université de BORDEAUX

Master Biology - Health

Cancer Biology international track

- all teaching is in English -

Semester 1

- Cancer cell biology	9 ECTS
- Introduction to bioinformatics and “omics” data analysis in oncology[2]	3 ETCS
- Molecular imaging and histopathology[2]	3 ECTS
- Experimental design in biomedical research[2]	3 ECTS
- Technologies in molecular and cell biology[1]	9 ECTS
- Scientific english[1]	3 ECTS

Semester 2

- Cancer immunobiology and immunotherapies	6 ECTS
- High-throughput sequencing and bioinformatics	3 ECTS
- Molecular basis of pathologies[1]	9 ETCS
- Research internship	12 ECTS
- *Extra-curricular option:* animal experimentation training and certification	6 ECTS

Semester 3

- Microenvironment and tumor heterogeneity	6 ECTS
- Modeling and therapeutic innovation in cancer	6 ECTS
- Tutored interdisciplinary project	3 ECTS
- Communication and project conception	9 ETCS
Two courses to be chosen from:	
- Concept and causality of pathologies	3 ECTS
- Microbiota and physiopathology	3 ECTS
- Pharmaceutical sciences	3 ECTS
Other courses offered in the “Biology - Health” master program	3 ECTS

Semester 4

- Research internship	30 ECTS

[1] Course common to all tracks of the “Biology - Health” master (Molecular and Cellular Genetics; Physio-Pathology and Cell Biology; Microbiology and Immunology)

[2] Optional course for the other tracks of “Biology - Health” master

Courses organization

Semester 1

Cancer Cell Biology

Objectives

Understanding of the molecular and cellular processes underlying oncogenesis, in physiological and pathological conditions. Framing the abnormalities of cancerous cells in terms of causes and consequences of oncogenesis.

Contents

- This teaching unit follows the paradigm “Hallmarks of Cancer”.
- Lectures presented by external experts on Cancer Cell Biology research topics: Cell Death, Cell - Extracellular Matrix interactions, Stem Cells, Senescence and Quiescence, Cell Polarity, Energy metabolism, Biosynthesis pathways.
- This course includes a particular focus on Cell Cycle. There is a 20h (five lectures and five tutorial classes) specifically on Cell Cycle related topics.
- Tutorial classes consist in scientific article presentations and discussion by students on the topics addressed in the theoretical lecture - typically one review article and one original article provided by the external experts. In a flipped classroom approach students prepare the article presentations before the lectures on the topic.
- Lab courses include basic techniques used in current Cancer Cell Biology research: conventional and 3D cell culture (organoids), transfection, FACS, for the study of cell cycle progression, cell viability and tumorigenic properties following anti-cancer treatments. The lab course present a continuity with other teaching units - Technologies in Molecular Cell Biology and Molecular Imaging and Histopathology.

Teaching modalities

Theoretical lectures - 26 hours
Tutorial classes - 30 hours
Laboratory courses - 16 hours

Introduction to bioinformatics and “omics” data analysis in oncology

Objectives

Getting started with bioinformatics and big data analysis in oncology.

Contents

- Search and processing of “omics” data in order to build and analyze gene networks.
- Programming, coding and statistical analysis on R software.
- Proteomics. Transcriptomics. Cancer Bioenergetics. Image modeling.
- Tutorials and practical works take form of case studies in bioinformatic classrooms.

Teaching modalities

Theoretical lectures - 8 hours
Tutorial classes - 3 hours
Practical courses - 20 hours

Molecular Imaging and Histopathology

Objectives

Knowledge and understanding of the main cellular and preclinical models in translational research in oncology, and of the main molecular imaging methods, from single cell to preclinical models. Introduction to numerical analysis of molecular imaging data.

Contents

• Basic notions and techniques in molecular histopathology: flow cytometry, specialized primary cell cultures, 3D cell cultures, clonal cell assays, xenograft models.
• Imaging and histology of patient tumors taught by pathologists. Analyses of molecular tumor heterogeneity used in hospital routine.
• Molecular imaging techniques: enzymatic and fluorescence detections, multiple detection. FISH technique.
• High-resolution imaging: confocal, multiphoton, TIRF.
• Molecular Imaging *in vivo*. Xenograft imaging in mice. Bioluminescence.
• Lab course in continuity with Cancer Cell Biology teaching unit. Imaging of cell cycle and proliferation markers expression (p21, Ki67) following a therapeutic treatment in cancer cells in vitro by immunofluorescence and on tissue-sections or tumor xenografts by immunohistochemistry. Image processing with Image J software.

Teaching modalities

Theoretical lectures - 2 hours
Tutorial classes - 10 hours
Laboratory courses - 14 hours

Experimental Design in Biomedical Research

Objectives

Establish a rigorous experimental approach in biomedical research. Develop critical analysis skills. Integrate statistical analysis in scientific research.

Contents

• Notions on Epistemology: Uncertainty, Falsifiability, Paradigm shift, Induction, Deduction. Establishing Causality and Proof in Science. The importance of reproducibility.
• Defining the Hypothesis, the variables tested and the experimental outcomes. The reductionist approach. The most parsimonious explanation. Outlining the experiment as an hypothesis test; defining positive result and negative result. Identifying false positive and false negative results (type 1 and type 2 errors).
• The notions of reference and normalization; choosing the appropriate control group. Identifying the sources of experimental variation (biological variation, technical variation). Identifying sources of errors (cognitive biases, logical fallacies, base rate neglect, experimental biases).
• Ethical aspects of experimental design: Regulations, Scientific integrity.
• Integrating statistics in experimental design. Statistics notions (Significance, Magnitude, variability). Statistical hypothesis testing (defining the null Hypothesis, what is the p-Value, p-Value testing, what not to do with the p-Value, choosing the appropriate statistical test). Important statistical procedures in Biomedical Research (Bonferoni correction, Bradford-Hill criteria, Kaplan-Meier estimator).

Teaching modalities

Theoretical lectures - 12 hours
Tutorial classes - 14 hours

Technologies in Molecular and Cell Biology

Objectives

Theoretical and practical training in Molecular and Cell Biology techniques.

Contents

• Manipulation of nucleic acids: Techniques of extraction, purification, detection and quantification (quantitative PCR). Main enzymatic tools (for cloning, mRNA mapping), chemical (oligonucleotides) and enzymatic synthesis.
• DNA structural and chemical modifications (methylation, G-quadruplex) and specific techniques for their detection.
• Cloning and gene transfer strategies (vectors, libraries and transfer techniques).
• Strategies for the study of gene expression modification: reporter genes, deletions, RNA interference, conditional alleles, over-expression, inducible promotors.
• Interactions' study through Biochemical (SELEX, FRET) and Genetic (suppression, synthetic lethality, complex haploinsufficiency) approaches.
• Production and purification of recombinant proteins: methods for production, purification, detection, fusion and tagged proteins vectorization. Choice of expression systems (vectors, hosts).

Teaching modalities

Theoretical lectures - 34 hours
Tutorial classes - 16 hours
Laboratory courses - 40 hours

Scientific English

Objectives

The goal is to improve students' autonomy in using English for their studies and professional life, based on authentic Biology documents. The competences developed are document search and analysis, and oral communication in a Biology disciplinary setting. This teaching also adresses norms and conventions allowing to communicate and participate efficiently in their scientific and professional communities.

Contents

An English instructor and a Biology instructor collaborate to integrate the disciplinary content in English teaching; 20 hours of teaching, including 5 hours with the Biology instruction. The interventions of the Biology specialist are both prepared upstream and harnessed downstream with the English instructor. In class, study of scientific written and audio-visual documents, related to the topic being studied. Students work individually, two by two or in small groups allowing to guide students on language aspects (grammar, phonology, lexicon). Discourse genres in Biology are explored to identify norms and conventions. Students, two by two, prepare an oral presentation on a disciplinary theme defined by the Biology instructor.

Teaching modalities

Tutorial classes - 25 hours

Semester 2

Cancer immunobiology and immunotherapies

Objectives

Gaining knowledge and analytical expertise related to the role of the immune system in cancer developpment, to the reciprocal interactions between the immune system and developing cancers, and on the bases of immune-based interventions (cancer immunotherapies) and their limits.

Develop writing and oral communication skills through the presentation and discussion of primary research articles and through grant-type mini-proposal conception writing and oral defense.

Contents

• Cancer immunoediting: mechanisms responsible for cancer immunosurveillance (bases of antitumor immune responses) and conversely, for cancer escape from immune detection and elimination (immunosuppression and immunosubversion).

Analysis of the factors affecting the balance between anti-cancer immunity and cancer immune evasion, using trans-disciplinary approaches.

• Bases of cancer immunotherapies, the successes, limits and current problems associated these therapeutic approaches. Combination therapies (chimio-immunotherapies, radio-chimio-immunotherapies…)

• Role of the immune system in cancer invasion and metastatic dissemination.

• Team work and cooperative research work through the conception of a mini-research project (identification of a scientific question in the field, building of a hypothesis and elaboration of a research plan and methodology to address the proposed hypothesis).

Teaching modalities

Theoretical lectures - 20 hours
Tutorial classes - 16 hours
Laboratory courses - 20 hours

High-throughput sequencing and bioinformatics

Objectives

Knowledge and understanding of the high throughput nucleotide sequencing technologies (Chip seq, DNA seq, RNA seq, single cell), epigenetics, circulating DNA, mutational load.

Contents

• Cancer molecular databases, data extraction and analysis.

• Conceptualization of NGS data analysis pipelines. Introduction to the use of NGS software and coding.

• High throughput sequencing and applications: DNAseq, RNAseq, ChipSeq, single cell sequencing, epigenetics, circulating DNA, mutational charge.

Teaching modalities

Theoretical lectures - 9 hours
Tutorial classes - 3 hours
Laboratory courses - 13 hours

Molecular basis of pathologies

Objectives

Describe the cellular and molecular mechanisms involved in the diverse cellular processes and their deregulation, in the context of major pathologies.

Contents

• The teaching unit is based on *in vitro* studies using higher eukaryotic organisms and on animal physiopathology models in relation with human disease.

• Molecular basis of gene expression and regulations (transcriptional, post-transcriptional and post-translational). DNA repair mechanisms and cell cycle checkpoints.

• Molecular basis of developmental processes (determination, differentiation and gene expression). Developmental pathologies and Cancer.

• Myogenesis and cardiac development and associated pathologies.

Teaching modalities

Theoretical lectures - 44 hours
Tutorial classes - 28 hours
Laboratory courses - 4 hours

Research Internship

Objectives

Initiation to research and / or development through participation in a laboratory scientific project.

Contents

• This 8 week internship exposes students to the scientific and professional environment, and completes their skills and training on the latest research tools dedicated to the study of cancer biology.

• The research project is established through an interaction between the student and the supervisor. The student reviews the literature in the subject and is an active participant outlining and executing the research plan.

• Students present the results of their work orally, and in a poster form.

Teaching modalities

Full time work in a research lab (8 weeks), supervised by an experienced research.

Semester 3

Microenvironnement and intra-tumoral heterogeneity

Objectives

Knowledge and understanding of intra-tumoral heterogeneity and of the elements composing the tumor microenvironment at the origin of cancer initiation, progression and dissemination: recent methods and pre-clinical experimental models used, clinical implications and challenges for treatment.

Being able to design and implement experimental approaches, models and methods to study microenvironment and tumor heterogeneity in oncology translational research; to extract information from cancer molecular databases; to critically analyze scientific news.

Contents

• Intra-tumoral heterogeneity, hierarchical organization. Interactions between cancer stem cells and their microenvironment (stromal, vascular, immune, microbiota, niche). Clinical implications and challenges for treatment.

• Hematological cancers: stem cell heterogeneity and hierarchy in hematological malignancy. Chronic myeloid leukemia.

• Epithelial-Mesenchymal transition, invasion and metastasis. RhoGTPases and invasion in hepatocellular carcinoma. Invadopodia in Melanomas progression.

• Gastrointestinal adenocarcinoma: characterization and targeting of cancer stem cells in gastric carcinoma; cancer stem cells and metastasis initiating cells in colorectal cancer

• Tumor neo-angiogenesis : example in brain tumors (glioblastoma).

• Metabolism and NADPH oxidases in skin cancer.

• Immune and infectious microenvironment. *H. pylori* and gastric cancer. Bacterial genotoxins and digestive cancers. CMV infection and LTgd in colorectal cancer.

Teaching modalities

Theoretical lectures - 3 hours
Integrated classes - 44 hours
Tutorial classes - 4 hours

Modeling and therapeutic innovation in Cancer

Objectives

Introduction to innovative and interdisciplinary therapeutic strategies in cancer (biomarkers, personalized medicine, immunotherapies, nanoparticules and vectorisation).

Training in technological innovations dealing with biological (organoids and animal models) and mathematical modeling of tumorigenesis; artificial intelligence and new imaging technologies to improve management of cancer therapy.

Contents

• Conventional treatments in oncology: chemotherapies and radiotherapy, clinical trials.

• Modeling: Biological models of oncogenesis - Stem cells and oncogenesis - iPS models of leukemic and pancreatic stem cells, modeling cutaneous T-cell lymphoma - in vivo models (mouse models, chicken chorioallantoic membrane (CAM) and angiogenesis zebrafish and yeast as models for cancer research).

• Genomics, biomarkers and personalised medicine. Targeted therapy: oncogenic addiction and use of TKI (tyrosine kinase inhibitors) in cancer treatment, TKI resistance. Gene therapy.

Teaching modalities

Integrated classes - 43 hours
Tutorial classes - 8 hours

Tutored interdisciplinary project

Objectives

Being able to propose a research plan answering cancer biological issues using technological solutions. Developing a project encompassing basic biology, translational research and technology teams. Building a project autonomously in the context of an interdisciplinary team work.

Contents

• Tutoring by a tandem of experts composed of a biologist and a specialist of the technological field interested in the project.
• Team work mixing students with diverse backgrounds. Students will work in strong interaction with academic research labs and, whenever applicable, private companies.
• Lectures and tutorials on intellectual property, research valorization and entrepreneurship.

Teaching modalities

Theoretical lectures - 8 hours
Tutorial classes - 20 hours

Communication and project conception

Objectives

Being able to review the literature, summarize it, elaborate a research plan and present it.

Contents

• This teaching unit is based on the research project the student will conduct during semester 4. The student will review the literature on the subject and propose a research plan feasible in one semester.
• The student will work in close interaction with the supervisor.
• The student will produce a written document and an oral presentation to a jury.

Teaching modalities

Personal work only, no face-to-face teaching.

Optional courses

Conceptual biology and medicine: causality and diseases

Objectives

How to use a conceptual approach in biology and medicine to help clarify research questions and use the right terms.

Contents

• What conceptual biology and medicine are.
• Basics of causality in medical and in biological sciences.
• Structure and classification of disease entities.
• Basics of demonstration

Teaching modalities

Theoretical lectures - 3 hours
Integrated classes - 24 hours

Microbiota and physiopathology

Objectives

Understanding of the physiological role of microbiota and of its relationships with metabolic disorders, immune diseases and cancer.

Contents

• Microbiota and Cancer: Gastric Cancer; Gastric lymphomagenesis; anti-cancer immunotherapy.
• Microbiota and antibiotics resistance. Mycobiota and Cystic fibrosis.
• Technologies for the study of microbiota: Bioinformatics and microbiome; culturomics methods.
• Microbiota and auto-immune diseases.
• Microbiota and inflammatory bowel disease.
• Microbiota and obesity.

Teaching modalities

Theoretical lectures - 3 hours
Integrated classes - 24 hours

Pharmaceutical Sciences

Objectives

Introduction to drug design and delivery, monoclonal antibody therapeutics and radio-pharmaceutics in cancer.
Being knowledgeable in the conception of therapeutic and diagnostic tools in oncology.

Contents

• Drug design: molecular modeling and virtual screening.
• Effects on the target: ligand/targets interactions; activity; ligand on the target efficiency.
• Monoclonal antibodies based therapies in Cancer.
• Radiopharmaceutics: imaging applications and perspectives in oncology therapies; Production of medicinal radiocompounds for research.

Teaching modalities

Theoretical lectures - 21 hours
Tutorial classes - 2 hours
Laboratory courses - 4 hours

Semester 4

Research Internship

Objectives

Student exposure to a professional environment for the management and completion of a scientific research project following "good laboratory practices", the "quality approach", as well as ethical and deontological aspects linked to scientific research. The purpose of the training is to mentor and advise the student in his / her participation in the project design, its completion, the critical analysis of the results, and the synthesis of the result presentation (written report and oral communication) in French or in English.

Contents

• Individualized supervision of research work by scientists from University, research institutes (CNRS, INRA, INSERM, IRD, etc.), hospital or private companies, in France or abroad.

• Practical learning of experimental techniques, effective technological and scientific monitoring, communication of results (written report and oral communication) to interdisciplinary audiences.

• Delivery of a well-structured written report on the basis of a scientific results: appointment of 2 reviewers for in-depth expertise of the written report. Oral presentation: 10 minute presentation, and 15 minute questions / discussion with committee members.

Teaching modalities

Full time work in a research lab (one semester), supervised by an experienced research.