cross-validation and bootstrap resampling methods. These are broadly useful techniques for high-throughput data and it is intended that this course will provide students with an applied statistical toolkit that is relevant across domains of biology and across genomic technologies. Learning Objectives • Understand key basic statistical concepts and notation • Perform exploratory and inferential data analysis • Perform and evaluate differential gene expression by array and RNA-seq • Understand key aspects of experimental design of high-throughput experiments • Extend differential expression analysis to more complex experimental designs • Perform and evaluate unsupervised cluster analysis • Generate prediction models in high-dimensional data and evaluate their accuracy • Plan for, identify, and correct for batch effects • Perform meta-analysis of independent experiments Suggested pre-requisites: • Basic programming skills. The course will assume that the students are familiar with basic programming concepts (variables, functions). • Familiarity with the R language. The course will use R to demonstrate data analyses. We will introduce software from the Bioconductor project, but will not cover a basic introduction to the R language. Students unfamiliar with R are recommended to review the Online R resources below. Related Resources R Books: •Software for Data Analysis: Programming with R (Statistics and Computing) by John M. Chambers (Springer) •S Programming (Statistics and Computing) Brian D. Ripley and William N. Venables (Springer) •Programming with Data: A Guide to the S Language by John M. Chambers (Springer) Online R resources: •R reference card (PDF) by Tom Short (more can be found under Short Documents and Reference Cards here) •Quick-R: quick online reference for data input, basic statistics and plots: Thomas Girke's R & Bioconductor manuals Free online statistics textbooks • OpenIntro Statistics (referred to in outline as OIS) : Intro Stat with Randomization and Simulation (referred to in outline as ISRS) .	Each week will include a hands-on lab sessions that will be reviewed and discussed, but not graded. There will be three graded projects: two in the format of a scientific article, and one oral presentation. These will be graded for quality of analysis, but also for presentation style and clarity. These projects will also introduce students to reproducible research by Literate Programming using the R “knitr” package and its implementation in RStudio.
Cancer Models	Dr. Marina Mione	12	The course focuses on in vivo models as experimental tools in cancer research. It will explore the ethics of using animal models, the usefulness of the models and the potential benefits for human health.	Presentations of selected papers by the students in a minisimposium, roundtable and

			Topics include: genetic models in cancer research (mouse and zebrafish), tools for genetic manipulation, spontaneous/induced mutations, transgenesis, clonal analysis. Experimental models to study metastatis, immune responses, and personalized medicine.	working groups.
Genomic and proteomic biomarkers: from target discovery to drug development applications	Dr. Enrico Domenici	12	The objective of the course is to introduce the concept of biomarkers, with a particular emphasis on disease and clinical response biomarkers, and their applications in the identification of novel therapeutic targets and patient stratification strategies. A number of examples of genome- or proteome wide-approaches for biomarker discovery and validation will be provided and their potential impact in drug discovery will be highlighted. A special focus will be given to translational neuroscience biomarkers and their promise to personalized therapies. Biomarkers and Translational approaches • definition and field of applications • biomarker needs in neuroscience Biomarker investigations by expression analysis • genomics, proteomics and metabolomics approaches in biological fluids • examples from neurodegenerative and neuropsychiatry disorders Genetic biomarkers • from GWAS to patient stratification strategies	The evaluation will be based on small group journal clubs focusing on specific biomarker topics, where each student will be assessed for group and individual effort.
Introduction to the CIBIO Core Facilities	Facility Managers	6+6	The courses will provide an introduction to techniques and instruments related to each Core Facility, together with examples of current applications. Part of the course will be dedicated to the discussion of specific topics and the possibility of a practical session will be evaluated on a case-by-case basis. Cibio Core Facilities are: • High Throughput Screening (HTS) • Next Generation Sequencing (NGS) • Cell Analysis and Separation • Advanced Imaging • Proteomics	

The students enrolled at the International PhD Program in Biomolecular Sciences are obliged to attend courses, seminars, symposia and practical courses organized by the PhD Program.

Seminars. National and international researches are invited to present their research within the seminar cycle. Internal seminars (journal clubs and progress report) must regularly organized in order to present and discuss new published results or to shown data of ongoing research activities. The students must attend at least 15 seminars per year.

Symposia. A symposium (named *work in progress*) which all the doctorate students have to attend is organized once a year. All PhD students will give a short presentation of their results. For the doctorate student, this meeting is the occasion to socialize and in particular to know the projects and the results of his/her colleagues. Moreover, students have the opportunity to gain experience in communication and presentation of scientific results.

COURSE	SPEAKER	HOURS		YEAR
Journal Club	PhD candidate	3	The Journal club is an important scientific update and discussion and it is part of the teaching program of the PhD student. The Journal Clubs aim to guide the students to a critical reading of a scientific work, with particular attention to the methodological approaches, research and analysis, other than those normally used in their specific field of research and interpretation of data as well as to implement the knowledge of young researchers. Period: twice a year.	1-2-3
Progress Report	PhD candidate	3	Twice a year, the student must present a summary of the results achieved as well as the status of the project.	1-2-3

Doctoral students must obtain 32 ECTS credits over the three years, corresponding to:
- 120 educational hours (1 credit every 6 hours)
- 15 seminars (2 credits) per year,
- 1 Journal clubs and progress(1 credit) per year,
- 1 progress reports (1 credit) per year.

The PhD students must obtain at least 10 ECTS credits from courses by the end of the first year