PEOPLE'S DEMOCRATIC REPUBLIC OF ALGERIA
MINISTRY OF HIGHER EDUCATION AND SCIENTIFIC RESEARCH

Compliance Template for Training Offer
L.M.D. System

ACADEMIC BACHELOR'S DEGREE

Academic Year:

2014 - 2015

Institution	Faculty/Institute	Department
University of Jijel	Faculty of Natural and Life Sciences	Molecular and Cellular Biology

Field	Program	Specialty
Natural and Life Sciences	Biological Sciences	Molecular Biology

Semester 5 and 6 Teaching Organization Sheet

Semester 5

Teaching Unit	Semester hours	Weekly hours				Coeff	Credits	Evaluation	
	14-16 weeks	C	SW	PW	Others			Continuous (40%)	Exam (60%)
Fundamental teaching unit									
FTU 3.1.1(O/P) *Fundamentals of Molecular Biology*	**90h00**	**3h00**	**3h00**	**-**	**6h00**	**4**	**8**	**X**	**X**
Matter 1: *Fundamentals of Molecular Biology*									
FTU 3.1.2(O/P) *Molecular Genetics of Microorganisms*	**90h00**	**3h00**	**3h00**	**-**	**6h00**	**4**	**8**	**X**	**X**
Matter 1: *Molecular Genetics of Microorganisms*									
Methodology teaching unit									
MUT 3.1.1: *Preparative and Analytical Techniques of Macromolecules I*	**67h30**	**3h00**		**1h30**	**3h 30**	**3**	**6**	**X**	**X**
Matter 1: *Preparative and Analytical Techniques of Macromolecules I*									
Discovery Unit									
DUT 3.1.1(O/P) : *Structure and Function of Macromolecules*	**67h30**	**3h00**	**1h30**		**2h00**	**3**	**5**	**X**	**X**
Matter 1: *Structure and Function of Macromolecules*									
Transversal Unit									
(UET 3.1.1) – *Scientific English*	**22h30**	**1h30**				**1**	**3**		**X**
Matter 1: ***Scientific English***									
Total Semester	**337h39**	**13h30**	**7h30**	**1h30**	**17h30**	**15**	**30**		

Semester 6

Teaching Unit	Semester hours	Weekly hours				Coeff	Credits	Evaluation	
	14-16 weeks	C	SW	PW	Others			Continuous (40%)	Exam (60%)
Fundamental teaching unit									
FTU 3.2.1(O/P) : *Genetic Engineering*	**90h00**	**3h00**	**3h00**	**-**	**-**	**4**	**8**	**X**	**X**
Matter: *Genetic Engineering*									
FTU 3.2.2(O/P) : *Gene Activity Signaling and Regulation*	**67h30**	**3h00**	**1h30**	**-**	**1h30**	**4**	**8**	**X**	**X**
Matter: *Gene Activity Signaling and Regulation*									
Methodology teaching unit									
MUT 3.2.1(O/P) *Bioinformatics* And *Preparative and Analytical Techniques of Macromolecules I*I							**6**		
Matter 1 : *Bioinformatics*	**45h00**	**1h30**	**-**	**1h30**	**1h30**	**2**	**3**	**X**	**X**
Matter 2 : ***Preparative and Analytical Techniques of Macromolecules I*I**	**45h00**	**1h30**	**-**	**1h30**	**1h30**	**2**	**3**	**X**	**X**
Discovery Unit									
DUT 3.2.1 (O/P) Enzymology	**67h30**	**3h00**	**1h30**		**3h00**	**2**	**5**	**X**	**X**
Matter: Enzymology									
Transversal Unit									
TUT 3.2.1 (O/P) : *Life Sciences and Society*	**22h30**	**1h30**	**-**	-	**-**	**1**	**3**		**X**
Matter 1 : *Life Sciences and Society*									
Total Semester	**337h30**	**13h30**	**6h00**	**3h00**	**07h30**	**15**	**30**		

Detailed Course Sheet

Semester: 5
Fundamental Teaching Unit 1 (UEF 3.1.1): Fundamentals of Molecular Biology
Course Title: Fundamentals of Molecular Biology
Credits: 8
Coefficient: 4

Learning Objectives:

At the end of this course, students will have acquired in-depth knowledge of the structure and function of nucleic acids and proteins, the organization and functioning of the eukaryotic genome (particularly the human genome), as well as the alterations affecting the genome and the molecular mechanisms of DNA repair.

Recommended Prerequisites:

Basic knowledge of chemistry, structural biochemistry, genetics, and general microbiology.

Course Content :

Chapter I: DNA

1. **DNA as the Carrier of Genetic Information**
    - Griffith's Experiment
    - In vitro transformation: Work of Dawson and Sia, Alloway
    - Analysis of the transforming factor: Avery, McLeod, McCarty (1944)
2. **Structure and Properties of DNA**
    - Nitrogenous bases and their chemical properties
    - Modified bases
    - Nucleosides and nucleotide composition
    - Phosphodiester bond
    - Three-dimensional DNA structure: the double helix, A, B, and Z forms
    - Physicochemical properties: hyperchromic effect, melting temperature, hysteresis
3. **DNA Replication**
    - Watson & Crick's hypothesis
    - Meselson & Stahl experiment
    - Replication in prokaryotes and eukaryotes (DNA polymerases, main steps)
4. **DNA Mutability**
    - Natural origins of mutations: physical (cosmic rays, radioactivity, UV) and chemical
    - Types of mutations : point mutations, chromosomal (large-scale), genomic mutations

5. **DNA Repair (Maintenance of DNA Integrity)**
    - Damage prevention systems (superoxide dismutase, acid-base balance, reductive systems)
    - Fidelity of replication
    - Repair mechanisms: excision repair, recombination repair, direct repair (photoreactivation)

Chapter II: RNAs

1. **Description, Structure, and Properties of RNA**
    - General characteristics
    - Different types of RNA: mRNA, tRNA, rRNA
    - Ribosomal RNAs (prokaryotic and eukaryotic)
    - tRNA (3D structure, unusual bases, important functional sites)
    - Small nuclear RNAs (snRNA)
    - Small cytoplasmic RNAs (scRNA)

Chapter III: Protein Biosynthesis

Transcription
1.1. Definitions and general background
1.2. Transcription in eukaryotes
1.2.1. RNA polymerases
1.2.2. Transcription of protein-coding genes and mRNA synthesis

1.2.2.1. Overview of gene structure in eukaryotes (Introns and exons)

1.2.2.2. Initiation of transcription

1.2.2.3. Elongation

1.2.2.4. Termination

1.2.2.5. RNA processing (maturation):
a. 5’ cap formation on the pre-mRNA
b. Polyadenylation
c. RNA splicing

Translation
2.1. The genetic code

2.1.1. Principles and definition

2.1.2. Characteristics of the code

2.1.2.1. Universality of the code
a. Exceptions observed in some mitochondria
b. Exceptions observed in yeast
c. Exceptions observed in certain protozoa

2.1.2.2. Non-overlapping nature of the code

2.1.2.3. Degeneracy of the code

2.2. Codon/anticodon relationship – the Wobble phenomenon

2.2.1. Principle and definition

2.2.2. Different types of Wobble

2.3. Translation mechanism in eukaryotes

2.3.1. Ribosomes

2.3.2. Stages of translation

2.3.2.1. Initiation

2.3.2.2. Elongation

2.3.2.3. Termination

Chapter IV: Regulation of Gene Expression

Different levels of regulation

1.1. Regulation through modification of the DNA primary structure
1.2. Transcriptional regulation
1.3. Post-transcriptional regulation
1.4. Translational regulation

Evaluation Methods ***(Type of assessment and weighting)***

Continuous Assessment /20

Two quizzes per semester (each graded out of 10)

One theoretical mini-project /20

Written part: /8

Oral presentation: /7

Test on all presented mini-projects: /5

Final Exam (ETLD) /20

Bibliographic References ***(Books, handouts, websites, etc. — list at least 3 or 4 classical and important references)***

- **LA CELLULE- Biologie Moléculaire**.
Harvey Lodish, James Darnell et David Baltimore. Editions Vigot. 1988.

- **Biologie cellulaire et moléculaire**.
Gerald Karp. Edition De Boeck université. 2004.

- **Analyse génétique moderne**.
Anthony J. F. Griffiths, Chrystelle Sanlaville. Edition De Boeck université. 2004

- **Génétique**. William S. Klug, Michael R. Cummings, Charlotte A. Spencer. Edition: Pearson Education France. 2006

- **Introduction à l'analyse génétique.**
Anthony Griffiths, Susan Wessler, Rechard Lewontin, Sean Carroll. Editions De Boeck. 2010.
- **Génétique- Les grands principes**.
Daniel L. Hartl, Elisabeth W. Jones. Edition Dunod. 2003.

- **Génétique moléculaire humaine-**une introduction aux mécanismes des maladies héréditaires. Jack J. Pasternak. Editions De Boeck université. 2003

- **Biologie moléculaire et médecine**.
Jean-Claude Kaplan, Marc Delpech. Edition : Flammarion Médecine-sciences, 1994.

Teaching Unit Fundamental 2 (UEF 3.1.2): Elements of Molecular Genetics of Microorganisms

Subject 1: Elements of Molecular Genetics of Microorganisms
Credits: 8
Coefficient: 4

Learning Objectives
This unit complements the previous one. It focuses on structural aspects and the genetic and molecular mechanisms involved in gene expression in bacteria, eukaryotic microorganisms, and viruses. Fundamental knowledge will be acquired on the organization and functioning of microbial genomes and the ability to compare them with higher eukaryotes (humans).

Recommended Prerequisites
This unit requires knowledge of general microbiology, as well as genetics, structural biochemistry, and virology.

Course Content

Part 1: Bacteria

Chapter 1: The Bacterial Genome

1. Structure of the bacterial genome
   1.1. The bacterial chromosome
   1.2. Mobile genetic elements
   1.2.1. Plasmids
      - General organization of plasmids
      - Classification of plasmids:
         - R plasmids
         - Fertility plasmids (F factor)
         - Col plasmids
         - Degradative plasmids
         - Virulence plasmids
      - Properties of plasmids
        1.2.2. Transposons
      - General structure of transposons
      - Types of transposons
      - Mechanisms of transposition in bacteria:
        a. Replicative transposition
        b. Conservative transposition
        c. Effects of transposition on gene expression
        1.3. Organization of prokaryotic genes
2. Replication of the bacterial genome
3. Alterations and repair mechanisms of the bacterial genome

Chapter 2: Horizontal Gene Transfers

1. Transformation
2. Conjugation
3. Transduction
4. Genetic mapping

Chapter 3: Protein Biosynthesis

1. Transcription
    - Initiation
    - Elongation
    - Termination
2. Translation mechanism
    - Synthesis of aminoacyl-tRNA
    - Structure and function of the ribosome
    - Initiation of translation
    - Elongation
    - Termination

Chapter 4: Regulation of Gene Expression

1. Definition and concept of the operon
2. Inducible operons: the lactose operon
3. Repressible operons: the tryptophan operon
4. Expression modulator system: attenuation
5. Regulation by DNA sequence inversion

Part 2: Fungi (Yeast as a Model System)

1. Overview of yeast biology
    - Generalities
    - Culture and nutrition
2. Yeast genome
3. Yeast transcriptome
4. Yeast proteome
5. Analysis of biochemical mutations and tetrads
6. Complementation and gene conversion

7. Mitochondrial genetics
8. Transposable elements
9. Tools and techniques for yeast genetic transformation: practical applications
10. Cell division and cell cycle
11. Sexual reproduction in yeast (haplodiplobiontic cycle)

Part 3: Viruses

1. Virus structure and classification
2. Viral nucleic acids
    - DNA genomes
    - RNA genomes
    - Case of bacteriophages
3. Viral cycle
    - Lytic cycle
    - Lysogenic cycle
4. Replication of viral genetic material
    - DNA virus replication (Model: Bacteriophage T4)
    - RNA virus replication

Evaluation Method (type and weighting)

- **Continuous assessment (/20):**
    - Lab report evaluation (average, /20)
    - Lab exam (/10)
    - One quiz on practical work (/10)
    - Article analysis (presentation /5, written summary /5, test /10)
- **Final Exam (/20)**

References

Introduction à la microbiologie.

Gerard J. Tortora, Berdell R. Funke, Christine L. case. Editions du renouveau pédagogique Inc. 2003

Introduction à l'analyse génétique. Anthony J. F. Griffiths, Jeffrey H. Miller, David T. Suzuki, Richard C. Lewontin, William M. Gelbart. Edition De Boeck université. 2002.

Genetics of Bacteria. Sheela Srivastava. Springer 2013.

Génétique- Les grands principes. Daniel L. Hartl, Elisabeth W. Jones. Edition Dunod. 2003.

Génétique. William S. Klug, Michael R. Cummings, Charlotte A. Spencer. Edition: Pearson Education France. 2006

Les éléments transposables bactériens. Christophe Merlin, Ariane Toussaint. m/s n° 8-9, vol. 15, 1999 (article).

Methodology Teaching Unit 1 (UEM 3.1.1): Preparative and Analytical Techniques of Macromolecules I

Subject 1: Preparative and Analytical Techniques of Macromolecules I
Credits: 6
Coefficient: 3

Learning Objectives
Enable students to acquire a solid foundation in the main techniques used in Biochemistry and Molecular Biology: centrifugation, electrophoresis, chromatography, immunological and radioisotopic techniques.

Recommended Prerequisites
Knowledge in Biology, Chemistry, Enzymology, and Biochemistry is essential to fully benefit from this course.

Course Content

Separation Techniques

1. Cell fractionation methods (filtration, sedimentation: centrifugation and ultracentrifugation, dialysis and electrodialysis). Preparation of cellular and subcellular organelles; application to prokaryotic and eukaryotic cells. Characterization using various marker enzymes and definition of parameters (activity, purification factor).
2. Electrophoretic techniques (agarose, cellulose acetate, PAGE); native and denaturing electrophoresis.
    - Preparative and analytical isoelectric focusing
    - Two-dimensional electrophoresis
    - Immunoelectrophoresis
    - Pulsed-field electrophoresis
    - Capillary electrophoresis
    - Isotachophoresis
3. Chromatographic techniques:
   A) Liquid phase chromatography: adsorption, partition, affinity and immunoaffinity, ion exchange, gel filtration, hydrophobic chromatography, supercritical chromatography. Principles and techniques. HPLC and FPLC.
   B) Gas chromatography
4. Labeling methods:
   A) Use of radioisotopes in biochemistry and molecular biology, main isotopes used, counting and detection techniques, basic radiation safety.
   B) Use of fluorescent molecules as tracers or cold probes
5. Immunological techniques (ELISA, RIA, Western blot)

Evaluation Method (type and weighting)

- **Continuous assessment (/20):**

    - Average of lab reports (/10)
    - Lab exam (/10)
- **Final Exam (/20)**

References

- Séparation et analyse des biomolécules : Méthodes physico-chimiques. Jean-Pierre Sine. Editeur Amazon.2003
- Biologie moléculaire de la cellule. Bruce Alberts, Alexander Johnson, Julian Lewis, JohnWilson et Tim Hunt. Editeur : Flammarion, 2004
- Méthodes instrumentales d'analyse chimique et applications. Méthodes chromatographiques, électrophorèses et méthodes spectrales. Gwenola Burgot et Jean-Louis Burgot. Editeur : Tec et Doc, Editions médicales internationales (EMI), 2006

Discovery Teaching Unit 1 (UED 3.1.1): Structure and Function of Macromolecules

Subject 1: Structure and Function of Macromolecules
Credits: 5
Coefficient: 3

Learning Objectives

This course aims to provide students with an in-depth understanding of the structure, function, and physicochemical and biological properties of the main constituents of living matter (proteins, lipids, and carbohydrates). The course will also address the structure, function, and structure/function relationships of macromolecules formed from the association of these three components (e.g., glycoproteins, lipoproteins, etc.).

Recommended Prerequisites

Students are expected to have acquired knowledge during the first two years of the undergraduate program in Biochemistry, Genetics, Immunology, and Organic Chemistry.

Course Content

I – Proteins

1. **General Overview:** Main functions and cellular localization
2. **Three-Dimensional Structure of Proteins**
    - Review of the different levels of protein architecture
    - Protein folding: Folding mechanisms, families of molecular chaperones and their mechanisms of action
    - The concept of structural and functional domains
    - Quaternary or supramolecular structures: Modes of subunit association and arrangement, structural and functional advantages of quaternary associations
3. **Demonstrating the Relationship Between Structure and Function in Biomolecules**
    - Conservation of peptide sequence and functional specificity
    - Conservation of biological activity during denaturation/renaturation experiments
4. **Diversity of Biological Functions of Proteins**
    - Structural proteins (e.g., collagen)
    - Transport proteins (e.g., hemoglobin, oxygen transport)
    - Contractile and motility proteins (e.g., actin and myosin)
    - Defense and aggression proteins (e.g., immunoglobulins or antibodies)
5. **Modification of Molecular Interactions During Biological Activity**
    - Protein-protein interactions
    - Protein-DNA interactions

- Protein-polysaccharide interactions

II – Carbohydrates

1. **Importance of Polysaccharides from Animal, Plant, and Microbial Origins**
2. **Glycoproteins**
    - The carbohydrate portion
    - Biological roles of the carbohydrate portion
    - Blood group glycoproteins
    - Glycoproteins and infection
    - HIV envelope glycoproteins
3. **Glycolipids**
    - Glycerolipids
    - Glycosphingolipids
    - Blood group glycolipids

Assessment Method (type and weighting)

- **Continuous Assessment (/20):**
    - Quiz on tutorial sessions
    - Article analysis (oral presentation, written summary, and test)
- **Final Exam (/20)**

Recommended References

(No references were listed in your original; let me know if you'd like help adding standard textbooks.)

Biochimie générale. Cours et questions de révision : licence, PCEM, PCEP. Jacques-Henry Weil. Editeur : Dunod, 2009
Biochimie et biologie moléculaire. Cours Werner Müller-Esterl. Editeur : Dunod. 2007 **Chimie, biochimie et biologie moléculaire**. 1re année Santé - UE1 - Atomes, biomolécules, génome bioénergétique, métabolisme. Bernard Sablonnière. Editeur : Omniscience , 2e edition, 2010

Biologie moléculaire de la cellule Lodish H., Berk A., Matsudaira P., Kaiser C. A., 2005. De Boek University.

Biochimie et biologie moléculaire. Christian Moussard, Editeur : De Boeck, Septembre 2010 **Biologie moléculaire du gène**. James D. Watson , Tania Baker , Stephen Bell , Alexander Gann , Michael Levine , Richard Losick , Editeur Pearson Education

Transversal Teaching Unit 1 (UET 3.1.1): Scientific English

Subject 1: Scientific English
Credits: 3
Coefficient: 1

Learning Objectives

Enable students to apply their general and scientific English knowledge, particularly in oral presentations. Students must master the tools needed to write a text or scientific article in English.

Recommended Prerequisites

Students should have general and basic knowledge of English.

Course Content

Chapter I

- Study of scientifically relevant texts (reading, comprehension, translation from English to French), scientific terminology in biology, grammar revision, pronunciation, and phonetics.

Chapter II

- Introduction to methodology: characteristics of scientific research, writing a research proposal, structure of a scientific article, scientific writing.

Chapter III

- Development of scientific English listening comprehension using the knowledge gained in the previous two chapters, reading and analyzing scientific articles.

Assessment Methods (type and weighting)

- **Final Exam (/20)**
- **Quizzes**

References

Jonathan Upjohn, Listening Comprehension for Scientific English, Sciences.
Martin Hewings, Advanced Grammar In Use,

Cambridge U.P. Michael Swan, Catherine Walker

How English Works , Oxford U.P.

Fundamental Teaching Unit 1 (UEF 3.2.1): Genetic Engineering

Subject 1: Genetic Engineering
Credits: 8
Coefficient: 4

Learning Objectives

The objective is for students to acquire core techniques of genetic engineering and to handle biological tools such as cloning vectors, restriction enzymes, and more. The course also provides an introduction to the various application fields of genetic engineering.

Recommended Prerequisites

This unit requires knowledge of molecular biology, microbial genetics, as well as general biochemistry and microbiology.

Course Content

Chapter I: Enzymatic Tools in Genetic Engineering

1. Restriction enzymes

- The phenomenon of restriction
- Nomenclature of restriction enzymes
    - Type I, Type II, Type III enzymes
- Types of cuts induced by restriction enzymes

2. Other commonly used enzymes in molecular biology

- Polymerases
- Ligases

Nucleases

Chapter II: Molecular Hybridization

1. Review of hybridization principles

- DNA melting temperature and influencing factors

2. Liquid-phase hybridization

- Principle
- Quantitative analysis of hybrids
- Applications

3. Solid-phase hybridization

- Principle
- Influencing factors
- Nucleic acid immobilization supports

4. In situ hybridization

Chapter III: Vectors

1. General concepts

- Definition and properties of vectors
- General principles of vector use

2. Plasmids

- Use and preparation
- First, second, and third-generation plasmids

3. Phages

- Use and preparation
- First-generation phage: Lambda phage
- Second-generation phages

4. Other vectors

- Cosmids
- Shuttle vectors
- Eukaryotic viral vectors

Chapter IV: Probes

1. Concept of probes
2. Labeling agents

- Radioactive isotopes
- Non-radioactive labeling

3. Labeling strategies

- Nick translation
- Random priming
- Labeling of synthetic oligonucleotide probes
- Labeling of cloned single-stranded probes (M13 phage)
- RNA probes (riboprobes)

Chapter V: Cloning

1. Cloning principle
2. DNA cloning basics
3. DNA libraries

- Genomic libraries: creation and amplification
- cDNA libraries: reverse transcription, vector choice, bacterial transformation

4. Library screening (detection of recombinants)

Chapter VI: Genetic Transformation

1. Gene gun (biolistic) transformation
2. Transformation by *Agrobacterium tumefaciens*

Chapter VII: Genetic Engineering and Applications

1. Introduction
2. Recombinant protein expression
3. Bacterial expression systems
4. Eukaryotic expression systems
5. Techniques for protein synthesis

- Examples in the pharmaceutical industry: drugs, vaccines

6. Plant genetic engineering: plant transgenesis

- Definition, gene transfer methods, conferred traits, advantages and limitations

7. Transgenic animals

- Definition, gene transfer methods, main applications, advantages and limitations

8. Genetic engineering in medicine

- Gene therapy: definition, regulations, vectors
- Gene therapy techniques
- Examples of gene therapy

Assessment Methods (type and weighting)

- **Continuous Assessment (/20):**
    - Average score of lab reports (/20)
    - Lab exam (/10)
    - One quiz on tutorial content
- **Final Exam (/20)**

Bibliographic References

Principes de génie-génétique.

Sandy Primrose, Richard Twyman, Robert W. Old. Edition De Boeck Supérieur. 2004.

Molecular cloning- A laboratory manual.

Joseph Sambrook, David W. Russell. CSHL Press. 2001.

Essential molecular biology.

T. A. Brown. Oxford University Press, 2001.

Introduction à la microbiologie.

Gerard J. Tortora, Berdell R. Funke, Christine L. case. Editions du renouveau pédagogique Inc. 2003

Génétique moléculaire humaine-une introduction aux mécanismes des maladies héréditaires. Jack J. Pasternak. Editions De Boeck université. 2003.

Biologie moléculaire et médecine.

Jean-Claude Kaplan, Marc Delpech. Edition : Flammarion Médecine-sciences, 1994.

Fundamental Teaching Unit 2 (UEF 3.2.2): Signaling and Regulation of Gene Activity

Subject 1: Signaling and Regulation of Gene Activity
Credits: 8
Coefficient: 4

Teaching Objectives

At the end of this unit, students will have acquired a molecular understanding of signal transmission and transduction to the nucleus. This course also enables comprehension of gene activity modulation in response to extracellular signals.

Recommended Prerequisites

This course requires foundational knowledge in structural biochemistry and enzymology, as well as knowledge in molecular biology.

Course Content

Chapter I: Overview of the Molecular Organization of Biomembranes

1. Structure of biomembranes
    1.1. Asymmetry in lipid composition and distribution
    1.2. Distribution of membrane proteins
2. Membrane fluidity
3. Targeting mechanisms
    3.1. Intracellular vesicular trafficking of proteins
    3.2. Post-translational modifications of proteins
        3.2.1. Lipidation
        3.2.2. Glycosylation

Chapter II: Membrane Receptors and Intracellular Signaling Molecules

1. Membrane receptors and their ligands
    1.1. Receptor characteristics
    1.2. Receptor classification based on localization
        1.2.1. Nuclear receptors
        1.2.2. Membrane receptors
    1.3. Types of membrane receptors
        1.3.1. Ion channel-linked receptors
        1.3.2. G-protein-coupled receptors (GPCR)
        1.3.3. Receptors with intrinsic enzymatic activity
            1.3.3.1. Receptor tyrosine kinases (RTK)
            1.3.3.2. Serine/threonine kinase receptors
        1.3.4. Guanylate cyclase-linked receptors
        1.3.5. Tyrosine kinase-associated receptors
        1.3.6. Serine/threonine kinase-associated receptors
2. General scheme of a signaling pathway
3. Network of intracellular signaling molecules
    3.1. Main adaptor proteins

3.1.1. Protein-protein interaction domains
3.1.1.1. SH domains (Src Homology)
3.1.1.2. PTB domains (PhosphoTyrosine Binding)
3.1.2. SH2 domain adaptor proteins
3.1.2.1. Grb2
3.1.2.2. Shc
3.2. Monomeric small G proteins
3.2.1. Ras protein superfamily
3.3. Regulatory proteins associated with small G proteins
3.3.1. GEFs (Guanine nucleotide Exchange Factors)
3.3.2. GAPs (GTPase Activating Proteins)
3.4. Enzymes and intracellular second messengers
3.4.1. Properties of second messengers
3.4.2. Synthesis reactions of second messengers and enzymes
3.4.2.1. cAMP and adenylate cyclase
3.4.2.2. DAG, IP3 and phospholipase C
3.4.2.3. PIP2 and PI3-kinase
3.4.2.4. cGMP and guanylate cyclase
3.5. Protein kinases
3.5.1. Phosphorylation reactions and kinase domains
3.5.2. Main protein kinases
3.5.2.1. Protein kinase A (PKA)
3.5.2.2. Protein kinase C (PKC)
3.5.2.3. Protein kinase B (Akt)
3.5.2.4. MAP kinases (Mitogen-Activated Protein Kinases)

Chapter III: Molecular Basis of Signaling by Receptor Tyrosine Kinases (RTK)

1. Activation mechanisms of RTKs
   1.1. Receptor dimerization
   1.2. Receptor transphosphorylation

2. Activation of the MAP kinase cascade
   2.1. Transcription factors activated by MAP kinases: AP1

3. Activation of the PI3K pathway
   3.1. PI3K lipid kinase activity
   3.2. Classes of PI3K
      3.2.1. Class IA
      3.2.2. Class IB
      3.2.3. Role of PI3K subunits
   3.3. RTK-mediated PI3K activation
      3.3.1. Direct activation
      3.3.2. Activation via IRS (insulin receptor substrate)
      3.3.3. Activation via Ras
   3.4. PDK (Phosphoinositide-dependent kinase 1) recruitment
   3.5. Akt (PKB) activation

Chapter IV: Signaling Pathways of G-Protein Coupled Receptors (GPCRs)

1. Heterotrimeric G proteins
    1.1. Structure of G proteins (α, β, γ subunits)
    1.2. Types of Gα subunits: αs, αi, αq, α12
    1.3. Activation/inactivation cycle of G proteins
2. Activation of adenylate cyclase by Gαs
3. Activation of phospholipase Cβ (PLCβ) by Gαq
    3.1. Release of second messengers: DAG and IP3
    3.2. DAG and activation of PKC
    3.3. IP3 and mobilization of intracellular calcium
4. Involvement of Gβγ in PI3K activation
5. CREB transcription factor

Chapter VI: Signal-Dependent Transcription Factors

1. Simplified classification of transcription factors
    1.1. Constitutively active transcription factors
    1.2. Regulated transcription factors
        1.2.1. Membrane signal-regulated transcription factors
            1.2.1.1. Nuclear-localized: C/EBP, AP1
            1.2.1.2. Cytoplasmic-localized:
                a. STAT (Signal Transducer and Activator of Transcription)
                b. SMAD
                c. NF-κB
2. Activation of STATs via cytokine signaling
    2.1. Definition and classes of cytokines
    2.2. Cytoplasmic tyrosine kinase-coupled receptors (JAK)
        2.2.1. JAK family members
        2.2.2. Receptor activation by JAKs
    2.3. Signal transduction via STATs
        2.3.1. STAT family members
        2.3.2. STAT protein structure
        2.3.3. STAT activation and nuclear translocation
    2.4. JAK/STAT pathway activation by IL-6
    2.5. JAK/STAT pathway activation by IFN-γ
3. SMAD activation via TGF-β
    3.1. SMAD family members
    3.2. SMAD protein structure
    3.3. Canonical activation via serine/threonine kinase receptors
4. Canonical NF-κB pathway activation via IL-1β and TNF-α
    4.1. NF-κB family members
    4.2. NF-κB structural features
    4.3. IκB inhibitors (α and β)
    4.4. IKK (IκB kinase)
    4.5. NF-κB activation via IL-1β
        4.5.1. IL-1β receptor complex

4.5.2. MyD88-dependent IL-1 signaling
4.6. NF-κB activation via TNF-α
4.6.1. TNF-α receptors
4.6.2. TNF-α receptor type 1 signaling pathway
4.7. NF-κB response genes

Assessment Methods

- **Continuous assessment /20:**
  - Two quizzes (each graded /10)
  - Article analysis/presentation (oral /5, written summary /5, test /10)
- **Final exam (ETLD) /20**

References (books, lecture notes, websites, etc.)

At least 3–4 key and classical references must be cited. Examples might include:

Biochimie et biophysique des biomembranes : aspects structuraux et fonctionnels.

Emanuel Shechter. Edition Dunod, 2004.

Biologie moléculaire, biochimie des communications cellulaires. Christian Moussard. Edition De Boeck, 2006.

Signalisation cellulaire et cancer. Jacques Robert. Springer, 2010.

Biologie cellulaire et moléculaire. Gerald Karp. Edition De Boeck université. 2004

Biologie Moléculaire de la cellule. Lodish, Baltimore, Berk , Zipursky , Matsudaira, Darnell. Edition De Boeck, 2000.

Biochimie et biologie moléculaire illustrées. Jacques-Paul Borel, Michel Sternberg. Edition Frison-Roche, 2000.

Teaching Unit Methodology 1 (UEM 3.2.1): Bioinformatics and Preparative and Analytical Techniques of Macromolecules II

Subject 1: Bioinformatics

Credits: 3
Coefficient: 2

Teaching Objectives:

- Introduction to basic principles for research and analysis of biological information;
- Introduction to methods for comparison and alignment of biological sequences;
- Familiarization with 2D/3D drawing software and molecular modeling;
- Guidance on searching biological information;
- Mastery of script programming;
- Visualization of 3D structures and study of structure-activity relationships.

Recommended prior knowledge:
Thorough knowledge of protein structure as taught in the course *Structure and Function of Macromolecules*.

Course content :

- Introduction to computational tools in biology;
- Script programming and study of 3D structures of biological macromolecules;
- Use of databases for research and analysis of biological information;
- Methods for comparison and alignment of biological sequences;
- Introduction to molecular modeling (force fields and conformational search).

Evaluation method: (types and weight)

- Continuous assessment /20
    - Average evaluation of lab reports (graded out of 10)
    - Lab exam (graded out of 10)
- Final exam (EMD) /20

Bibliographic references:

Bioinformatique , Génomique et post-génomique. Frédéric Dardel et François Képès. Editeur : Les Éditions de l'École polytechnique, Ellipses, 2002

Introduction à Perl pour la bioinformatique. James Tisdall. Editeur : O'Reilly, 2002

Bioinformatique : Principes d'utilisation des outils. Denis Tagu et Je an-Loup Risler. Editeur : Quae, 2010

Biologie moléculaire de la cellule. Bruce Alberts, Alexander Johnson, Julian Lewis, JohnWilson et Tim Hunt. Editeur : Flammarion, 2004

Subject 2: Preparative and Analytical Techniques of Macromolecules II

Credits: 3
Coefficient: 2

Teaching Objectives:
Mastery of techniques for analysis and quantification of macromolecules (DNA, RNA, and proteins) by organic chemistry, analytical, and physical methods. Analysis and/or quantification of these macromolecules using techniques such as UV, infrared, visible spectrophotometry, fluorometry, mass spectrometry, NMR, and radioactive labeling.

Recommended prior knowledge:
Students should have knowledge in general biochemistry, organic and analytical chemistry, and biochemical analysis techniques.

Course content:
Chapter I. Spectral methods (definition, principle, apparatus type, applications): UV-visible spectroscopy, absorption and fluorescence. Chromophores, fluorophores, and biologically relevant fluorescent probes. Quantification of biomolecules (proteins, nucleic acids), ions (free and total), and substrates (NADH, FADH2). Enzyme activity measurement. Near IR and IR spectroscopy. Quantification of water, lipids, and carbohydrates by near IR. Determination of protonated and ionized species of carboxylates. Atomic absorption spectroscopy.

Chapter II. NMR Spectroscopy: (^{1}H, ^{13}C, ^{31}P NMR. D-glucose: ^{13}C NMR and biochemical applications. In vivo ^{1}H and ^{31}P NMR spectra, metabolite identification after labeled precursor incorporation. Structure determination of small biomolecules (carbohydrates, nucleic bases, substrates)).

Chapter III. Mass Spectrometry: Use of mass spectrometry for biomolecule characterization (chemical ionization, electrospray, coupling with gas and liquid chromatography). Some applications of mass spectrometry in biochemistry.

Evaluation method: (types and weight)

- Continuous assessment /20
- Average evaluation of lab reports
- Lab exam
- Final exam (EMD) /20

Bibliographic references:

- La spectrométrie de masse en couplage avec la chromatographie en phase gazeuse. Stéphane Bouchonnet. Editeur : Hermès - Lavoisier, Tec et Doc, 2009
- Biologie moléculaire de la cellule. Bruce Alberts, Alexander Johnson, Julian Lewis, JohnWilson et Tim Hunt. Editeur : Flammarion, 2004
- Spectroscopie moléculaire. Structures moléculaires et analyse spectral. Emile Biémont.Editeur : De Boeck, 2008
- Méthodes instrumentales d'analyse chimique et applications. Méthodes chromatographiques, électrophorèses et méthodes

Teaching Unit Discovery 1 (UED 3.2.1): Enzymology
Subject 1: Enzymology
Credits: 5
Coefficient: 2

Teaching Objectives:
This second subject of UEF3 aims at acquiring detailed fundamental data on single-substrate enzymes and various types of inhibition, introduction to two-substrate enzymes and allosteric enzymes; methods for analyzing enzymatic kinetics results. Experimental implementation of enzymatic kinetics analysis techniques.

Recommended prior knowledge:
Students must have knowledge in general biochemistry, structural and functional biochemistry, and biochemical analysis techniques.

Course content :

Chapter I: In-depth analysis of the Michaelis-Menten equation under equilibrium and steady-state assumptions. Meaning of the kcat/Km ratio.

Chapter II: Demonstration and analysis of equations for linear representations to determine kinetic parameters (Lineweaver-Burk, Hanes-Woolf, Eadie-Hofstee, Cornish-Bowden); nonlinear fitting methods; ligand binding in the absence of cooperativity, graphical determination of n and Kd (Scatchard).

Chapter III: Kinetic analysis and demonstration of expressions for competitive, non-competitive, mixed, and partial inhibitions; illustration of parameter determination in presence of different inhibitors (Dixon, Hanes-Woolf, etc.).

Chapter IV: Examples of inhibitor applications in biomedicine.

Chapter V: Introduction to two-substrate enzymes; sequential and substituted mechanisms; presentation of reaction velocity equations and basic graphical representations.

Chapter VI: Enzymatic activities and applications: activity assay methods; analytical applications.

Chapter VII: Allosteric enzymes: kinetic behavior, allosteric effects, cooperativity, desensitization effects, oligomeric states, R<->T allosteric transitions, Monod-Wyman-Changeux model, Koshland model, allosteric modulations of K and V types, molecular interpretations.

Chapter VIII: Introduction to enzyme engineering: enzyme immobilization, immunoenzymology.

Evaluation method:

- Continuous assessment /20
- Final exam (EMD) /20

Bibliographic references:

- *Molecular and Cellular Enzymology* Volumes 1 and 2, Jeannine Yon-Kahn and Guy Hervé. EDP Sciences, 2005
- *Enzymology and Applications*, Jean-Pierre Sine. Ellipses, 2010
- *Metabolic Regulation; Genes, Enzymes, Hormones and Nutrients*, René Cacan. Ellipses, 2008

- *General Biochemistry. Course and Review Questions: Licence, PCEM, PCEP*, Jacques-Henry Weil. Dunod, 2009

Transversal Teaching Unit (UET 3.2.1): Life Sciences and Society
Subject 1: Life Sciences and Society
Credits: 3
Coefficient: 1

Teaching Objectives:
Enable students to process and analyze current scientific topics in life sciences related to everyday life and to communicate about these topics.

Recommended prior knowledge:
Students must have knowledge in Biochemistry and Molecular Biology.

Course content:
Chapter I – Sustainable Development and Environment
1.1 – Biotechnologies and Malnutrition
1.2 – Biotechnologies and Pollution
1.3 – Biodiversity
1.4 – Genetically Modified Organisms

Chapter II – Bioethics, Progress in Biology and Societal Impact
2.1 – Reproductive and Therapeutic Cloning
2.2 – Justice and Recombinant DNA: Genetic Fingerprinting
2.3 – Sterility, Artificial Insemination and Sperm Banks
2.4 – Traceability of Agricultural and Food Products

Evaluation method:

- Presentation (oral presentation/5, written summary/5, test/10)
- Final evaluation (ETLD) /20