Programme Specification

Degree in Bioinformatics

CONTENTS

1) PROFESSIONAL COMPETENCES

1.1. General competences

G01: Use learning strategies autonomously for their application in the continuous improvement of professional practice.
G02: Perform the analysis and synthesis of problems of their professional activity and apply them in similar environments.
G03: Cooperate to achieve common results through teamwork in a context of integration, collaboration and empowerment of critical discussion.
G04: Reason critically based on information, data and lines of action and their application on relevant issues of a social, scientific or ethical nature.
G05: Communicate professional topics in Spanish and/or English both orally and in writing.
G06: Solve complex or unforeseen problems that arise during the professional activity within any type of organisation and adapt to the needs and demands of their professional environment.
G07: Choose between different complex models of knowledge to solve problems.
G08: Recognise the role of the scientific method in the generation of knowledge and its applicability to a professional environment.
G09: Apply information and communication technologies in the professional field.
G10: Apply creativity, independence of thought, self-criticism and autonomy in the professional practice.

1.2 Specific Competences

1.1.1. *Specific competences of the degree*

CE1: Solve mathematical problems that may arise in bioinformatics, by integrating the knowledge acquired in algebra, geometry, differential and integral calculus, optimisation and numerical methods.
CE2: Develop the use and programming of computers, databases and computer programs and their application in bioinformatics.
CE3: Apply the fundamental concepts of mathematics, logic, algorithmics and computational complexity to solve problems specific to bioinformatics.
CE4: Program applications in a robust, correct, and efficient way, choosing the paradigm and the most appropriate programming languages, applying knowledge about basic algorithmic procedures and using the most appropriate types and data structures.
CE5: Implement well-founded applications, previously designed and analysed, in the characteristics of the databases.

CE6: Apply the fundamental principles and basic techniques of intelligent systems and their practical application in the field of bioinformatics.

CE7: Apply the principles, methodologies and life cycles of software engineering to the development of a project in the field of bioinformatics.

CE8: Evaluate applications and computer systems, previously designed, developed and selected, ensuring their reliability and quality, in accordance with ethical principles and current legislation and regulations

CE9: Develop and maintain descriptive documentation of the genesis, production and operation of computer systems.

CE10: Design and deploy the architecture of IT systems through the definition of software, hardware and the necessary communications according to some requirements.

CE11: Apply the principles and techniques of concurrent or parallel computing for the creation and simulation of bio-inspired processes.

CE12: Apply the principles and techniques of protein computational modelling to predict their biological function, their activity or new therapeutic targets (Structural Bioinformatics, Computational Toxicology)

CE13: Apply omics technologies for the extraction of statistically significant information and for the creation of relational databases of biodata that can be updated and publicly accessible to the scientific community.

CE14: Use programming languages, most commonly used in the field of Life Sciences, to develop and evaluate techniques and/or computational tools.

CE15: Infer the evolutionary history of genes and proteins through the creation and interpretation of phylogenetic trees

CE16: Plan linkage and association studies for medical and environmental purposes.

CE17: Induce complex relationships between samples by applying statistical and classification techniques.

CE18: Apply statistical and computational methods to solve problems in the fields of molecular biology, genomics, medical research and population genetics.

CE19: Explain the main biochemical reactions by applying the principles of chemical kinetics and thermodynamics.

CE20: Relate the overall functioning of the organism with the basic mechanisms at the cellular and molecular level.

CE21: Apply computational and data processing techniques for the integration of physical, chemical and biological concepts and data for the description and/or prediction of the activity of a substance in a given context.

CE22: Identify the legal and ethical aspects of the bioinformatics sector.

CE23: Develop a business plan, taking into account the economic and business aspects of bioinformatics activities.

CE24: Be able to develop and carry out a bioinformatics project, anticipating obstacles and possible alternative strategies to solve them.

2 PROGRAMME STRUCTURE

MODULES	SUBJECT	TYPE (MB/OB/OP)	SEMESTER	ECTS CREDITS
First Year				
Mathematics	Algebra	MB	I	6
Social and professional skills	English	OB	I	6
Chemistry	General chemistry	OB	I	6
Life Sciences	Introduction to biology	MB	I	6
IT	Introduction to programming	MB	I	6
Mathematics	Analysis and calculation	MB	II	6
Social and professional skills	Christian social thought	OB	II	6
Bioinformatics	Introduction to bioinformatics	OB	II	6
Life Sciences	Introduction to biochemistry and molecular biology	MB	II	6
IT	Data structures and algorithms	OB	II	6
				60
Second year				
Mathematics	Computational mathematics and simulation	OB	III	6
	Biostatistics	MB	III	6
Life Sciences	Introduction to genetics	MB	III	6
	Introduction to physiology	MB	III	6
IT	Computer architecture	OB	III	6
	IT Systems	OB	IV	6
Chemistry	Pharmaceutical chemistry	OB	IV	6
Life Sciences	Genomics	OB	IV	6
Bioinformatics	Intelligent systems	OB	IV	6
	Autonomous learning and evolution	OB	IV	6
				60
Third year				
Life Sciences	Phylogenetics	OB	V	6
IT	Introduction to software engineering	OB	V	3
Social and professional skills	Ethics	OB	V	3
	Economy and business administration	OB	V	3
Bioinformatics	Omics analysis	OB	V	6
	Databases for bioinformatics	OB	V	3
	Structural bioinformatics	OB	V	3
	Data visualisation	OB	V	3
Bioinformatics	Image analysis	OB	VI	6
Social and professional skills	Ethics and deontology	OB	VI	3
IT	High performance computing	OB	VI	3
	Networks and communications	OB	VI	3
Life Sciences	Population genetics	OB	VI	3
Electives	Elective I	OP	VI	3 | 6*
	Elective II*	OP	VI	3
Final Degree Project	Final Degree Project	OB	VI	6
Students who choose "Work Placement-6 ECTS" only need to take this elective.				**60**

2.1 Elective Subjects

MODULE	SUBJECT	SEMESTER	ECTS	TYPE
Electives 18 ECTS	Biomarkers	VI	3	OP
	Computational toxicology	VI	3	OP
	Distributed systems and web technologies	VI	3	OP
	Information technologies	VI	3	OP
	Work placement*	VI	6	OP

Students who choose "Work Placement" only need to take this elective.
Students must choose two elective subjects, corresponding to 6 ECTS.

2. CONTENTS

2.1. Module 1 – Social and professional skills

Name of module: MODULE 1: Social and professional skills	**ECTS Credits:** 21

Subject 1: English

ECTS Credits: 6

Character: Obligatory subject

Contents:
English aimed at improving writing, comprehension and reading skills to enable the student to feel confident with the subjects taught in this language, either in whole or in part.

Learning outcomes:
After completing this subject, students will be able to:

- Understand the main ideas of the discourse related to the field of bioinformatics, health and study, whenever expressed clearly and simply.
- Identify and understand the main ideas of academic and educational texts related to bioinformatics and health (reading comprehension)
- Participate in simple conversations about personal, professional and academic issues (oral interaction).
- Simply connect phrases to describe, explain processes and projects, review and give instructions (speaking)
- Write structured texts related to pharmacy and health. Take notes from original sources (writing).
- Use strategies to facilitate the pronunciation of unknown pharmaceutical terms.

Subject 2: Christian social thought

ECTS Credits: 6

Character: Obligatory subject

Description:
The subject places emphasis on education in the Humanities, in particular the defence of the dignity and respect for freedom, from an interdisciplinary perspective and from the Social Doctrine of the Church, contextualised in a pluralistic, democratic and multicultural society. It aims to promote moral intelligence, i.e. the ability to deal effectively and honestly to the challenges and commitments involved in contemporary life from commitment and active participation. It also attempts to lay the foundations for a better human being in a fairer society from the scientific rigour required by all reflection at a university level.

Learning outcomes:
After completing this subject, students will be able to:

- Explain the main ideological reductionism and its influence on history.
- Define the concept of the individual applied to the human being in its individual and social dimensions, and in its individualistic and collectivist restrictions.
- Demonstrate personal self-control that allows students to devise life projects and put them into practice.
- Understand the main components of human interdependence, as the foundation of the attitudes of social and professional commitment.
- Distinguish the cultural and political foundations that enable the development of the principles of solidarity, participation, subsidiarity and authority in civil society.
- Identify the ideological influences to which professionals are exposed in the habitual exercise of their profession.

Subject 3: Ethics

ECTS Credits: 3

Character: Obligatory subject

Contents:
Ethical principles according to the laws, regulations and administrative provisions governing the practice, understanding the ethical implications of health in a changing social context.

Learning outcomes:
After completing this subject, students will be able to:

- Define the theoretical foundations of ethics, the bioethics that affect professionals in Bioinformatics.
- Understand the ethical scope and responsibility of decisions taken (and omitted) in practising the profession.
- Analyse the importance of ethical reflection in the development of professional activity, as well as in all walks of life.
- Understand human dignity as the main reference in the field of bioethics and as a requirement of absolute respect for people.
- Recognise people with whom we work for what they are: people who have absolute value.
- Identify the seriousness of bioethical issues that are at stake today and develop their relevant critical sense, considering the centrality of total respect for people.
- Combine moral capacity for reflection and deliberation to deal with situations and conflicts that arise.

Subject 4: Economy and business administration

ECTS Credits: 3

Character: Obligatory subject

Contents:
Introduction to the business. Basic techniques for analysing economic and financial calculation problems. Development and evaluation of projects and investment alternatives. Management and leadership. Teamwork in Business Administration. Special situations of the business environment.

Learning outcomes:
After completing this subject, students will be able to:

- Analyse the costs within the company.
- Evaluate investment alternatives.
- Define financial statements
- Understand the organisational structure of a company.
- Analyse the planning and organisation of a company.
- Develop a business plan according to the model explained in the classroom.
- Conduct a basic market analysis.
- Understand the basic tools of management and human resources planning.

Subject 5: Ethics and deontology

ECTS Credits: 3

Character: Obligatory subject

Contents:
Ethical principles according to the laws, regulations and administrative provisions governing the practice.

Learning outcomes:
After completing this subject, students will be able to:

- Define the theoretical foundations of professional ethics, as well as key aspects of legislation affecting professionals in Pharmacy.
- Explain the main aspects of the codes of ethics in bioinformatics, as well as legislation in this field, while taking into account the difference between what is legal and moral.

2.2. Module 2 - Mathematics

Name of module: MODULE 2: Mathematics	**ECTS Credits:** 24

Subject 1: Algebra

ECTS Credits: 6

Character: Core subject

Contents:
Vectoral space Linear arrays and applications. Diagonalisation of endomorphisms. Euclidean vector space. Geometry. Linear programming: Simplex method.

Learning outcomes:
After completing this subject, students will be able to:

- Solve optimisation problems in the field of linear programming
- Develop the concepts and basic techniques of matrix algebra.
- Apply matrix algebra techniques to the resolution of linear system
- Apply the concepts of vector space and homomorphisms
- Find the canonical forms of endomorphisms and matrices
- Apply the concept of scalar product, its matrix expressions and the concept of orthonormalisation for solving various geometric problems.
- Use accurate and correct language and different symbolic, formal and technical mathematics.
- Connect canonical forms of endomorphisms and matrices with their properties as geometric operators

Subject 2: Analysis and calculation

ECTS Credits: 6

Character: Core subject

Contents:
Real functions of real variables, vectors and functions of several variables. Differential calculus and applications. Integral calculus and applications. Numerical sequences and series. Introduction to numerical calculation

Learning outcomes:
After completing this subject, students will be able to:

- Resolve optimisation problems
- Solve problems calculating lengths, areas, volumes.
- Solve approximation problems
- Use numerical algorithms in problem solving
- Program different numerical calculation algorithms to solve analysis problems
- Select, from several options, the one that best adapts to the characteristics of a specific problem
- Use accurate and correct language and different symbolic, formal and technical mathematics.

Subject 3**: Computational mathematics and simulation**

ECTS Credits: 6

Character: Obligatory subject

Contents:
Mathematical models that lead to ODEs. Ordinary differential equations: problems of initial values and problems of limits. Equations in partial derivatives. Contour problems for parabolic equations. Contour problems for hyperbolic equations.

Learning outcomes:
After completing this subject, students will be able to:

- Explain the mathematical models that can be described by Ordinary Differential Equations
- Solve systems of ordinary differential equations with initial values or contour problem
- Resolve contour problems for parabolic equations.
- Resolve contour problems for parabolic equations.
- Choose the most appropriate technique for solving a system of differential equations

Subject 4: Biostatistics

ECTS Credits: 6

Character: Core subject

Contents:
Importance of biostatistics in bioinformatics. Descriptive statistics. Probability. Estimate. Contrasts of hypothesis. Comparison of proportions. Comparisons of measurements. Correlation and regression

Learning outcomes:
After completing this subject, students will be able to:

- Explain the importance of the sample in the analysis of population phenomena
- List the basic sampling methods
- Explain the basic techniques of Statistics: descriptive, probability, hypothesis testing and regression and correlation.
- Interpret real situations from statistical reasoning and vice versa
- Select appropriate statistical techniques that allow you to perform a statistical analysis correctly and rigorously.
- Program a spreadsheet to obtain basic statistical results.

2.3. Module 3 - IT

Name of module: MODULE 3: IT	**ECTS Credits:** 33

Subject 1: **Introduction to programming**

ECTS Credits: 6

Character: Core subject

Contents:
Introduction to programming. Variables and operators. Expressions and assignments. Control structures. Algorithms and pseudocode. Vectors and matrices. Memory. Simple and structured data types. Arrays, structures, pointers, and strings. Basic input and output.

Learning outcomes:
After completing this subject, students will be able to:

- Identify the different types of variables and associated operators.
- Construct expressions and make assignments of values correctly.
- Apply the different control structures (if / else, while, for, etc.)
- Design algorithms that meet the established needs
- Program efficiently algorithms
- Use memory structures (vectors, matrices) suitable for multidimensional problems.
- Use the input / output of keyboard / screen or files for the execution of programs.
- Present documentation about programming works
- Use written technical language
- Identify implementation errors in a programming language.
- Manage programming development environments.

Subject 2: Data structures and algorithms

ECTS Credits: 6

Character: Obligatory subject

Contents:
Arrays, structures, pointers, and strings. ADT (Abstract Data Type). Lists. Stacks. Queues. Dispersion tables. Trees. Graphs. Algorithm.

Learning outcomes:
After completing this subject, students will be able to:

- Design a set algorithms that meet needs and optimally meet specific standards of quality.
- Efficiently implement algorithms.
- Quality source code comment.
- Determine implementation errors.
- Use programming development environments.
- Create and manage data structures.
- Optimise and evaluate algorithms.

Subject 3: Computer architecture

ECTS Credits: 6

Character: Obligatory subject

Contents:
Principles of computer organisation. Data and control routes. **Memory hierarchies.** Machine and assembly language. Instruction repertoire. RISC and CISC architectures.

Learning outcomes:
After completing this subject, students will be able to:

- Relate the physical information and its mathematical and logical representation.
- Understand the different encodings of information and the conversion of the data between them.
- Know and understand the basic concepts of computer architecture.
- Know and understand the internal architecture of current microprocessors and their set of
- instructions.
- Learn about the current devices of programmable logic and their fields of use.

Subject 4: IT Systems

ECTS Credits: 6

Character: Obligatory subject

Contents:
Introduction to information systems. The relational data model. Modelling of relational databases. Manipulation of relational databases using the SQL language.

Learning outcomes:
After completing this subject, students will be able to:

- Apply the theory of relational database design information systems data.
- Apply the theory of semi-structured data modelling to the design of information systems.
- Design real models for its representation in an information system.
- Learn the language of communication with databases (SQL).
- Install, manage and optimise a commercial DBMS.

Subject 5: Introduction to software engineering

ECTS Credits: 3

Character: Obligatory subject

Contents:
Software development methodologies applied to bioinformatics. Agile methods. Basics of software design. Big data management. Evaluation strategies (test). Principles of multidisciplinary team management.

Learning outcomes:
After completing this subject, students will be able to:

- Explain the challenges of software engineering and management involved in the development of bioinformatics
- Properly implement agile methodologies in software development.
- Establish software development plans
- Design software

Subject 6: High performance computing

ECTS Credits: 3

Contents: Obligatory subject

Description:
Parallel processing and architectures. Programming models: shared memory and message transmission. Identification of parallelism in applications, synchronization methods, dependency analysis, task scheduling, communications and collective operations, I/O parallels. Measurement of performance and power consumption of parallel applications. Tools, programming languages, libraries and frames.

Learning outcomes:
After completing this subject, students will be able to:

- Know the different challenges that are addressed in high performance computing
- Identify parallelism in applications
- Understand the paradigm of parallel computing
- Develop programs that exploit the parallelisation of different algorithms
- Analyse the performance and power consumption of parallel applications

Subject 7: Networks and communications

ECTS Credits: 3

Contents: Obligatory subject

Description:
Networking basics. Introduction to TCP/IP architecture. Safety on the net.

Learning outcomes:
After completing this subject, students will be able to:

- Explain the TCP/IP architecture.
- Describe the fundamentals in computer networks.
- Describe the main problems related to security in networked environments.
- Develop network applications.

2.4. Module 4 - Chemistry

Name of module: MODULE 4: Chemistry	**ECTS Credits:** 12

Subject 1: General chemistry

ECTS Credits: 6

Character: Core subject

Contents:
Atoms and atomic theory. Link theories. Types of chemical compounds and their formulas. Isomer Intermolecular links and their relationship with the physicochemical properties of the compounds. Solutions Principles of chemical equilibrium Principles of chemical kinetics. Safety in the chemistry laboratory.

Learning outcomes:
After completing this subject, students will be able to:

- Explain the structure of simple molecules
- Classify chemical compounds according to their organic or inorganic nature
- Formulate and name simple inorganic compounds
- Recognise the main functional groups of organic molecules
- Recognise the different types of isomerism
- Estimate the intensity of the physicochemical properties of a substance depending on the type of intermolecular interaction
- Make solutions of solid in liquid and liquid in liquid
- Differentiate between kinetic and thermodynamic viability of a chemical process
- Solve simple theoretical problems of thermodynamic equilibrium and chemical kinetics
- Solve simple practical (laboratory) problems of thermodynamic equilibrium and chemical kinetics
- Manipulate equipment and waste following good laboratory practices

Subject 2: Pharmaceutical chemistry

ECTS Credits: 6

Character: Obligatory subject

Contents:
Concept of drug (active principle), medication, bioactive compound and therapeutic target. Factors that influence the ligand (drug) and receptor interaction, types of ligand-receptor interaction. Dosage-response curves. Computational representation of molecules. SAR and QSAR Optimisation of a prototype: basic principles.

Learning outcomes:
After completing this subject, students will be able to:

- Differentiate between drug, medication, bioactive compound, receptor and therapeutic target
- Describe the main types of interaction between ligand and receptor
- Define the main parameters that characterize the ligand-receptor interaction
- Infer the nature of the drug-receptor complex from the type of interaction between both.
- Interpret dose-response curves
- Represent small molecules using computer tools
- Explain the relationship between molecular structure and the main parameters of bioactivity
- Explain the main approaches in the optimisation of drug prototypes

2.5. Module 5 - Life Sciences

Name of module: MODULE 5: Life Sciences	**ECTS Credits:** 39

Subject 1: Introduction to biology

ECTS Credits: 6

Character: Core subject

Contents:
Cells as a structural and functional unit of the living world. Plasma membrane and cell surface. Maintenance, expression and replication of genetic information. Endomembrane system Energy system of the cell. Shape and cellular motility Cellular cycle. Sexual reproduction and embryonic development. Human histology: epithelial tissue, connective tissue, supporting tissue, muscle tissue, nervous tissue. The optical microscope. Safety in the biology laboratory.

Learning outcomes:
After completing this subject, students will be able to:

- Describe the functions of the different parts that make up the eukaryotic animal and plant cell
- Interpret the cell as a whole, where the proper functioning of the parts contributes to the good global functioning
- Distinguish each of the phases, processes and structures involved in the cell cycle.
- Describe the structure, general organization and genesis of different human tissues
- Explain the function of each human tissue from its structure
- Identify different tissues and human cells and their components through images obtained by optical microscopy.
- Manipulate equipment and waste following good laboratory practices

Subject 2: Introduction to biochemistry and molecular biology

ECTS Credits: 6

Character: Core subject

Contents:
Water: importance and properties Main biomolecules: lipids, carbohydrates, nucleotide and nucleic acids, amino acids and proteins. Enzymology Cellular communication Introduction to metabolism.

Learning outcomes:
After completing this subject, students will be able to:

- Explain the importance of water in the context of biochemistry and molecular biology
- Describe the basic structural characteristics of different biomolecules that form the living being.
- Relate the functions of the various biomolecules with the proper functioning of the living being.
- Solve practical problems in the process of isolating nucleic acids, lipids and proteins, following good laboratory practices.
- Classify different types of lipids, sugars, nucleic acids and proteins
- Define the basic concepts of metabolism.

Subject 3: Introduction to genetics

ECTS Credits: 6

Character: Core subject

Contents:
Genetics in biology and society. Mendel and the basic principles of inheritance. Chromosomal bases of the inheritance. Types of inheritance Molecular nature of the gene. Gene and chromosomal mutations Interactions between genes and environment. Genetic diseases.

Learning outcomes:
After completing this subject, students will be able to:

- Explain the molecular basis of the gene
- Describe the fundamentals of the processes that determine the transmission and expression of genetic information
- Interpret family trees
- Explain the causes and consequences of genetic variation
- Interpret real situations with a genetic basis, in the laboratory, in nature or in society
- Analyse genetic data or DNA / protein sequences using computer tools

Subject 4: Introduction to physiology

ECTS Credits: 6

Character: Core subject

Contents:
Main organs and functions of: renal system, hepatic system, cardiovascular system, central nervous system, circulatory system, lymphatic system, excretory system, reproductive system and respiratory system.

Learning outcomes:
After completing this subject, students will be able to:

- Describe the functions of the nervous system
- Connect the physiological action of hormones with metabolism and its regulatory mechanisms
- Describe the functioning of the heart and blood vessels
- Explain the mechanisms of regulating the cardiovascular system and its role in maintaining the
  homeostatic equilibrium of the organism
- Describe how lungs work.
- Explain the mechanisms of gas exchange in the lungs and tissues and the mechanisms of gas transport by blood
- Explain the mechanisms of regulating the respiratory system and its role in maintaining the homeostatic balance of the organism
- Connect the function of the kidneys with the general maintenance of the internal environment, the pH, the hydro-electrolyte balance and the mechanism of urine formation.
- Describe the process of digestion and absorption of nutrients.
- Explain the functions of the female and male reproductive systems, as well as their hormonal regulation.
- Explain the synapse process
- Describe the functioning of skeletal, cardiac and smooth muscle (muscle contraction and its control).
- Explain the bases of physiological changes that occur with aging, in degenerative processes and in response to agents harmful to the body

Subject 5: Genomics

ECTS Credits: 6

Character: Obligatory subject

Contents:
Methods for the analysis of genetic polymorphisms. Sequencing techniques: de novo and alignment to reference genomes. Use of markers in identification and diagnosis. Experimental design and methods of analysis for the study of differential gene expression. Experimental design and analysis of proteomic data. Functional genomics Pharmacogenetics and Pharmacogenomics.

Learning outcomes:
After completing this subject, students will be able to:

- Identify genetic polymorphisms.
- Plan experimental designs for genomic and proteomic analysis.
- Interpret results of experimental analysis techniques.
- Apply functional genomics to the pharmaceutical environment

Subject 6: Phylogenetics

ECTS Credits: 6

Character: Obligatory subject

Contents:
Introduction to phylogenetic analysis: characters and taxa. Evolution mechanisms. Character coding. Introduction to phylogenetic systematics, concepts and cladistic methods. Phylogenetic classification: Nomenclature and phylocode. Construction of cladograms. Polarisation and rooting of characters. Search and optimisation of trees, consensus and ambiguity. Analysis of morphological data.

Learning outcomes:
After completing this subject, students will be able to:

- Define the concept of phylogenetics
- Describe the main terms associated with phylogenetics
- Explain the evolutionary mechanisms required to build phylogenetic trees.
- Discriminate the different phylogenetic tree construction methodologies.
- Compose phylogenetic trees from morphological data.

Subject 7: Population genetics

ECTS Credits: 3

Character: Obligatory subject

Contents:
Variability and genetic structure of populations. Genetic analysis of populations in equilibrium, migration and population structure. Genetic drift in finite populations. Neutral theory of molecular evolution. Genetic description of adaptive traits. Ecological context of adaptive evolution.

Learning outcomes:
After completing this subject, students will be able to:

- Define the concept of variability and genetic structure of a population
- Identify factors that influence the equilibrium state of a population
- Discriminate if a population is in equilibrium
- Distinguish adaptive traits in the process of evolution
- Apply adaptive evolution to the ecological context

2.6. Module 6 - Bioinformatics

Name of module: MODULE 6: Bioinformatics	**ECTS Credits:** 39

Subject 1: Introduction to bioinformatics

ECTS Credits: 6

Character: Obligatory subject

Contents:
Basic concepts of molecular biology, central dogma. Basic concepts of DNA / RNA / proteins (bases, codons, amino acids, etc.). Analysis of sequence and similarity by alignment. Basic interpretation of genomic data; mutations, alterations in the number of copies, functional impact of said alterations. Data storage / most common databases. HTS for the generation of data. Introduction to R / Python programming.

Learning outcomes:
After completing this subject, students will be able to:

- Describe the basic information units of biomolecules as well as the functional effect of their mutations
- Analyse comparatively biomolecules for the search of functional interrelations, possible function and structure
- Recognise the different genetic polymorphisms, their detection and their applications
- Create simple databases of biodata for modification and access, direct or through programming languages
- Describe the main HTS technologies and the data they offer, organising them based on statistical criteria and data quality
- Compile basic level programs and functions in R and Python
- Interpret significant relationships between samples through statistical analysis

Subject 2: Intelligent systems

ECTS Credits: 6

Character: Obligatory subject

Contents:
Introduction to Artificial Intelligence. Representation, algorithms, planning and learning. Statistical modelling Supervised learning. Learning without supervision.

Learning outcomes:
After completing this subject, students will be able to:

- Learn the basics of knowledge representation in artificial intelligence.
- Apply artificial intelligence algorithms and methods.
- Understand planning methods and algorithms.
- Apply statistical algorithms and methods.
- Apply machine learning algorithms and methods.

Subject 3: Autonomous learning and evolution

ECTS Credits: 6

Character: Obligatory subject

Contents:
Viterbi, Baum Welsch, subsequent decoding, SCFG applied to RNA folding, gene prediction algorithms, Infernal (INFERence of RNA Alignment software), secondary protein structure prediction algorithms. Algorithms of domain profiles. HMM algorithms. Prediction of genes. Dynamic programming, database search (BLAST), compression-based substring search (DNA aligners), assembly algorithms, multiple sequence alignment, RNA folding algorithms (Zuker, Nussinov), structural overlay algorithms.

Learning outcomes:
After completing this subject, students will be able to:

- Contrast the different autonomous learning algorithms for use in different biotechnological areas
- Choose the best autonomous learning tools in each case
- Apply existing bioinformatics tools to search for sequence and structural homologies
- Predict genes that encode proteins or RNA in an unknown genomic environment
- Derive the evolutionary history of biological sequences and genomic rearrangements
- Calculate the secondary structure of RNA and proteins
- Classify the relevant results of a gene expression microarray
- Discriminate biologically important information from public databases for use in autonomous learning algorithms

Subject 4: Databases for bioinformatics

ECTS Credits: 3

Character: Obligatory subject

Contents:
Information systems in bioinformatics: Requirements and categories. Integration architectures (distribution, autonomy and heterogeneity, Federated DB, Data Warehouses, Mediator-based DB, Peer DB). XML technology for bioinformatics (XML Schema, XSLT, XQuery, XML and DB). Management of schemas and metadata in integrated information systems (Matching- and Mapping-techniques).

Learning outcomes:
After completing this subject, students will be able to:

- Define information systems and know their fundamental components
- Recognise patterns of integration architectures (such as client-server), their rules, models
- Apply patterns of integration architectures to the "omic" annotation
- Determine the need to integrate or not integrate data from diverse databases in different environments
- Develop programs to manage files encoded in XML directly or through databases

Subject 5: Structural bioinformatics

ECTS Credits: 3

Character: Obligatory subject

Contents:
Databases for 3D structures. Molecular viewers Analysis and prediction of 3D structures of biological macromolecules. Generalizations of macromolecular structures in 3D. Principles of molecular folding, evolution and union interactions. QSAR and computation: experimentally solved structures and computational models.

Learning outcomes:
After completing this subject, students will be able to:

- Interpret the information contained in public databases of proteins and chemicals
- Use tools for visualisation, modification and analysis of proteins
- Modelling the secondary structure of proteins using the sequence of amino acids or homologs of known structure
- Identify homologous proteins of known 3D structure and subsequent comparative 3D modelling
- Predict potential protein domains and their function
- Determine potential relationships between chemical structure and bioactivity

Subject 6: Omics analysis

ECTS Credits: 3

Character: Obligatory subject

Contents:
Genomic analysis of a single nucleotide (variants / polymorphisms). Mutations and genetic aberrations. Genotype-phenotype association studies. Linkage disequilibrium. Haplotype blocks **Identification of ancestry.** Staging and imputation. The gene expression. Microarrays Transcriptomics: sequencing, mapping, genes and promoters. Detection of alternative points of union and union. Epigenomics Proteomics.

Learning outcomes:
After completing this subject, students will be able to:

- Identify the main "-omic" databases for later exploitation
- Describe the state of the art of different "-omic" platforms
- Plan linkage and association studies
- Use bioinformatics tools to find statistical differences between cases and controls
- Calculate gene imbalance and associations
- Analyse differential expression to identify specific biomarkers associated with disease
- Predict the coding of alternative mRNAs by using algorithms
- Predict the existence of epigenetic markers from the genome
- Analyse the proteome of different species to obtain relevant biological information

Subject 7: Data visualisation

ECTS Credits: 3

Character: Obligatory subject

Contents:
Concepts of visual design and data metaphors. The spaces of colour. Bitmaps and vector graphics (PostScript, SVG). 2D and 3D representation Grammar of the graphics. Visualisation of data in Bioinformatics: annotations of genomes and browsers; Display structure; Network manipulation tools. Plots of the hive. Graphic libraries.

Learning outcomes:
After completing this subject, students will be able to:

- Know the current graphic libraries for bioinformatics
- Understand colour spaces and vector graphics
- Understand the concept of rendering
- Select the most appropriate graphic library for a problem
- Visualise biological data

Subject 8: Image analysis

ECTS Credits: 6

Character: Obligatory subject

Contents:
Representation of images on computers. Types of images Sampling. Coding and compression of images. Image processing and image restoration. Point operators. Fundamentals of frequency analysis. Histogram operations. Neighbourhood operators. Mathematical morphology Segmentation. Analysis of forms and extraction of characteristics. Classification and theory of the decision.

Learning outcomes:
After completing this subject, students will be able to:

- Know the peculiarities of digital image processing, especially of biomedical images, as a particular case of data analysis.
- Understand the particular terminology of the field of digital image processing.
- Learn the technical details related to the different formats, techniques of acquisition and storage of digital images.
- Know the basic problems and terminology and essential concepts in the fields of pattern recognition and visualisation.
- Apply different types of algorithms related to the processing of digital images.
- Use tools and programming libraries for the processing of digital images.

2.7. Module 7 - Electives

Name of module: MODULE 7: Electives	**ECTS Credits:** 12

Subject 1: Biomarkers

ECTS Credits: 3

Character: Elective Subjects

Contents:
Different types of biomarkers. Detection methods of biomarkers. Prediction of generation of biomarkers. Use of biomarkers.

Learning outcomes:
After completing this subject, students will be able to:

- Contrast the main types of molecular biomarkers
- Compose a bookmark quality set for further linkage and association studies
- Describe the different technologies of last generation to analyse and sequence genomic markers such as microsatellites, SNPs and microRNA
- Predict new miRNA and its targets using the RNA folding method, RNAseq technologies and databases
- Predict post-translational modifications and signal sequences in proteins

Subject 2: Computational toxicology

ECTS Credits: 3

Character: Elective Subjects

Contents:
Mechanisms of drug toxicity. Introduction to the toxicity prediction databases. Therapeutic windows of drugs.

Learning outcomes:
After completing this subject, students will be able to:

- Describe the chemical and biological factors that determine the toxicity of a chemical compound
- Predict toxicity using information from public databases
- Compare in silico modelling methods to predict chemical toxicity
- Use known software and tools to implement prediction methods
- Predict the individual pharmacological dose from the study of pharmacogenomic markers
- Use R and Python packages to implement existing techniques

Subject 3: Distributed systems and web technologies

ECTS Credits: 3

Character: Elective Subjects

Contents:
HTTP applications through Servlets. Dynamic pages JSP. Web Services. AJAX and MVC.

Learning outcomes:
After completing this subject, students will be able to:

- Use the basic structure of Servlets
- Develop JSP applications that perform Web services
- Apply AJAX technology
- Use the Java Enterprise Edition platform to develop large applications

Subject 4: Information technologies

ECTS Credits: 3

Character: Elective Subjects

Contents:
Concepts and applications. Data warehousing, data marts and OLAP. Methods and algorithms for cleaning and data preprocessing. Data mining. Complex data types. Web Data Mining.

Learning outcomes:
After completing this subject, students will be able to:

- Understand data storage techniques and access methods
- Schedule operations queries in a heuristic way and based on cost estimates
- Create transaction processing taking into account integrity, concurrency control and recovery techniques

Subject 5: Work Placement

ECTS Credits: 6

Character: Elective Subjects

Contents:
The main objective of San Jorge University's degree programmes is to fully prepare professionals to successfully enter the business world. To obtain this goal, excellent academic background and training in personal values of quality is not enough; it is also essential that students experience this business world so they can learn to develop all the required personal and instrumental skills that they will need for their professional future In the subject "Work Placement" the student will experience the day-to-day in a company and will have to use the resources that have been acquired during their time at San Jorge University on a scientific and technical level and on a human level.

Learning outcomes:
After completing this subject, students will be able to:

- Work responsibly and adapt to the standards established in the company
- Work in a team and communicate properly with colleagues, customers and users
- **Understand the impact of their work on society and the importance of industry standards and regulations**
- Implement the process comprising a project in the field of bioinformatics, including economical and innovative aspects
- Work efficiently at the various development stages of a bioinformatics project

2.8. Module 8- Final Degree Project

Name of module: MODULE 8: Final Degree Project	**ECTS Credits:** 6

Subject 1: Final Degree Project

ECTS Credits: 9

Character: Obligatory subject

Contents:
This subject is the culmination of all the training that the student has received throughout the Bioinformatics degree. **During the Final Project, students will showcase all the skills that have been acquired throughout the training process.** Students must prepare a project that reflects their personal and professional maturity over the years studying their degree.

Learning outcomes:
After completing this subject, students will be able to:

- Individually plan and complete an original project of a professional nature in the field of bioinformatics showcasing the skills acquired in the degree.
- Prepare, present and defend orally, before a university tribunal, an original project of a professional nature in the field of bioinformatics.