The University of Jordan  
Faculty: Pharmacy  
Department: Biopharmaceutics and Clinical Pharmacy  
Program: Pharmacy  
Academic Year/ Fall Semester: 2014/15

<table>
<thead>
<tr>
<th>Credit hours</th>
<th>3</th>
<th>Level</th>
<th>2nd year</th>
<th>Pre-requisite</th>
<th>-</th>
</tr>
</thead>
</table>
| Coordinator/ Lecturer | Prof. Dr. Yasser K. Bustanji  
Dr. Areej Assaf  
Dr. Violet Kasabri | Office number | bustanji@ju.edu.jo  
areej_assaf@ju.edu.jo  
v.kasabri@ju.edu.jo | Office phone | - |
| Course website | - | E-mail | Place | Pharmacy | - |

**Course Objectives:**
This course is the second course in a two-semester sequence in biochemistry. The students are expected to:
1- Use the knowledge gained in Biochemistry I to understand the basic concepts of metabolism
2-Understand the metabolic pathways of the major biomolecules; carbohydrate, lipids, proteins and nucleotides.
3-Understand the main issues regarding the storage and expression of genetic information

**Learning Outcomes:**
A. Knowledge and Understanding of:

**A1. DNA, RNA, AND THE FLOW OF GENETIC INFORMATION**

**A1.1 Nucleotide Biosynthesis**
- Purine Bases Can Be Synthesized de Novo or Recycled by Salvage Pathways
- Deoxyribonucleotides Synthesized by the Reduction of Ribonucleotides Through a Radical Mechanism
- Key Steps in Nucleotide Biosynthesis Are Regulated by Feedback Inhibition
- In de Novo Synthesis, the Pyrimidine Ring Is Assembled from Bicarbonate, Aspartate, and Glutamine
- Nucleoside Monophosphate Kinases: Catalyzing Phosphoryl Group Exchange between Nucleotides Without Promoting Hydrolysis
- Disruptions in Nucleotide Metabolism Can Cause Pathological Conditions

**A1.2 DNA Structure, Replication, Recombination, and Repair**
- A Nucleic Acid Consists of Four Kinds of Bases Linked to a Sugar-Phosphate Backbone
- A Pair of Nucleic Acid Chains with Complementary Sequences Can Form a Double-Helical Structure
- DNA Is Replicated by Polymerases that Take Instructions from Templates
- DNA Can Assume a Variety of Structural Forms
- DNA Polymerases Require a Template and a Primer
- Double-Stranded DNA Can Wrap Around Itself to Form Supercoiled Structures
- DNA Replication of Both Strands Proceeds Rapidly from Specific Start Sites
- Double-Stranded DNA Molecules with Similar Sequences Sometimes Recombine

**A1.3 RNA Synthesis and Splicing**
Transcription Is Catalyzed by RNA Polymerase
Eukaryotic Transcription and Translation Are Separated in Space and Time
The Transcription Products of All Three Eukaryotic Polymerases Are Further Subjected to Downstream Processing
Most Eukaryotic Genes Are Mosaics of Introns and Exons

A1.4 Protein Synthesis
Gene Expression Is the Transformation of DNA Information Into Functional Molecules
Amino Acids Are Encoded by Groups of Three Bases Starting from a Fixed Point
Protein Synthesis Requires the Translation of Nucleotide Sequences Into Amino Acid Sequences
Mutations Involve Changes in the Base Sequence of DNA
Aminoacyl-Transfer RNA Synthetases Read the Genetic Code
A Ribosome Is a Ribonucleoprotein Particle (70S) Made of a Small (30S) and a Large (50S) Subunit
Protein Factors Play Key Roles in Protein Synthesis
Eukaryotic Protein Synthesis Differs from Prokaryotic Protein Synthesis Primarily in Translation Initiation and Subsequent Coupling Reactions.

A1.5 The Gene Expression Regulation
Prokaryotic DNA-Binding Proteins Bind Specifically to Regulatory Sites in Operons
The Greater Complexity of Eukaryotic Genomes Requires Elaborate Mechanisms for Gene Regulation
Transcriptional Activation and Repression Are Mediated by Protein-Protein Interactions
Some Receptors Dimerize in Response to Ligand Binding and Signal by Cross-Phosphorylation
Gene Expression Can Be Controlled at Posttranscriptional Levels

A1.6 Molecular Basis of Inherited Diseases
Restriction Enzymes: Performing Highly Specific DNA-Cleavage Reactions
DNA Recombinations Are Helpful in Establishing Genomic as Well as cDNA Libraries
Antibiotic Resistance Genes Can Select for the Transfected Cloning Vector
The Utility of Sanger Dideoxy Method Is Basically for Purified DNA Sequencing
Restriction Fragment Length Polymorphism Analysis Is a Direct Diagnostic Tool of Sickle Cell Disease
Polymerase Chain Reaction Is Highly Advantageous in Detecting/Tracing Low Abundance Nucleic Acid Sequences
Microarray Technique Is Quite a Handy Analytical Means of Determinations of the Gene Expression Products
ELISA and Western Blots Can Be Important Techniques to Investigate Specific Proteins

A2. Transducing & Storing of Energy
Intermediary Metabolism

A2.1 Glycolysis and Gluconeogenesis
Metabolism Is Composed of Many Coupled, Interconnecting Reactions
The Oxidation of Carbon Fuels Is an Important Source of Cellular Energy
Glycolysis Is an Energy-Conversion Pathway in Many Organisms
The Glycolytic Pathway Is Tightly Controlled
Glucose Can Be Synthesized From Noncarbohydrate Precursors
Gluconeogenesis and Glycolysis Are Reciprocally Regulated

A2.2 Citric Acid Cycle
The Citric Acid Cycle Oxidizes Two-Carbon Units
Entry to the Citric Acid Cycle and Metabolism Through It Are Controlled
A2. 3 The Pentose Phosphate Pathway

- The Pentose Phosphate Pathway Generates NADPH and Synthesizes Five-Carbon Sugars
- The Metabolism of Glucose 6-Phosphate by the Pentose Phosphate Pathway Is Coordinated with Glycolysis
- Glucose 6-Phosphate Dehydrogenase Plays a Key Role in Protection Against Reactive Oxygen Species

A2. 4 Glycogen, hexoses and disaccharides Metabolism

- Glycogen Breakdown Requires the Interplay of Several Enzymes
- Phosphorylase Is Regulated by Allosteric Interactions and Reversible Phosphorylation
- Epinephrine and Glucagon Signal the Need for Glycogen Breakdown
- Glycogen Is Synthesized and Degraded by Different Pathways
- Glycogen Breakdown and Synthesis Are Reciprocally Regulated
- All hexoses are to be phosphorylated before they are any further metabolized
- Hexose epimerase can substitute for lacking dietary sources of galactose
- Lactose synthesis is mainly mediated by galactosyltransferases

A3. LIPID METABOLISM

A3. 1 Fatty Acid Metabolism

- Triacylglycerols Are Highly Concentrated Energy Stores
- The Utilization of Fatty Acids as Fuel Requires Three Stages of Processing
- Certain Fatty Acids Require Additional Steps for Degradation
- Fatty Acids Are Synthesized and Degraded by Different Pathways
- Acetyl Coenzyme A Carboxylase Plays a Key Role in Controlling Fatty Acid Metabolism via Carnitine shuttle modulation
- Elongation and Unsaturation of Fatty Acids Are Accomplished by Accessory
- Ketogenesis is strictly hepatic and ketone bodies can be consumed by brain as well as muscle cells

A3. 2 The Biosynthesis of Membrane Lipids and Steroids

- Phosphatidic acid Is a Common Intermediate in the Synthesis of Phospholipids and Triacylglycerols
- Cholesterol Is Synthesized from Acetyl Coenzyme A in Three Stages
- The Complex Regulation of Cholesterol Biosynthesis Takes Place at Several Levels
- Important Derivatives of Cholesterol Include Bile Salts and Steroid Hormones

A4. PROTEIN TURNOVER AND AMINO ACID CATABOLISM

- Proteins Are Degraded to Amino Acids
- Protein Turnover Is Tightly Regulated
- Many Enzymes Are Activated by Specific Proteolytic Cleavage
- The First Step in Amino Acid Degradation Is the Removal of Nitrogen
- Ammonium Ion Is Converted Into Urea in Most Terrestrial Vertebrates
- Carbon Atoms of Degraded Amino Acids Emerge as Major Metabolic Intermediates
- Inborn Errors of Metabolism Can Disrupt Amino Acid Degradation
- Amino Acids Are Precursors of Many Biomolecules

A5. THE INTEGRATION OF METABOLISM

- Metabolic Pathways Contain Many Recurring Motifs
- Metabolism Consist of Highly Interconnected Pathway
- Each Organ Has a Unique Metabolic Profile
Food Intake and Starvation Induce Metabolic Changes
Ethanol Alters Energy Metabolism in the Liver

Peptide hormones, namely insulin and glucagon, are actively involved in reciprocal regulation of metabolism during absorptive and postabsorptive phases

B. Intellectual skills (cognitive and analytical):
- Integrate metabolic pathways, and analyze the complete integrated metabolic map.
- Interpret metabolic abnormalities and relate them to possible causes and mechanisms.
- Relate the biochemical events at the cellular level to the physiological processes occurring in the whole animal.
- Follow up the flow of genetic information: DNA→RNA→Protein

C. Subject specific skills

D. Transferable Skills
- The development of problem solving and critical thinking skills.
- Use oral communication to effectively transmit ideas and conclusions to a scientific audience.

References:

<table>
<thead>
<tr>
<th>ISBN</th>
<th>Title</th>
<th>Author</th>
<th>Year</th>
</tr>
</thead>
<tbody>
<tr>
<td>716712261</td>
<td>BIOCHEMISTRY 4TH EDITION</td>
<td>STRYER, LUBERT</td>
<td>1995C</td>
</tr>
<tr>
<td>781769604</td>
<td>BIOCHEMISTRY LIPPINCOTT'S ILLUSTRATED REVIEWS, 4TH EDITION</td>
<td>CHAMPE, PAMELA; HARVEY, RICHARD; FERRIER, DENISE; COOPER, MICHAEL</td>
<td>2008C</td>
</tr>
<tr>
<td>7167743396</td>
<td>LEHNINGER PRINCIPLES OF BIOCHEMISTRY</td>
<td>LEHNINGER, ALBERT</td>
<td>2005C</td>
</tr>
<tr>
<td>9780071765763</td>
<td>HARPER'S ILLUSTRATED BIOCHEMISTRY-27ED.</td>
<td>MURRAY, ROBERT K. (ROBERT KINCAID)</td>
<td>2012</td>
</tr>
<tr>
<td>0272797138</td>
<td>ESSENTIALS OF HUMAN BIOCHEMISTRY</td>
<td>PATERSON, COLIN RALSTON</td>
<td>1983</td>
</tr>
</tbody>
</table>

Lecture notes are available on
http://blackboard.ju.edu.jo
User name: pharm_std
Password: pharm_std
## Course Contents and Schedule

<table>
<thead>
<tr>
<th>Subject</th>
<th>No. of lectures</th>
</tr>
</thead>
<tbody>
<tr>
<td>Introduction</td>
<td>1</td>
</tr>
<tr>
<td>Storage and expression of genetic information.</td>
<td></td>
</tr>
<tr>
<td>- Nucleotide metabolism.</td>
<td>3</td>
</tr>
<tr>
<td>- DNA structure and replication</td>
<td>3</td>
</tr>
<tr>
<td>- RNA structure and synthesis</td>
<td>2</td>
</tr>
<tr>
<td>- Protein Synthesis</td>
<td>3</td>
</tr>
<tr>
<td>- Regulation of gene expression</td>
<td>3</td>
</tr>
<tr>
<td>- Molecular basis of inherited disease</td>
<td>5</td>
</tr>
<tr>
<td>Intermediary metabolism.</td>
<td></td>
</tr>
<tr>
<td>- Glycolysis.</td>
<td>2</td>
</tr>
<tr>
<td>- Gluconeogenesis</td>
<td>2</td>
</tr>
<tr>
<td>- Hexose Monophosphate pathway</td>
<td>2</td>
</tr>
<tr>
<td>- Citric acid cycle</td>
<td>2</td>
</tr>
<tr>
<td><strong>MIDTERM</strong></td>
<td></td>
</tr>
<tr>
<td>Carbohydrate metabolism</td>
<td></td>
</tr>
<tr>
<td>- Glycogen metabolism</td>
<td>2</td>
</tr>
<tr>
<td>- Metabolism of monosaccharides and disaccharides</td>
<td></td>
</tr>
<tr>
<td>Lipid metabolism</td>
<td></td>
</tr>
<tr>
<td>- Metabolism of dietary lipids</td>
<td>2</td>
</tr>
<tr>
<td>- Fatty acid and triacylglycerol metabolism</td>
<td>2</td>
</tr>
<tr>
<td>- Phospholipid metabolism</td>
<td>1</td>
</tr>
<tr>
<td>- Cholesterol and steroid metabolism</td>
<td>3</td>
</tr>
<tr>
<td>Nitrogen metabolism</td>
<td></td>
</tr>
<tr>
<td>- Disposal of Nitrogen</td>
<td>2</td>
</tr>
<tr>
<td>- Metabolism of carbon skeleton</td>
<td>1</td>
</tr>
<tr>
<td>- Conversion of amino acids to specialized products</td>
<td>1</td>
</tr>
<tr>
<td>Integration of metabolism.</td>
<td></td>
</tr>
<tr>
<td>- Metabolic effects of insulin and glucagon</td>
<td>1</td>
</tr>
<tr>
<td>- Metabolism in the well-fed state</td>
<td>1</td>
</tr>
<tr>
<td>- Metabolism in starvation and diabetes mellitus</td>
<td>1</td>
</tr>
<tr>
<td><strong>FINAL EXAM</strong></td>
<td></td>
</tr>
</tbody>
</table>