UNIVERSITY OF CALCUTTA

Notification No. CSR/28/19

It is notified for information of all concerned that the Syndicate in its meeting held on 27.08.2019 (vide Item No.06) approved the new revised syllabus for the B.Sc. Course of Studies in Biochemistry (Honours/General) under CBCS, incorporating some modifications of the previous notification (CSR/12/18, dt. 04.6.18), as laid down in the accompanying pamphlet.

The above shall take effect from the Odd Semester Examinations, 2019 & onwards.

SENATE HOUSE
KOLKATA-700 073
The 2nd September, 2019

Prof.(Dr.) Debasis Das
Registrar (Acting)
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1. Scheme for CBCS Curriculum

1.1 Credit Distribution across Courses

<table>
<thead>
<tr>
<th>Course Type</th>
<th>Total Papers</th>
<th>Theory + Practical</th>
<th>Theory*</th>
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</thead>
<tbody>
<tr>
<td>Core Courses</td>
<td>14</td>
<td>14*4 = 56</td>
<td>14*4 = 56</td>
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<tr>
<td></td>
<td></td>
<td>14*2 = 28</td>
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<tr>
<td>Discipline Specific Electives</td>
<td>4</td>
<td>4*4 = 16</td>
<td>4*4 = 16</td>
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<tr>
<td>Generic Electives</td>
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<td>4*4 = 16</td>
<td>4*4 = 16</td>
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<tr>
<td></td>
<td></td>
<td>4*2 = 8</td>
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<tr>
<td>Ability Enhancement Language Courses</td>
<td>2</td>
<td>2*2 = 4</td>
<td>2*2 = 4</td>
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<tr>
<td>Skill Enhancement Courses</td>
<td>2</td>
<td>2*2 = 4</td>
<td>2*2 = 4</td>
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<tr>
<td>Totals</td>
<td>26</td>
<td>140</td>
<td></td>
</tr>
</tbody>
</table>

*Credit distribution assuming that all four GE courses a student has chosen have practical components.*
Marking scheme for Honours & General Core & DSE courses:

1. 5 X 2 marks=10 marks (10 questions need to be set taking from all ‘Units’ in an uniform manner; students have to answer any 5 out of 10 questions)
2. 2 X 5 marks=10 marks (4 questions need to be set taking from all ‘Units’ in an uniform manner; students have to answer any 2 out of 4 questions)
3. 3 X 10 marks=30 marks [for a paper with 3 ‘Units’, 6 questions need to be set taking 2 from each ‘Unit’ in an uniform manner; students have to answer any 3 questions taking at least one from each unit (for a Paper with 2 ‘Units’, 6 questions need to be set taking 3 from each Unit; students have to answer any 3 questions taking at least one from each unit and the rest from any one Unit)]

<table>
<thead>
<tr>
<th>Sem</th>
<th>Core</th>
<th>Electives</th>
<th>Ability Enhancement</th>
<th>Total Credits</th>
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<tbody>
<tr>
<td></td>
<td></td>
<td>General</td>
<td>Skill</td>
<td></td>
</tr>
<tr>
<td>I</td>
<td>6X2=12</td>
<td>6</td>
<td>-</td>
<td>20</td>
</tr>
<tr>
<td>II</td>
<td>6X2=12</td>
<td>6</td>
<td>-</td>
<td>20</td>
</tr>
<tr>
<td>III</td>
<td>6X3=18</td>
<td>6</td>
<td>2</td>
<td>26</td>
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<tr>
<td>IV</td>
<td>6X3=18</td>
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<td>2</td>
<td>26</td>
</tr>
<tr>
<td>V</td>
<td>6X2=12</td>
<td>-</td>
<td>- 6X2=12</td>
<td>24</td>
</tr>
<tr>
<td>VI</td>
<td>6X2=12</td>
<td>-</td>
<td>- 6X2=12</td>
<td>24</td>
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<tr>
<td>Total Credits</td>
<td>84</td>
<td>24</td>
<td>4</td>
<td>24</td>
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Structure of B.Sc. (Hons) Biochemistry under CBCS

<table>
<thead>
<tr>
<th>Semester</th>
<th>Core Course</th>
<th>Course Code</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>CC-1: Molecules of Life</td>
<td>BCM-A-CC-1-1</td>
</tr>
<tr>
<td>II</td>
<td>CC-3: General Physical Chemistry</td>
<td>BCM-A-CC-2-3</td>
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<tr>
<td>II</td>
<td>CC-4: Enzymes</td>
<td>BCM-A-CC-2-4</td>
</tr>
<tr>
<td>III</td>
<td>CC-5: Bio-physical Chemistry</td>
<td>BCM-A-CC-3-5</td>
</tr>
<tr>
<td>III</td>
<td>CC-6: Metabolism of Carbohydrates and Lipids</td>
<td>BCM-A-CC-3-6</td>
</tr>
<tr>
<td>III</td>
<td>CC-7: Cell Biology</td>
<td>BCM-A-CC-3-7</td>
</tr>
<tr>
<td>IV</td>
<td>CC-8: Membrane Biology and Bioenergetics</td>
<td>BCM-A-CC-4-8</td>
</tr>
<tr>
<td>IV</td>
<td>CC-9: Metabolism of Amino Acids and Nucleotides</td>
<td>BCM-A-CC-4-9</td>
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<tr>
<td>IV</td>
<td>CC-10: Basic Microbiology and Microbial Genetics</td>
<td>BCM-A-CC-4-10</td>
</tr>
<tr>
<td>V</td>
<td>CC-11: Gene, Gene Expression and Regulation</td>
<td>BCM-A-CC-5-11</td>
</tr>
<tr>
<td>V</td>
<td>CC-12: Physiology and Hormones</td>
<td>BCM-A-CC-5-12</td>
</tr>
<tr>
<td>VI</td>
<td>CC-13: Genetic Engineering and Biotechnology</td>
<td>BCM-A-CC-6-13</td>
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<tr>
<td>VI</td>
<td>CC-14: Immunology</td>
<td>BCM-A-CC-6-14</td>
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# Duration for Practical Examinations under CBCS curriculum

## Core & DSE Practical Examinations:

<table>
<thead>
<tr>
<th>Semester</th>
<th>Practical</th>
<th>Core Course</th>
<th>Marks</th>
<th>Duration</th>
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<tbody>
<tr>
<td>I</td>
<td>P1</td>
<td>Molecules of life</td>
<td>30</td>
<td>5 hrs</td>
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<tr>
<td>I</td>
<td>P2</td>
<td>Organic Chemistry</td>
<td>30</td>
<td>5 hrs</td>
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<td>II</td>
<td>P3</td>
<td>General Physical Chemistry</td>
<td>30</td>
<td>5 hrs</td>
</tr>
<tr>
<td>II</td>
<td>P4</td>
<td>Enzymes</td>
<td>30</td>
<td>5 hrs</td>
</tr>
<tr>
<td>III</td>
<td>P5</td>
<td>Bio-Physical Chemistry</td>
<td>30</td>
<td>5 hrs</td>
</tr>
<tr>
<td>III</td>
<td>P6</td>
<td>Metabolism of Carbohydrates &amp; lipids</td>
<td>30</td>
<td>Clubbed; 6 hrs</td>
</tr>
<tr>
<td>III</td>
<td>P7</td>
<td>Cell Biology</td>
<td>30</td>
<td></td>
</tr>
<tr>
<td>IV</td>
<td>P8</td>
<td>Membrane biology &amp; Bioenergetics</td>
<td>30</td>
<td>5 hrs</td>
</tr>
<tr>
<td>IV</td>
<td>P9</td>
<td>Metabolism of amino acids &amp; nucleotides</td>
<td>30</td>
<td>Clubbed; 2 days</td>
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<tr>
<td>IV</td>
<td>P10</td>
<td>Basic Microbiology &amp; Microbial Genetics</td>
<td>30</td>
<td>6 hrs/day</td>
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<tr>
<td>V</td>
<td>P11</td>
<td>Gene, Gene Expression and Regulation</td>
<td>30</td>
<td>Clubbed; 2 days; 6hrs/day</td>
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<tr>
<td>V</td>
<td>P12</td>
<td>Physiology &amp; Hormones</td>
<td>30</td>
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<tr>
<td>V</td>
<td>DSE-A-P1</td>
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<td>30</td>
<td>5 hrs</td>
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<tr>
<td>V</td>
<td>DSE-B-P2</td>
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<td>30</td>
<td>5 hrs</td>
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<tr>
<td>VI</td>
<td>P13+P14</td>
<td>RDT &amp; Genetic Engineering +Immunology</td>
<td>60</td>
<td>Clubbed; 2 days; 6hrs/day</td>
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<tr>
<td>VI</td>
<td>DSE-A-P1</td>
<td></td>
<td>30</td>
<td>5 hrs</td>
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<tr>
<td></td>
<td>DSE-B-P1</td>
<td></td>
<td>30</td>
<td>5 hrs</td>
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Discipline Specific Elective (Any four)

**DSE-A**
[Any one (A1 or A2) to be chosen for Semester 5]
DSE A1: Nutritional Biochemistry
DSE A2: Molecular basis of infectious human diseases

[Any one (A3 or A4) to be chosen for Semester 6]
DSE A3: Advanced Cell Biology
DSE A4: Molecular basis of non-infectious human diseases

**DSE-B**
[Any one (B1 or B2) to be chosen for Semester 5]
DSE B1: Advanced Biochemistry
DSE B2: Plant Biochemistry

[Any one (B3 or B4) to be chosen for Semester 6]
DSE B3: Molecular diagnostics
DSE B4: Research Methodology

Skill Enhancement Elective Course (Any two; one in Semester III & one in Semester IV)

Semester III
(Any one to be chosen)
SEC A: Tools and Techniques in Biochemistry
SEC A: Protein Purification Techniques

Semester IV
(Any one to be chosen)
SEC B: Clinical Biochemistry
SEC B: Recombinant DNA Technology
### 1.1 Scheme for Biochemistry (Honours) CBCS Curriculum

<table>
<thead>
<tr>
<th>Semester</th>
<th>Course Name</th>
<th>Course Code</th>
<th>Course Detail</th>
<th>Credits</th>
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<tbody>
<tr>
<td>I</td>
<td>Core course–1</td>
<td>BCM-A-CC-1-1-TH</td>
<td>Molecules of Life</td>
<td>4</td>
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<td>Core course–1 Practical</td>
<td>BCM-A-CC-1-1-P</td>
<td>Molecules of Life</td>
<td>2</td>
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<td>Core course–2</td>
<td>BCM-A-CC-1-2-TH</td>
<td>General Organic Chemistry</td>
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<td>Organic Chemistry</td>
<td>2</td>
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<td>Core course–3</td>
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<td>General Physical chemistry</td>
<td>4</td>
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<td>General Physical chemistry</td>
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<td>Core course–4</td>
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<td>Enzyme</td>
<td>4</td>
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<td>Enzyme</td>
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<td>Core course–5</td>
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<td>Bio-Physical chemistry</td>
<td>4</td>
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<td>BCM-A-CC-3-5-P</td>
<td>Bio-Physical chemistry</td>
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<td>Core course–6</td>
<td>BCM-A-CC-3-6-TH</td>
<td>Metabolism of Carbohydrates and Lipids</td>
<td>4</td>
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<td>Core course – 6 Practical</td>
<td>BCM-A-CC-3-6-P</td>
<td>Metabolism of Carbohydrates and Lipids</td>
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<td>Core course–7</td>
<td>BCM-A-CC-3-7-TH</td>
<td>Cell Biology</td>
<td>4</td>
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<td>Core course–7 Practical</td>
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<td>Cell biology</td>
<td>2</td>
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<td>Skill Enhancement Course A</td>
<td>BCM-A-SEC-A</td>
<td>Any one of the following: Tools and Techniques in Biochemistry Protein Purification Techniques</td>
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<td>BCM-A-CC-4-8-TH</td>
<td>Membrane Biology and Bioenergetics</td>
<td>4</td>
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<td>Core course–8 Practical</td>
<td>BCM-A-CC-4-8-P</td>
<td>Membrane Biology and Bioenergetics</td>
<td>2</td>
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<tr>
<td>Core course–9</td>
<td>BCM-A-CC-4-9-TH</td>
<td>Metabolism of Amino Acid and Nucleic Acid</td>
<td>4</td>
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<td>Core course–9 Practical</td>
<td>BCM-A-CC-4-9-P</td>
<td>Metabolism of Amino Acid and Nucleic Acid</td>
<td>2</td>
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<td>Core course–10</td>
<td>BCM-A-CC-4-10-TH</td>
<td>Basic Microbiology and Microbial Genetics</td>
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<td>BCM-A-CC-4-10-P</td>
<td>Basic Microbiology and Microbial Genetics</td>
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<td>Core course–11</td>
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<td>Gene, Gene Expression and Regulation</td>
<td>4</td>
<td></td>
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<tr>
<td>Core course–11 Practical</td>
<td>BCM-A-CC-5-11-P</td>
<td>Gene, Gene Expression and Regulation</td>
<td>2</td>
<td></td>
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<td>Core course–12</td>
<td>BCM-A-CC-5-12-TH</td>
<td>Physiology and Hormones</td>
<td>4</td>
<td></td>
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<td>Core course–12 Practical</td>
<td>BCM-A-CC-5-12-P</td>
<td>Physiology and Hormones</td>
<td>2</td>
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<tr>
<td>Discipline Specific Elective (A1 or A2)</td>
<td>BCM-A-DSE-A-5-TH</td>
<td>Theoretical</td>
<td>4</td>
<td></td>
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<td>Discipline Specific Elective B (B1 or B2)</td>
<td>BCM-A-DSE-B-5-TH</td>
<td>Theoretical</td>
<td>4</td>
<td></td>
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<tr>
<td>Discipline Specific Elective B</td>
<td>BCM-A-DSE-B-5-P</td>
<td>Practical</td>
<td>2</td>
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</tr>
<tr>
<td>Core course–13</td>
<td>BCM-A-CC-6-13-TH</td>
<td>Genetic Engineering and Biotechnology</td>
<td>4</td>
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<tr>
<td>Core course–13 Practical</td>
<td>BCM-A-CC-6-13-P</td>
<td>Genetic Engineering and Biotechnology</td>
<td>2</td>
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<td>Core course–14</td>
<td>BCM-A-CC-6-14-TH</td>
<td>Immunology</td>
<td>4</td>
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<tr>
<td>Core course–14 Practical</td>
<td>BCM-A-CC-6-14-P</td>
<td>Immunology</td>
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<tr>
<td>Discipline Specific Elective A (A3 or A4)</td>
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<td>Theoretical</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>Discipline Specific Elective A</td>
<td>BCM-A-DSE-A-6-P</td>
<td>Practical</td>
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</table>
Discipline Specific Elective B          BCM-A-DSE-B-6-TH          Theoretical          4
Discipline Specific Elective B          BCM-A-DSE-B-6-P          Practical          2

1.2 Choices for Discipline Specific Electives

<table>
<thead>
<tr>
<th>Discipline Specific Elective A</th>
<th>Discipline Specific Elective B</th>
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</thead>
<tbody>
<tr>
<td>[Any one (A1 or A2) to be chosen for Semester 5]</td>
<td>[Any one (B1 or B2) to be chosen for Semester 5]</td>
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<tr>
<td>DSE A1: Nutritional Biochemistry</td>
<td>DSE B1: Advanced Biochemistry</td>
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<tr>
<td>DSE A2: Molecular basis of infectious human diseases</td>
<td>DSE B2: Plant Biochemistry</td>
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<tr>
<td>[Any one (A3 or A4) to be chosen for Semester 6]</td>
<td>[Any one (B3 or B4) to be chosen for Semester 6]</td>
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<tr>
<td>DSE A3: Advanced Cell Biology</td>
<td>DSE B3: Molecular diagnostics</td>
</tr>
<tr>
<td>DSE A4: Molecular basis of non-infectious human diseases</td>
<td>DSE B4: Research Methodology</td>
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1.3 Choices for Skill Enhancement Courses

<table>
<thead>
<tr>
<th>Skill Enhancement Course-1 (Any one) (SEM 3)</th>
<th>Skill Enhancement Course-2 (Any one) (SEM 4)</th>
</tr>
</thead>
<tbody>
<tr>
<td>SEC-1 Tools and Techniques in Biochemistry</td>
<td>SEC-3 Clinical Biochemistry</td>
</tr>
<tr>
<td>SEC-2 Protein purification techniques</td>
<td>SEC-4 Recombinant DNA technology</td>
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# Core Course Detailed Syllabus

## Core Course 1 – Molecules of Life  (Semester 1)  BCM-A-CC-1-1-TH

**Molecules of Life**  
4 Credits; 50 hours

**The foundations of biochemistry**

**Cellular and chemical foundations of life**

### Unit-I

**Water**

Unique properties, weak interactions in aqueous systems, ionization of water, buffers, water as a reactant and fitness of the aqueous environment.

**Carbohydrates and glycobiology**

Monosaccharides - structure of aldoses and ketoses, ring structure of sugars, conformations of sugars, mutarotation, anomers, epimers and enantiomers, structure of biologically important sugar derivatives, oxidation of sugars. Formation of disaccharides, reducing and non-reducing disaccharides. Polysaccharides – homo- and heteropolysaccharides, structural and storage polysaccharides. Structure and role of proteoglycans, glycoproteins and glycolipids (gangliosides and lipopolysaccharides). (definition, structure, functions, examples only) Carbohydrates as informational molecules, working with carbohydrates (applications of carbohydrate)

**Introduction to amino acids, peptides and proteins**

Amino acids:

Definition, classification & structures. Physico-chemical properties of amino acids (amphoteric molecules, ionisation, zwitterions, pk values, isoelectric point, Lambert-Beer’s law, optical density, absorption spectra), titration of amino acids (glycine, glutamic acid, lysine, histidine), Formol titration of glycine (only reaction and principle), reaction of amino acids: reaction due to amino groups (reaction with mineral acids, alkyl halides, acetyl chloride, acetic anhydride in presence of base, nitrous acid, ninhydrin and fluorescamine), reaction due to carboxylic acid group (reaction with base, alcohol, LiAlH₄, metal oxide), separation and analysis of amino acids by paper & thin layer chromatography and HPLC.

### Unit-II

**Peptides & Proteins:**

Peptide bond: Definition, structure and geometry of peptide bond, example of
biologically important peptide and its functions in brief (glutathione-peptide of non protein origin), Merrifield solid-phase peptide synthesis using protection/ deprotection protocol (brief outline). N-terminal amino acid determination (Edman degradation, dansyl chloride reagent, Sanger’s reagent) and C-terminal amino acid determination (carboxypeptidase and using hydrazine).

Proteins: Definition of structure, primary, secondary, tertiary and quaternary structure (definition and example), structure of globular protein (albumin, globulin, haemoglobin & myoglobin – Structure, function and occurrence in brief) and fibrous protein (keratin, collagen -role of Vitamin C in hydroxylation, elastin- Structure, function and occurrence in brief ), Forces that stabilise structure of proteins, behaviour of proteins in solutions, salting in and salting out, absorbance of proteins, example of metalloprotein, lipoprotein. Biuret and Folin-Lowry test for protein.

Biologically important peptides - hormones, antibiotics and growth factors. Multimeric proteins, conjugated proteins and metallo-proteins. Diversity of function (Specific examples of Proteins/Peptides may be included under each category)

**Three dimensional structures of proteins**

Nature of stabilizing bonds - covalent and non-covalent. Importance of primary structure in folding. The peptide bond - bond lengths and configuration.

**Protein folding and conformational diseases**

Denaturation and renaturation of Ribonuclease A (Preliminary concept only). Introduction to thermodynamics of folding and molten globule. Assisted folding by molecular chaperones, chaperonins and PDI. Defects in protein folding. Diseases – Alzheimer’s and Prion based.

**Myoglobin and haemoglobin and Membrane Proteins**

Structures of myoglobin and haemoglobin, Oxygen binding curves, influence of 2, 3-BPG, CO2 and Cl-. Hill plot. Cooperativity between subunits and models to explain the phenomena - concerted and sequential models.

**Haemoglobin disorders**


**Lipids**
Building blocks of lipids - fatty acids, glycerol, ceramide. Storage lipids - triacyl glycerol and waxes. Structural lipids in membranes – glycerophospholipids, galactolipids and sulpholipids, sphingolipids and sterols, structure, distribution and role of membrane lipids. Lipids as signals, cofactors and pigments (preliminary ideas only)

Nucleic acids

Nucleotides - structure and properties. Nucleic acid structure – Watson-Crick model of DNA. Structure of major species of RNA - mRNA, tRNA and rRNA. Nucleic acid chemistry
- UV absorption, effect of acid and alkali on DNA. Other functions of nucleotides - source of energy, component of coenzymes, second messengers (examples & functions only)

Reference Books

  Fundamental of Biochemistry, Voet and Voet- provide necessary details on latest edition
  Edited by Prof. Hiren K Das (JNU)

Core Course 1-P Molecules of Life Lab (Semester 1) BCM-A-CC-1-1-P

Molecules of Life 2 Credits; 60 hours

List of Practical

1. Separation of amino acids by thin layer chromatography.
2. Qualitative test for carbohydrate, lipid, amino acids & proteins.
3. Assay of proteins using Lowry method, standard curve preparation
4. SDS-PAGE analysis of proteins (BSA, Lysozyme, Ovalbumin)
Unit-I

1. Atomic Structure (briefly)
   Concept of atomic orbital, shapes of s, p and d orbitals, radial and angular probability of s, p and d orbitals (qualitative idea). Many electron atoms, Pauli Exclusion Principle, Hund’s rule of maximum multiplicity, exchange energy, Aufbau (building up) principle and its limitations, Electronic energy levels and electronic configurations of hydrogen like and polyelectronic atoms and ions (concept only), Ground state term symbols of atoms and ions (concept only).

2. Intermolecular forces
   a. Ionic bonding
      Size effects- radius ratio rules and their limitations. Packing of ions in crystals, Lattice energy (concept only), Born-Lande equation (derivation not required) and its applications; Born-Haber cycle (derivation not required) and its application. Preliminary ideas of solvent energy, polarizing power and polarisibility, ionic potential and Fajan’s rules.
   b. Covalent bonding
      Lewis structures, formal charge, Preliminary idea of Valence Shell Electron Pair Repulsion (VSEPR) Theory, shapes of molecules and ions containing lone pairs and bond pairs. Partial ionic character of covalent bonds, bond moment and dipole moment, Partial ionic character from dipole moment values and electro negativity differences, Preliminary idea of valence Bond Theory (Heitler-London approach). Directional character of covalent bonds, hybridization, equivalent and non equivalent hybrid orbital, Bent’s rule; Concept of resonance, resonance energy, resonance structures, bonding, non-bonding, antibonding molecular orbitals (concept only) elementary pictorial approach of H₂ and O₂ molecular orbitals, sigma and pi bonds, multiple bonding. Concept of Bond order, bond length, bond strength, bond energy
   c. Weak Chemical Forces
      Van der Waal’s forces, ion-dipole, dipole–dipole interactions, London
forces, Hydrogen bonding; Effect of chemical forces on physical properties

d. Co-ordination compounds

Double salts and complex salts, Werner’s theory, ambidentate and polydentate ligands, chelate complexes, Naming of co-ordination compounds (up to two metal centres). Isomerism of co-ordination compounds: Constitutional, geometrical and optical isomerism in respect co-ordination numbers 4 and 6. Determination of configuration of cis-, trans-, isomers by chemical methods.

3. Radioactivity

Laws of radioactivity, Radioactive decay, decay constant, average life of radio elements and its relation with half life, radioactive equilibrium, properties of α,β,γ radiations, radiation damage, radiation protection and safety aspects, units of radioactivity, radioactive carbon dating

Atomic Nucleus

Fundamental particles of atomic nucleus, atomic number and its significance, nucleus stability, neutron proton ratio and different modes of decay, nuclear binding energy, nuclear forces.

Applications of radioactive isotopes

Examples of radio isotopes (14C, 3H, 32P, 35S, 2H, 125I) and their uses in biological systems. Basic principles of liquid scintillation counter. Radiation absorption, Radiation therapy in cancer (examples only)

Unit-II

4. Stereochemistry of Carbon Compounds

Concept of hybridisation, resonance (including hyperconjugation), inductive effect Huckel’s rules for aromaticity & antiaromaticity. dipole moment, bond distance, bond angles Tautomerism: keto-enol tautomerism ionization of acids and bases: effect of structure, substituent and solvent on acidity and basicity (Simple Aliphatic and aromatic Acids, Phenols and amines).Stereochemistry Optical activity of chiral compounds: specific rotation, measurement of specific rotation by polarimeter, racemisation (general principle) resolution of simple acids and bases. Representation of molecules in saw horse, Fischer, flying-wedge and Newman formulae and their inter translations, Configuration: stereocentres: systems involving 1, 2, 3 centres, stereogenicity, chirotopicity. pseudoasymmetric (D/L and R/S descriptor threo/erythro and syn/anti nomenclatures ii) stereoaxis in C=C & C=N systems, cis/trans, syn/anti, E/Z descriptors. Coformation: Conformational nomenclature, eclipse, staggard, gauch and anti forms; dihedral angel, torsion angel, energy barrier of rotation; Conformational analysis of ethane, propane and n-butane; Conformational analysis of cyclohexane(chair and boat forms), symmetry properties, optical activity and relative stabilities of cyclohexane systems;
5. General treatment of reaction mechanisms (concept only)

Ionic and radical reactions; heterolytic and, homolytic bond cleavage
Reactive intermediates: carbocations (carbenium and carbonium ions),
carbanions, carbon radicals, carbenes – structure using orbital picture,
electrophilic/nucleophilic behaviour, stability, generation and fate.
Reaction kinetics: transition state theory, rate constant and free energy
of activation, free energy profiles for one step and two step reactions
(concept only).

Nucleophilic substitution reactions- SN1, SN2 mechanisms. Effect of
substrate structure, nucleophiles and medium on reactivity and
mechanism; neighboring group participations.

Elimination Reactions- E1, E2 mechanisms. Saytzeff and Hofmann rules.
Elimination vs substitution reaction.

Electrophilic and Activated Nucleophilic substitution reactions of
Benzene (Nitration, sulphonation, Halogenation and Friedel Craft
reactions)

Addition reactions to Carbon–carbon multiple bonds- Electrophilic
additions mechanisms (concept only), ozonolysis.
Nucleophilic addition to carbonyl groups: relative reactivity of carbonyl
compounds. Formation of acetal, Grignard reactions, Cannizzaro, aldol
condensation.

6. Specific Reactions and Heterocycles

Heterocycles- Structural aspects of five and six membered heterocycles
containing hetero atoms (furan, pyran, pyridine, pyrrole, furanose,
pyranose, purines, pyrimidines).

Reference Books

1. Organic Chemistry (vol.1&2) – I. L. Finar
3. Stereochemistry of Carbon Compounds- D. Nasipuri
4. Basic Stereochemistry of Organic Compounds- S. Sengupta
5. General &Inorganic Chemistry-R. P. Sarkar
6. Inorganic Chemistry-R. L. Dutta
7. New Concise Inorganic Chemistry-J. D. Lee
List of Practical

1. Physical characteristics (colour, odour, texture)

2. Detection of special elements (N, Cl, S) by Lassaigne’s tests.

3. Solubility and classification (Solvents: H₂O, 5% HCl, 5% NaHCO₃, 5% NaOH)

4. Detection of the following functional groups by systematic chemical tests: (aromatic amino (–NH₂), Amido (–CONH₂, including imide), aromatic nitro (–NO₂), Phenolic –OH, Carboxylic acid (–COOH), Carbonyl (>C=O); only one test for each functional group is to be reported)

*Each student, during laboratory session, is required to carry out qualitative chemical tests for all the special elements and the functional groups in known and unknown organic compounds. Each student, during laboratory session, is required to analyze at least SIX (6) unknown organic samples. In practical examination, one unknown solid organic compound containing not more than two of the above functional groups (IV) shall be assigned to a candidate through a single draw lottery.

B. LABORATORY RECORDS

7. Candidates at the practical examinations are required to submit the day to day record of all types of laboratory works prescribed in the syllabus performed by them and duly signed by their teachers. Marks of the laboratory records shall be awarded by the examiner at the practical examination. Candidates failing to submit their laboratory note books may be debarred from the examination.

Practical Reference Books

(i) Advanced Practical Chemistry – Subhas Ch. Das
(ii) Handbook of Practical Chemistry – University of Calcutta
Unit-I

Principles of thermodynamics
(a) Definition of systems, surroundings and types of systems (isolated, closed and open). Extensive properties and intensive properties, concept of Thermodynamic equilibrium, concept of temperature, concept of heat and work, reversible work, irreversible work and maximum work.

(b) First law of Thermodynamics, internal energy as a state function, properties of a state function, definition of isothermal and adiabatic processes, Joule’s experiment and its consequences. Joule-Thomson experiment and enthalpy as a state function, calculation of work done, heat changes for isothermal and adiabatic changes involving ideal gas.

(c) Statement of Second law of Thermodynamics and their equivalence, Carnot’s cycle and Carnot’s theorem, Absolute scale of temperature, concept of Entropy as a state function, Entropy changes in various Physical processes.

(d) Clausius inequality, condition of reversibility and irreversibility of a process, auxiliary state function-Helmholtz free energy and Gibbs free energy and their simple applications.

Unit-II


Electrochemistry:
Flow of electrical charge: Electrical conductance, cell constant, specific conductance and equivalent conductance. Variation of equivalent conductances of strong and weak electrolytes with dilution, Kohlrausch’s law of independent migration of ions, ion conductances and ionic mobility, Equivalent conductances at infinite dilution for weak electrolytes and determination of dissociation constants of weak electrolytes from conductance measurements. Basic concepts of electrochemical cell and cell reactions. EMF of cell (no derivation), types of electrode, glass electrode, determination of pH
of a solution and potentiometric titration, redox reaction.

Ideal and non-ideal Solutions and Thermodynamics of EMF of Cells

Ideal solutions: Raoult’s law of relative lowering of vapour pressure (brief introduction). Thermodynamic derivation of colligative properties of solution (using chemical potential) and their inter relationships.


Unit-III


(i) Homogeneous equilibrium: Use of different standard states to define $K_p$, $K_c$, $K_x$ and their interrelations, examples of homogenous equilibrium in gas phase and ionic equilibrium in solution.

(ii) Heterogeneous equilibrium: Chemical equilibrium in different phases, Distribution/ partition constant.


Surface tension: Definition, angle of contact, interfacial tension, capillary rise, determination of surface tension, temperature effect.

Reference Books

1. Physical Chemistry-P.C.Rakshit
2. Lehninger Principles of Biochemistry-Nelson & Cox
3. Text Book of Physical Chemistry-K.L.Kapoor (Vol-II,V)
4. Physical Chemistry-Hrishikesh Chatterjee (Vol-I
5. Text Book of Physical Chemistry-K. L. Kapoor (Vol-II,III,V)
6. Physical Chemistry-Hrishikesh Chatterjee(Vol-I,II)
7. Lehninger Principles of Biochemistry-Nelson &Cox
8. Molecular Spectroscopy-C. N. Banwell& McCash
9. Organic Spectroscopy-William Kemp
10. Techniques and Methods in Biology-K. L. Ghatak
<table>
<thead>
<tr>
<th>List of Practical</th>
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</thead>
<tbody>
<tr>
<td>1. Safety measure in laboratories, use and calibration of pipettes</td>
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<tr>
<td>2. Preparation of normal, molar and percent solutions</td>
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<tr>
<td>3. Concept of pH and preparation of buffers.</td>
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<tr>
<td>4. Determination of specific rotation of a given optically active compound and</td>
</tr>
<tr>
<td>%composition of its aqueous solution using Polarimeter.</td>
</tr>
<tr>
<td>5. Formol titration (acidic, basic, neutral amino acid)</td>
</tr>
</tbody>
</table>
Unit-I

1. Introduction to enzymes

a. Definition of enzymes, *Nature of enzymes, protein and non-protein (ribozyme)* differences between biocatalysts and chemical catalysts

b. Cofactors: metal ions (Zn$^{2+}$, Mg$^{2+}$, Fe$^{2+}$), coenzymes, (NAD$^+$, NADP$^+$, HSCoA, FH4, cobalamin), prosthetic groups (FAD, TPP, PALPO, biotin), apoenzyme and holoenzymes, co-substrate (NAD$^+$) - one reaction of each.

c. IUBMB Classification of enzymes, Name & two examples of each class with reaction

2. Features of enzyme catalysis, enzyme catalysis and basic thermodynamic principles of enzymatic reactions

a. Concept of active site, Catalytic power and specificity of enzymes (stereospecificity and geometric specificity)

b. Standard free energy change, Energy of Activation of both non enzymatic and enzymatic reactions; rate determining step, binding energy, Concept of Collision theory and Transition State theory, Transition state analogue

c. Fischer’s lock and key hypothesis, Koshland’s induced fit hypothesis, proximity and orientation effect, strain and distortion theory

d. Mechanism of enzyme catalysis (basic concepts)

i) acid- base catalysis (example- RNase A)

ii) Metal ion catalysis: Metal activated enzymes (eg hexokinase) and metalloenzymes (eg carbonic anhydrase)

iii) covalent catalysis (example- chymotrypsin and lysozyme)

e. Catalytic reactions: Homogeneous catalysis, primary salt effects, Autocatalysis, Adsorption of gases on solids, Langmuir adsorption isotherm, Heterogeneous catalysis (one example of each type of catalysis)

Unit-II

3. Enzyme kinetics

   Chemical Kinetics:
a. Concepts of rate, rate constant, order and molecularity of a reaction, integrated form of rate expressions of first order reaction (derivation); half-life period and its significance.

b. Pseudo-unimolecular reactions, multi step reactions, zero and fractional orders, rate expressions for complex reactions, opposing reaction, parallel reaction and consecutive reaction with example.

c. Factors on which enzyme catalyzed reactions depend: Substrate concentration, enzyme concentration, pH, temperature, Temperature dependence of rate constant, Arrhenius’ equation, time, metal ions on the activity of enzyme (Zn$^{+2}$, Cu$^{+2}$, As$^{+3}$, Hg$^{+2}$ - one example of each).

d. Concept of pre steady state and steady state kinetics, initial rate, maximum velocity (Vmax), Relationship between initial velocity and substrate concentration, steady state kinetics, equilibrium constant - monosubstrate reactions, association and dissociation constant, Michaelis-Menten equation (derivation and graphical representation), Lineweaver- Burk plot, Eadie-Hofstee and Hanes plot. Km and Vmax, Kcat and turnover number, Kcat/Km.

Numerical problems on each section

4. Enzyme inhibition

a. Reversible inhibition (competitive, uncompetitive, non-competitive, mixed – one eg of each)

b. Irreversible inhibition- Mechanism based inhibitors (suicide substrate or suicide inhibitor) - antibiotics as inhibitors

Unit-III

5. Regulation of enzyme activity

a. Control of activities of single enzymes (end product inhibition) and metabolic pathways, feedback inhibition, allosteric regulation (aspartate transcarbamoylase),
b. Reversible covalent modification phosphorylation (glycogen phosphorylase).
c. Proteolytic cleavage- zymogen (chymotrypsinogen).
d. Multienzyme complex as regulatory enzymes. Occurrence and properties (pyruvate dehydrogenase, fatty acid synthase)
e. Isoenzymes - properties and physiological significance (lactate dehydrogenase).
f. Involvement of coenzymes in enzyme catalysed reactions

6. Extraction, Separation and Characterization of Proteins/enzymes

a. Solubilization of proteins from their cellular and extracellular locations. Use of simple
grinding methods, homogenization, ultrasonication, French press and centrifugation, sedimentation coefficient, (brief outline).

b. Ammonium sulphate fractionation, solvent fractionation, dialysis and lyophilisation.

c. Principles of chromatography: partition coefficient, phase systems, liquid and gas chromatography; HPLC, FPLC(brief concept), performance parameters: retention, resolution, basis of peak broadening, peak symmetry; chromatography equipment; modes of chromatography: Ion- exchange chromatography, molecular sieve chromatography, hydrophobic interaction/reverse phase chromatography, affinity chromatography

d. Determination of purity, specific activity, extinction coefficient and IEF, SDS-PAGE and molecular weight determination, 2-D electrophoresis.


► Enzymes, Malcolm Dixon, Edwin Clifford Webb- provide necessary details

► Biochemical Calculations, Segel- provide necessary details

Core Course 4-P Enzymes (Semester 2) BCM-A-CC-2-4-P

<table>
<thead>
<tr>
<th>Enzymes</th>
<th>2 Credits; 60 hours</th>
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<tbody>
<tr>
<td>List of Practical</td>
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</table>


2. Effect of pH on the enzyme activity

3. Determination of Km and Vmax using Lineweaver-Burk graph.


5. Ammonium sulphate fractionation of serum proteins. (Demonstration)
# Core Course 5  Bio-Physical Chemistry (Semester 3)  BCM-A-CC-3-5-TH

## Bio-Physical chemistry  
**4 Credits; 50 hours**

### Unit-I  
**Introduction**

Special chemical requirement of biomolecules; factors affecting analyte structure and stability: pH, temperature and solvent polarity; buffering systems used in biochemistry, osmolarity and colligative properties

### Spectroscopy-I  
Theories of light (wave-particle duality); the electromagnetic spectrum; UV/visible absorption spectroscopy: physical basis, Beer Lambert’s law, Deviations of Beer Lambert’s law; transitions, Applications of UV-visible spectroscopy; UV-visible spectroscopy of proteins and nucleic acids;

### Unit-II  
**Spectroscopy-II**


### Unit-III  
**Application of spectroscopy**

Fluorescence and Chemiluminescence: physical basis, measurement, quenching, protein folding studies; resonance energy transfer, applications in cell biology.

Techniques used in studying 3-D structures - X-ray diffraction and NMR (introductory) Motifs and domains. (bonding concept of protein, DNA)

Hydrodynamics and Bio-calorimetry

Sedimentation: physical basis, subcellular fractionation, sedimentation velocity and sedimentation equilibrium; thermodynamic parameters: activation energy, enthalpy, entropy and free energy

Reference Books

► Physical Biochemistry, Principles and Applications, David Sheehan
► Physical Biochemistry, David Friefelder- provide necessary details
► Biophysical Chemistry (Principles and Techniques); Upadhyay and Upadhyay- provide necessary details
► Physical Biochemistry, Van Holde- provide necessary details

Core Course 5-P  Bio-Physical Chemistry (Semester 3)  BCM-A-CC-3-5-P

Bio-Physical Chemistry 2 Credits; 60 hours

List of Practical

1. Determination of viscosity coefficient of a given liquid/solution with Ostwald viscometer.
2. Determination of extinction coefficient of different BSA solutions by spectrophotometer.
3. Column chromatography (size exclusion) by teaching kit. (Determination of Void volume)
<table>
<thead>
<tr>
<th>Metabolism of Carbohydrates and Lipids</th>
<th>4 Credits; 50 hours</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Unit-I</strong></td>
<td></td>
</tr>
<tr>
<td>Basic design of metabolism</td>
<td></td>
</tr>
<tr>
<td>Autotrophs, heterotrophs, metabolic pathways, catabolism, anabolism, ATP as energy currency, reducing power of the cell.</td>
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<tr>
<td>Glycolysis, Gluconeogenesis, pentose phosphate pathway and Glycogen metabolism</td>
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<tr>
<td>Glycolysis - a universal pathway, reactions of glycolysis, fermentation, fates of pyruvate, feeder pathways for glycolysis, galactosemia.</td>
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<tr>
<td>Synthesis of glucose from non-carbohydrate sources, reciprocal regulation of glycolysis and gluconeogenesis, pentose phosphate pathway and its importance.</td>
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<tr>
<td>Glycogenesis and glycogenolysis, regulation of glycogen metabolism, glycogen storage diseases.</td>
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<tr>
<td><strong>Citric acid cycle</strong></td>
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<tr>
<td>Production of acetyl CoA, reactions of citric acid cycle, anaplerotic reactions, amphibolic role, regulation of citric acid cycle, glyoxalate pathway, coordinated regulation of glyoxalate and citric acid pathways.</td>
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<tr>
<td><strong>Unit-II</strong></td>
<td></td>
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<tr>
<td>Fatty acid oxidation</td>
<td></td>
</tr>
<tr>
<td>Digestion, mobilisation and transport of cholesterol and triacyl glycerols, fatty acid transport to mitochondria, β oxidation of saturated, unsaturated, odd and even numbered and branched chain fatty acids, regulation of fatty acid oxidation, peroxisomal oxidation, ω oxidation, ketone body’s metabolism, ketoacidosis</td>
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<tr>
<td>Fatty acid synthesis</td>
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<tr>
<td>Fatty acid synthase complex. Synthesis of saturated, unsaturated, odd and even chain fatty acids and regulation.</td>
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<tr>
<td>Eicosanoids, cholesterol, steroids and isoprenoids</td>
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</tbody>
</table>
Precursor, regulation, functions and physiological importance of prostaglandins, leukotrienes and thromboxanes. Precursor, regulation, functions and physiological importance of Cholesterol, steroids and isoprenoids.

Membrane lipids

Precursor, regulation, functions and physiological importance of membrane phospholipids in prokaryotes and eukaryotes, respiratory distress syndrome, Precursor, regulation, functions and physiological importance of triacylglycerol, plasmalogens, sphingolipids and glycolipids, lipid storage diseases.

Reference Books:

- Biochemistry Book edited by Hiren Das
### List of Practical

1. Assay of amylase by Kit method.
2. Estimation of cholesterol from known source (Mustard oil)
3. Isolation of serum LDH by kit method.
### Core Course 7  
**Cell Biology (Semester 3)**  
**BCM-A-CC-3-7-TH**

<table>
<thead>
<tr>
<th>Unit-I</th>
<th>Introduction to cell biology</th>
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<tbody>
<tr>
<td></td>
<td>Prokaryotic (Archaea and Eubacteria) and eukaryotic cell (Animal and Plant cells),</td>
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<td></td>
<td>Tools of cell biology</td>
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<tr>
<td></td>
<td>Cells as experimental models, Light microscopy, phase contrast microscopy, fluorescencemicroscopy, confocal microscopy, electron microscopy, Centrifugation for subcellular fractionation.</td>
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<td>Structure and functions of different cell organelles</td>
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<table>
<thead>
<tr>
<th>Unit-II</th>
<th>Cytoskeletal proteins</th>
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<tr>
<td></td>
<td>Cell wall and extracellular matrix</td>
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<tr>
<td></td>
<td>Prokaryotic and eukaryotic cell wall, cell matrix proteins (concept &amp; examples). Adherence junctions, tight junctions, gap junctions, desmosomes, hemidesmosomes, focal adhesions and plasmodesmata. (Schematically and briefly)</td>
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<tr>
<th>Unit-III</th>
<th>Protein transport</th>
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<tbody>
<tr>
<td></td>
<td>Selective transport of proteins from cytosynthesis to the nucleus. Regulation of nuclear protein import and export. Targeting proteins to ER, smooth ER and lipid synthesis. Export of proteins and lipids from ER and into ER (only mechanism). Protein sorting and export from Golgi. Mechanism of vesicular transport, cargo selection, coat proteins and vesicle budding, vesicle fusion.</td>
</tr>
</tbody>
</table>
Cell cycle, cell death and cell renewal


Reference Books


Core Course 7-P Cell Biology (Semester 3)  

Cell Biology  

2 Credits; 60 hours

List of Practical

1. Visualization of animal (Squamous epithelium) and plant (Onion) cells by methylene blue.
2. Micrographs of different cell components and study of mitosis and meiosis from permanent slides (dry lab).
3. Molecular weight determination of protein by SDS-PAGE/Native gel electrophoresis.
4. Western blot using College kit from HIMEDA or any other suitable company.
### Core Course 8 Membrane Biology and Bioenergetics (Semester 4)  BCM-A-CC-4-8-TH

| Membrane Biology and Bioenergetics | 4 Credits; 50 hours |

#### Unit-I

**Introduction to biomembranes**


**Membrane structures and dynamics (Preliminary concept only)**

Polymorphic structures of amphiphilic molecules in aqueous solutions - micelles and bilayers. CMC, critical packing parameter. Membrane asymmetry. Macro and micro domains in membranes. Membrane skeleton, lipid rafts, caveolae. RBC membrane architecture. *(diagram only)*

Lateral, transverse and rotational motion of lipids and proteins. Techniques used to study membrane dynamics – FRAP *(Example with experiments)*. Transition studies of lipid bilayer, transition temperature. Membrane fluidity, factors affecting membrane fluidity.

**Membrane transport (Definition & concept only)**

Simple diffusion and facilitated diffusion. Passive transport - glucose transporter, anion transporter and porins. Primary active transporters - P type ATPases, V type ATPases, F type ATPases. Secondary active transporters (Preliminary concept only)- lactose permease, Na+-glucose symporter. ABC family of transporters - MDR, CFTR. Ion channels - voltage-gated ion channels (Na+/K+ voltage-gated channel), ligand-gated ion channels (acetyl choline receptor), aquaporins, and bacteriorhodopsin. Ionophores - valinomycin, gramicidin.

#### Unit-II

**Introduction to bioenergetics**

State functions, equilibrium constant, coupled reactions, energy charge, ATP cycle, phosphorylation potential, phosphoryl group transfers. Chemical basis of high standard energy of hydrolysis of ATP, other phosphorylated compounds and thioesters. Redox reactions, standard redox potentials and Nernst equation. Universal electron carriers.

**Oxidative phosphorylation**
Fo F1ATP synthase, structure and mechanism of ATP synthesis. 
Metabolite transporters in mitochondria. Regulation of oxidative phosphorylation. 
ROS production and antioxidant mechanisms. Thermogenesis.

Reference Books


Core Course 8-P Membrane Biology and Bioenergetics (Semester 4) BCM-A-CC-4-8-P
2 Credits; 60 hours

List of Practical

1. Determination of CMC of detergents.
2. RBC ghost cell preparation.
3. Separation of photosynthetic pigment by TLC/ silica gel column.
4. Determination of phosphate from crude phospholipid (Lecithin/Cephalin)
### Metabolism of Amino Acids and Nucleotides

#### Unit-I

**Overview of amino acid metabolism**

Role of pyridoxal phosphate, glucose-alanine cycle, Kreb’s bicycle, urea cycle and inherited defects of urea cycle.

**Catabolism of amino acids**


**Biosynthesis of amino acids**

Overview of amino acid synthesis. Biosynthesis of non-essential amino acids and its regulation.

**Precursor functions of amino acids**

Creatine and creatinine, polyamines (putresine, spermine, spermidine), catecholamines (dopamine, epinephrine, norepinephrine) and neurotransmitters (serotonin, GABA). Porphyrin biosynthesis, catabolism and disorders of porphyrin metabolism.

#### Unit-II

**Biosynthesis of purine and pyrimidine nucleotides**

De novo synthesis of purine and pyrimidine nucleotides, regulation and salvage pathways.

**Deoxyribonucleotides and synthesis of nucleotide triphosphate**

Precursor of deoxyribonucleotides and its regulation, conversion to triphosphates, biosynthesis of coenzyme nucleotides

**Degradation of purine and pyrimidine nucleotides**

Digestion of nucleic acids, degradation of purine and pyrimidine nucleotides. Inhibitors of nucleotide metabolism. Disorders of purine and pyrimidine metabolism – Lesch-Nyhan syndrome, Gout, SCID, adenosine deaminase deficiency. DHFR,
Metabolism of one carbon units.

Integration of metabolism

Integration of metabolic pathways (carbohydrate, lipid and amino acid metabolic pathways).

Reference Books

► Text Book of Molecular Biology by Sivarama Sastri, G Padmanavan and C. Subramanyam
► Harper’s Biochemistry-details
► Lubert Stryer’s Biochemistry-details

Core Course 9-P Metabolism of Amino Acids and Nucleotides (Semester 4)

List of Practical

1. Assay of serum transaminases – SGOT and SGPT.
2. Estimation of serum urea.
3. Estimation of serum uric acid.
Core Course 10 Basic Microbiology and Microbial Genetics (Semester 4)

BCM-A-CC-4-10-TH 4 Credits; 50 hours

Unit-I
Introduction:
Spontaneous generation (abiogenesis), Biogenesis, Germ Theory of Disease, Koch's Postulates, Scope of Microbiology.

Microorganisms in biological world:
Whittaker's Five-kingdom and three-kingdom concept of living organisms (General characteristics of those groups); General features of Eubacteria and Archaebacteria (major difference within Eubacteria).

Staining techniques and bacterial Morphology and subcellular structures:
Definition of auxochrome; Chromophores; Acidic and Basic dyes; Classification of stains; Simple and differential staining: theories of staining, Gram staining; acid fast staining; endospore staining; mechanism of gram staining.
Morphology of bacteria, Slime layer, Mycelial morphology: Actinomycetes, Capsule, Cell wall, Ribosome, Cytoplasmic membrane (Fluid mosaic model of Singer - Nicholson); Cytoplasmic inclusion bodies - (inorganic, organic); Exospores & Cysts: types & structure; Endospore, Flagella, Pilus, Fimbriae (structure, composition and functions). Bacterial cell wall biosynthesis and structure

Unit-II
Microbial Nutrition:
Nutritional types (definition and example) - Photoautotrophs, Photoorganotrophs, Chemolithotrophs (ammonia, nitrite, sulfur, hydrogen, iron oxidizing bacteria); Chemoorganotrophs, Effect of oxygen on growth - classification on the basis of oxygen requirement and tolerance.

Bacterial Growth and its regulation:
Synchronous culture (definition and brief description). Physical factors influencing growth temperature. pH, osmotic pressure, salt concentration.
Sterilization, disinfection, antiseptic, sanitizer, germicide, antimicrobial agent (definition, application & examples); physical method of disinfection and sterilization - dry heat, moist heat, filtration, radiation (mode of action, applications); Chemical control – dye solutions, alcohol, acid, alkali, halogen, heavy metal, phenol, phenol derivatives, formaldehyde, ethylene oxide, detergents (mode of action, applications). Chemotherapeutic agents - sulphonamides, antibiotics, (definition types); mechanism of action and antimicrobial spectrum of penicillin, streptomycin, tetracycline, chloramphenicol, Nalidixic acid and metronidazole; drug resistance - phenomena and mechanism.

Unit-III
Microbial Genetics:
Core Course 10-P Basic microbiology and microbial genetics (Semester 4) BCM-A-CC-4-10-P
2 Credits; 60 hours

List of Practical

1. Microbiology Laboratory Practices and Biosafety.
2. To study the principle and applications of important instruments (biological safety cabinets, autoclave, incubator, BOD incubator, hot air oven, light microscope, pH meter)
3. Preparation and sterilization of culture media for bacterial cultivation
4. Study of different shapes of bacteria, fungi, algae, protozoa using permanent slides/pictographs
5. Staining of bacteria using Gram stain
6. Isolation of pure cultures of bacteria by streaking method.

References:

# Core Course 11  Gene, Gene Expression and Regulation (Semester 5)  BCM-A-CC-5-11-TH

<table>
<thead>
<tr>
<th>Gene, Gene Expression and Regulation</th>
<th>4 Credits; 50 hours</th>
</tr>
</thead>
</table>

## Unit-I

### Structure of DNA

- DNA structure, features of the double helix, various forms of DNA, denaturation and reassociation of DNA.

### Genes and genomic organization

- Definition of a gene, organization of genes in viruses, bacteria, eukaryotes.
- Nucleosome structure and packaging of DNA into higher order structures.

### Replication of DNA

- The chemistry of DNA synthesis, DNA polymerase, the replication fork, origin of replication, enzymes and proteins in DNA replication, various modes of replication, stages of replication of E. coli chromosome. Inhibitors of DNA replication and applications in medicine.

### Transposition of DNA

- Transposition, three classes of transposable elements, importance of transposable elements in horizontal transfer of genes and evolution

### Molecular basis of mutations

- Importance of mutations in evolution of species. Types of mutations - transition, transversions, frame shift mutations, Gene mutations: Induced versus Spontaneous mutations, Back versus Suppressor mutations, Molecular basis of Mutations in relation to UV light and chemical mutagens, Ames test.

### Various modes of DNA repair

- Replication errors and mismatch repair system, repair of DNA damage, direct repair, base excision repair, nucleotide excision repair, recombination repair, SOS Repair.

## Unit-II

### Biosynthesis of RNA in prokaryotes

- RNA polymerases, transcription cycle in bacteria, sigma factor, bacterial promoters, identification of DNA binding sites by DNA foot printing, the three stages
of RNA synthesis, initiation, elongation and termination, rho-dependent and rho-independent termination. Inhibitors of transcription and applications as antimicrobial drugs.

The genetic code

Degeneracy of the genetic code, wobble in the anticodon, features of the genetic code, nearly universal code.

Biosynthesis of proteins

Messenger RNA, transfer RNA, attachment of amino acids to tRNA, the ribosome - initiation, elongation and termination of translation, regulation of translation. Comparison of prokaryotic and eukaryotic protein synthesis. Use of antibiotics in understanding protein synthesis and applications in medicine.

Unit-III

Regulation of gene expression in prokaryotes

Principles of gene regulation, negative and positive regulation, concept of operons, regulatory proteins, activators, repressors, DNA binding domains, regulation of lac operon, induction of SOS response.

Mendel’s principles & chromosomal basis of heredity and Extensions of Mendelism

Genetics:

Basic principles of Mendelian genetics (monohybrid and dihybrid, test and back crosses); Bacterial genetics-transformation, transduction, conjugation (mention of F\(^+\)/F\(^-\), Hfr strain, function of pilus)

Reference Books

- Lewin's GENES
Core Course 11-P Gene, Gene Expression and Regulation (Semester 5) BCM-A-CC-5-11-P

List of Practical | 2 Credits; 60 hours
--- | ---
1. **Determination of the melting temperature and GC content of DNA.**
2. **Study of viscosity of DNA solutions** (bacterial genomic DNA, plasmid DNA and DNA from different sp.[Calf thymus]).
3. **Extraction of total nucleic acids** (genomic DNA) from bacterial cells and quantitative estimation of DNA using colorimeter (Diphenylamine reagent) or spectrophotometer (A260 measurement). Agarose gel electrophoresis and estimation of DNA size by using markers.
4. **Concept of standard curve and estimation of unknown DNA concentration using calf thymus DNA.**
5. **Preparation of culture medium** (LB) for *E.coli* (both solid and liquid) and raise culture of *E.coli* and demonstration of antibiotic resistance. (Culture of E.coli containing plasmid (pUC 18/19) in LB medium with/without antibiotic pressure and interpretation of results).
6. **Induction of lac operon and enzyme assay** (beta-galactociadase assay).
Unit-I

**Homeostasis and the organization of body fluid compartments**


**Cardiovascular physiology and Respiration**

Relationship between cardiac cycle, control of cardiac function and output. Mechanism of respiration, pulmonary ventilation and related volumes, pulmonary circulation. Principles of gas exchange and transport. Regulation of respiration.

**Digestive mechanism**

Structure and functional organization, Biochemical mechanisms of carbohydrate, lipid, Protein or nucleic acid digestion, absorption

**Excretory mechanism**

Kidney: functional organization, GFR, selective re-absorption & secretion, buffering system, Acid base balance, acidosis and alkalosis, biochemical principles of water and electrolyte imbalance, polyuric states, nephrogenic Diabetes insipidus (antidiuretic hormone-vasopressin).

Unit-II

**Introduction to endocrinology**


**HORMONE:** Endocrine systems: Pituitary hormones functions and targets (tabular form)

**Hypothalamic and pituitary hormones**

Hypothalamic - Study the physiological and biochemical actions of hypothalamic hormones, pituitary hormones - GH, prolactin, TSH, LH, FSH, POMC
peptide family, oxytocin and vasopressin, feedback regulation cycle.

Endocrine disorders - gigantism, acromegaly, dwarfs, pigmies and diabetes insipidus.

Hormones of adrenals

Aldosterone, renin angiotensin system, cortisol, epinephrine and norepinephrine. (physiological and biochemical actions and their deficiencies) Fight or flight response, stress response.

Unit-III

Thyroid hormone

Name and biochemical actions of thyroid hormones and its regulations. Iodine requirement and deficiency of thyroid hormones.

Pancreatic and GI tract hormones

Regulation of release of insulin, glucagon, gastrin, secretin, CCK, GIP, adiposectin, leptin and ghrelin. Summary of hormone metabolite control of GI function. Physiological and biochemical action.

Hormone mediated signaling

Hormone receptors - extracellular and intracellular. Receptor - hormone binding, Scatchard analysis. G protein coupled receptors, G proteins, second messengers - cAMP, cGMP, IP3, DAG, Ca2+, NO. Effector systems - adenyl cyclase, guanyl cyclase, PDE, PLC.

Reference Books


Core Course 12-P   Physiology and Hormones   (Semester 5)   BCM-A-CC-5-12-P

<table>
<thead>
<tr>
<th>Physiology and Hormones</th>
<th>2 Credits; 60 hours</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>List of Practical</strong></td>
<td></td>
</tr>
<tr>
<td>1. Estimation of haemoglobin.</td>
<td></td>
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<tr>
<td>2. Separation of plasma proteins by SDS-PAGE.</td>
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<tr>
<td>5. Estimation of serum cholesterol by PAP method.</td>
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</tbody>
</table>
# Recombinant DNA Technology and Genetic Engineering

**Unit-I**

Introduction to recombinant DNA technology

Overview of recombinant DNA technology. Restriction and modification systems, restriction endonucleases and other enzymes used in manipulating DNA molecules (DNA polymerases, RNA Polymerases, Reverse Transcriptase, Ligases, Taq polymerase, Kinases), separation of DNA by gel electrophoresis. Extraction and purification of plasmid and bacteriophage DNA.

Cloning vectors for prokaryotes and eukaryotes

- Plasmids, classification, copy number and its regulation, incompatibility and curing.
- Plasmids and bacteriophages as vectors for gene cloning. Cloning vectors based on E. coli plasmids, pBR322, pUC8, pGEM3Z. Cloning vectors based on M13 and λ bacteriophage.


Ligation of DNA molecules. DNA ligase, sticky ends, blunt ends, linkers and adapters. Synthetic oligonucleotides, synthesis and use.

**Unit-II**

Introduction of DNA into cells and selection for recombinant clones


Expression of cloned genes

- Vectors for expression of foreign genes in E. coli, cassettes and gene fusions.
- Challenges in producing recombinant protein in E. coli.

Polymerase chain reaction

Fundamentals of polymerase chain reaction, designing primers for PCR. Studying PCR
products. Cloning PCR products. Quantitative PCR.

**Unit-III**

DNA sequencing

DNA sequencing by Sanger’s method, modifications based on Sanger’s method. Automated DNA sequencing.

Applications of genetic engineering in Biotechnology

Diagnostic use of PCR

Applications in medicine, production of recombinant pharmaceuticals such as insulin. Recombinant vaccines. Gene therapy. Applications in agriculture - plant genetic engineering, herbicide resistant crops, problems with genetically modified plants, safety concerns.

Reference Books


Recombinant DNA Technology by Watson

Core Course 13-P Recombinant DNA Technology and Genetic Engineering Lab (Semester 6) BCM-A-CC-6-13-P

Recombinant DNA Technology and Genetic Engineering 2 Credits; 60 hours

List of Practical

- Isolation of plasmid DNA from E. coli cells.
- Digestion of plasmid DNA with restriction enzymes and size estimation of fragments by gel electrophoresis.
- Preparation of competent cells, transformation and estimation of transformation efficiency.
<table>
<thead>
<tr>
<th>Core Course 14</th>
<th>Immunology</th>
<th>(Semester 6)</th>
<th>BCM-A-CC-6-14-TH</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Immunology</strong></td>
<td>4 Credits; 50 hours</td>
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</table>

**Unit-I**

**Cells and organs of the immune system**

Hematopoiesis, cells of the immune system, primary and secondary lymphoid organs and tissues (MALT).

**Innate immunity**

Anatomical barriers, cell types of innate immunity, soluble molecules and membrane associated receptors (PRR), connections between innate and adaptive immunity, cell adhesion molecules, chemokines.

**Immunogens and antigens**

Antigens and haptens, factors that dictate immunogenicity, B and T cell epitopes.

Structure and distribution of classes and subclasses of immunoglobulins (Ig), Ig fold, effector functions of antibody, antigenic determinants on Ig and Ig super family, antigen-antibody interaction

**Biology of the B and T lymphocyte**

Antigen independent phase of B cell maturation and selection, humoral response – T-dependent and T-independent response, anatomical distribution of B cell populations.

Structure and role of T cell receptor, and co-receptor, T cell development, generation of receptor diversity, selection and differentiation. General properties of effector T cells, cytotoxic T cells (Tc), natural killer cells; NKT cells and antibody dependent cellular cytotoxicity (ADCC).

**Unit-II**

**MHC complex and antigen presentation**

General organization and inheritance of MHC, structure, distribution and role of MHC class I and class II proteins, linkage disequilibrium, pathways of antigen processing and presentation, complement activation and its biological consequences

**Tolerance, autoimmunity and hypersensitivity**

Organ specific and systemic autoimmune diseases, possible mechanisms of
induction of autoimmunity, Gell and Coombs classification, IgE mediated (Type I) hypersensitivity, antibody mediated cytotoxic (Type II) hypersensitivity, immune complex mediated (type III) hypersensitivity and delayed type (Type IV) hypersensitivity.

Reference Books


Core Course 14 P   Immunology (Semester 6)   BCM-A-CC-6-14-P

Immunology 2 Credits; 60 hours

List of Practical

1. Assays based on agglutination reactions - Blood typing (active) & passive agglutination.
2. Assays based on precipitation reactions - Ouchterlony double diffusion (ODD) and Mancini radial immunodiffusion.
3. Enzyme linked immune-sorbent assay (ELISA).
4. Immunoelectrophoresis.
Discipline Specific Electives (DSE)
BCM-A-DSE A1-TH
Nutritional Biochemistry 5th Semester

Nutritional Biochemistry 4 Credits; 50 hours

Compulsory Elective

Introduction to Nutrition and Energy Metabolism

Defining Nutrition, role of nutrients. Unit of energy, Biological oxidation of foodstuff. measurement of energy content of food, Physiological energy value of foods, SDA. Measurement of energy expenditure. Direct and Indirect Calorimetry, factors affecting thermogenesis, energy utilization by cells, energy output – Basal and Resting metabolism, physical activity, factors affecting energy input - hunger, appetite, energy balance Energy expenditure in man. Estimating energy requirements, BMR factors Recommended Nutrient Intakes (RNI) and Recommended Dietary Allowances for different age groups.

Dietary carbohydrates and health

Review functions of carbohydrates. Digestion, absorption, utilization and storage, hormonal regulation of blood glucose. Dietary requirements and source of carbohydrates, Dietary fibre, role of fibre in lipid metabolism, colon function, blood glucose level and GI tract functions.

Dietary lipid and health

Review of classification, sources, functions, digestion, absorption, utilization and storage. Essential Fatty Acids; Functions of EFA, RDA, – excess and deficiency of EFA. Lipotropic factors, role of saturated fat, cholesterol, lipoprotein and triglycerides. Importance of the following: a) Omega – fatty acids. Omega 3/ omega 6 ratio b) Phospholipids c) Cholesterol in the body d) Mono, Polyunsaturated and Saturated Fatty Acids. Dietary implications of fats and oils, Combination ratios of n6 and n3, MUFA, PUFA and SFA.

Dietary Proteins and health

Nitrogen balance, transamination.

Fat and water soluble Vitamins

Vitamin A, C, E, K and D Dietary sources, RDA, Adsorption, Distribution, Metabolism and excretion (ADME), Deficiency. Role of Vitamin A as an antioxidant, in Visual cycle, dermatology and immunity. Role of Vitamin K in Gamma carboxylation. Role of Vitamin E as an antioxidant. Extra-skeletal role of Vitamin D and its effect on bone physiology. Hypervitaminosis. Vitamin C role as cofactor in amino acid modifications. Niacin- Metabolic interrelation between tryptophan, Niacin and NAD/NADP. Vitamin B6-Dietary source, RDA, conversion to Pyridoxal Phosphate. Role in metabolism, Biochemical basis for deficiency symptoms. Vitamin B12 and folate; Dietary source, RDA, absorption, metabolic role Biochemical basis for deficiency symptoms.

Minerals

Calcium, Phosphorus and Iron - Distribution in the body digestion, Absorption, Utilization, Transport, Excretion, Balance, Deficiency, Toxicity, Sources, RDA. Calcium: Phosphorus ratio, Role of iron in prevention of anemia. Iodine and iodine cycle. Iodine, Fluoride, Mg, Cu, Zn, Se, Manganese, Chromium, Molybdenum Distribution in the human body, Physiology, Function, deficiency, Toxicity and sources with special reference to Arsenic

Assessment of Nutritional status

BMI, Biochemical assessment; Basal metabolic panel, Comprehensive metabolic panel, CBC, Urine Analysis, Assessment of Anemia, ROS assessment, GTT and glycosylated Hb, Differential diagnosis of B12 and folate.

Food and drug interactions and Nutriceuticals

Alcohol, chewing tobacco and nutrient deficiency, Anti- depressants, psychoactive drugs and nutrient interactions, Appetite changes with drug intakes and malnutrition. Food as medicine.

Reference Books


Debojyoti Das’s Biochemistry Book- provide details

DSE A1-P
Nutritional Biochemistry Lab
Nutritional Biochemistry 2 Credits; 60 hours

List of Practical

1. Estimation of Vit-C from fruit juice.
2. Estimation of calcium from milk.
3. Estimation of total phenolic content from black-Tea.
4. Determination of iodine number from vegetable oil.
5. Estimation of phosphorous from milk.
Molecular basis of Infectious Human Diseases

Molecular basis of Infectious Diseases

4 Credits; 50 hours

Classification of infectious agents (brief introduction)


Overview of diseases caused by infectious agents (brief introduction)

Bacterial: Detailed study of tuberculosis: History, causative agent, molecular basis of host specificity, infection and pathogenicity, Diagnostics, Therapeutics, inhibitors and vaccines. Drug resistance and implications on public health. Other bacterial diseases including Typhoid, Diphtheria, Pertussis, Tetanus, Typhoid and Pneumonia.

Viral: Viral diseases including AIDS, hepatitis, influenza and polio: causative agents, Pathogenesis; Dengue & chikungunya

Parasitic: Detailed study of Malaria, history, causative agents, Vectors, life cycle, Host parasite interactions, Diagnostics, Drugs and Inhibitors, Resistance, Vaccine development. Other diseases including Leishmaniasis, Amoebiasis

Fungal: Aspergillosis

Reference Books

- Sherris Medical Microbiology: An Introduction to Infectious Diseases by Kenneth J. Ryan, C. George Ray, Publisher: McGraw-Hill
- Medical Microbiology by Patrick R. Murray, Ken S. Rosenthal, Michael A. Pfaller, Elsevier Health Sciences
DSE A2-P

Molecular basis of Infectious Human Diseases Lab 2 Credits; 60 hours

1. Identification of bacterial contamination (CFU) from water, soil and food products
2. PCR based diagnosis (Demo & tutorial only)
3. Dot Blot & ELISA based diagnosis (Demo & tutorial only)
4. Permanent slides of pathogens. Mycobacterium tuberculosis, Leishmania, Plasmodium falciparum
5. WIDAL test (Demo & tutorial only)
BCM-A-DSE A3-TH: Advanced Cell Biology (Theory) 4 Credits; 50 hours

Semester 6

1. Plasma Membrane and Nuclear Transport  
   Properties and Composition of Cell Membrane; Structure of Nuclear Envelope; Nuclear Pore Complex; Transport Across Nuclear Envelope; Regulation of Nuclear Protein Import and Export.

2. Cell-Cell Interaction  
   Cell-Cell Interactions and Cell-Matrix Interactions; Components of Extracellular Matrix: Collagen and Non-Collagen Components; Tight Junctions; Gap Junctions; Desmosomes; Hemidesmosomes; Focal Adhesions And Plasmodesmata; Cell Wall; Role Of Cell Interaction In Development.

3. Cell Cycle and Programmed Cell Death  
   Overview of The Cell Cycle; Eukaryotic Cell Cycle; Events Of Mitotic Phase; Cytokinesis; Events Of Meiosis And Fertilization; Regulation Of Cell Division And Cell Growth; Apoptosis And Necrosis, Stem Cells And Maintenance of Adult Tissues, Hematopoiesis, Embryonic Stem Cells and Therapeutic Cloning.

4. Cancer Biology  
   Development and causes Of Cancer; Genetic Basis of Cancer; Oncogenes, Tumor Viruses; Molecular Approach to Cancer Treatment.

5. Advanced Methods in Cell Biology  

DSE A3-P: ADVANCED CELL BIOLOGY (PRACTICALS) 2 Credits; 60 hours

1. Isolation of organelles by sub-cellular fractionation
2. Study of cell viability /death assay by use of trypan blue and tutorial for MTT assay.
3. Study of apoptosis through analysis of DNA fragmentation patterns (Ladder assay; tutorial for tunnel assay)
4. Identification and study of cancerous cells using permanent slides and photomicrographs.

SUGGESTED READINGS

Lifestyle disorders (examples only)
The factors and biochemistry underlying Diabetes and related complications e.g. hypertension, obesity: the influence of genetics and environment on the condition and management; Basic concepts of Hypothyroidism and stress, Cardio vascular disorders and Atherosclerosis- understanding the factors that contribute to the syndrome, the management of the conditions. Concept of Irritable bowel syndrome-biochemistry behind the disorder and the influence of diet, stress and environment on the condition.

Cancer (brief introduction)
Cancer: characteristics of a transformed cell, causes and stages of Cancer, molecular basis for neoplastic growth and metastasis, Proto-oncogenes and tumor suppressor genes; Cancer causing mutations; Tumor viruses; Adeno carcinoma, Biochemical analysis of cancer (PSA, AFB protein marker).

Other diseases (brief introduction)
Introduction to protein folding and proteosome removal of misfolded proteins; etiology and molecular basis for Alzheimer's, Prion diseases (mad cow), Huntington's Chorea, sickle cell anemia, Thalassemia, Parkinson’s.

DSE A4-P Molecular Basis of Non-Infectious Human Diseases Lab 2 Credits; 60 hours
1. Estimation of homocysteine levels in serum
2. Estimation of glycosylated hemoglobin
3. Permanent slides for different types of cancer
4. Bone densitometry test demonstration (visit to a nearby clinic)
Advanced Biochemistry

Photosynthesis


Carbohydrate Biosynthesis in Plants and Bacteria

Photosynthetic Carbohydrate Synthesis, Photorespiration and the C4 and CAM Pathways, Biosynthesis of Starch and Sucrose, Cell Wall Polysaccharides: Plant Cellulose and Bacterial Peptidoglycan, Integration of Carbohydrate Metabolism in the Plant Cell

Biomolecular interaction


Reference Books

► Lehninger’s Biochemistry
► Lubert Stryer
► Book on Biomolecular Interactions

Advanced Biochemistry Lab

List of Practical

1. Separation of photosynthetic pigments by TLC/silica gel column.
2. Spectrophotometric quantitation of protein (Lowry) and preparation of standard curve.
3. Absorption spectrum of haemoglobin and determination of concentration and extinction coefficient.
BCM-A-DSE B2-TH  Plant Biochemistry (Theory)  4 Credits; 50 hours

Semester 5

1 Introduction to Plant cell structure  No. of Hours : 4
Plasma membrane, Vacuole and tonoplast membrane, cell wall, plastids and peroxisomes

2 Photosynthesis and Carbon assimilation  No. of Hours : 14
Basic Structure of PSI and PSII complexes, Light reaction, Cyclic and non cyclic photophosphorylation, Basic concepts of Calvin cycle and regulation; C3 & C4 cycle, Photorespiration.

3 Respiration  No. of Hours : 12
Alternative reactions of glycolysis, Regulation of plant glycolysis, Glyoxalate cycle, Translocation of metabolites across mitochondrial membrane, TCA cycle, Alternative NAD(P)H oxidative pathways; Cyanide resistant respiration.

4 Nitrogen metabolism  No. of Hours : 14

5 Regulation of plant growth  No. of Hours : 4
Introduction to plant hormones and their effect on plant growth and development (basic concept only), Regulation of plant morphogenetic processes by light (Concept only).

6 Secondary metabolites (Definitions, examples and functions)  No. of Hours : 8
Representatives alkaloids & examples, function of alkaloids, Examples of major phenolic groups, flavonoids, tannins and lignin, biological role of plant phenolics, terpenoids and representative examples from each class, biological functions of terpenoids.

7 Plant tissue culture (basic concept only)  No. of Hours : 4
Cell and tissue culture techniques, types of cultures: organ and explants culture, callus culture, cell suspension culture and protoplast culture. Applications of cell and tissue culture.

BCM-A-DSE B2-P  PLANT BIOCHEMISTRY (PRACTICALS)  2 Credits; 60 hours

1. Induction of hydrolytic enzymes proteinases /amylases/lipase during germination (Demo & tutorials only)
2. Separation of carotenes by silica gel chromatography
3. Separation of photosynthetic pigments by TLC
4. Culture of plants (explants) (Demo & tutorials only).

SUGGESTED READINGS
<table>
<thead>
<tr>
<th>Molecular Diagnostics</th>
<th>4 Credits; 50 hours</th>
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<tbody>
<tr>
<td><strong>Introduction To Biochemical Diagnostics</strong></td>
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<tr>
<td>Inborn errors of metabolism.</td>
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<tr>
<td><strong>Diagnostic Enzymes</strong></td>
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<tr>
<td>Principles of diagnostic enzymology; Clinical significance of</td>
<td></td>
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<tr>
<td>aspartateaminotransferase, alanine aminotransferase, creatine</td>
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<tr>
<td>kinase, aldolase, lactatedehydrogenase, enzyme tests in</td>
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<td>determination of myocardial infarction, enzymes ofpancreatic</td>
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<td>origin and billiary tract.</td>
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<tr>
<td><strong>Immunodiagnostics</strong></td>
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<tr>
<td>Introduction, antigen-antibody binding and assays; Immunoassays</td>
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<tr>
<td>–types [RIA,ELISA, Chemiluminescent IA, FIA] and specific</td>
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<td>applications; Immunohistochemistry-principle and techniques.</td>
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<tr>
<td>Immunodiagnosics for detection of infectious agents, cancer,</td>
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<td>and autoimmune diseases; Immunosensors.</td>
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<tr>
<td><strong>Molecular Diagnostics</strong></td>
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<tr>
<td>Introduction to DNA based diagnostic techniques; Polymerase</td>
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<tr>
<td>chain reaction in diagnostics and analysis; Analysis of DNA</td>
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<tr>
<td>in forensic science and archaeology. Applications of DNA</td>
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<tr>
<td>finger printing, Techniques of chromosome analysis.</td>
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<td>Application of genetic test. Karyotyping, chromosome banding</td>
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<td>and fluorescence In-situ hybridization techniques.</td>
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<tr>
<td>Disease identification and Genetic tests for following</td>
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<td>disorders: Thalassemia, Sickle Cell anemia, Down Syndrome,</td>
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<td>Sex-linked inherited disorders, Allelic susceptibility test</td>
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<td>for multifactorial disorders (Male infertility).</td>
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</tbody>
</table>

**Reference Books**

- Recombinant DNA by Watson
- Experimental Biochemistry: A Student Companion
- Harper's Biochemistry
DSE B3-P

Molecular Diagnostics Lab

<table>
<thead>
<tr>
<th>Molecular Diagnostics</th>
<th>2 Credits; 60 hours</th>
</tr>
</thead>
</table>

List of Practical

1. **Estimation of Surface antigen of Hepatitis B & Hepatitis C virus.**
2. **Lipid profile: triglycerides and total cholesterol.**
3. **Permanent slides (histology/cytology) for different types of cancer and comparison with slides from normal tissues**
4. **Permanent slides of pathogens: Plasmodium vivax and P. falciparum**
5. **Estimation of serum Alkaline phosphatase and Acid phosphatase.**
Research Methodology

**Total Hours: 20 hrs Theory and 140 hrs Practical**

**CREDITS: 6; 70 hours**

1. **Introduction to Research Methodology**
   - Objectives and motivation in research
   - No. of Hours: 4

2. **Defining the Research Problem**
   - Selecting and defining a research problem, Reviewing and conducting literature search, developing a research plan.
   - No. of Hours: 4

3. **Designing of Experiment**
   - Different experimental designs – single and multifactorial design, Making measurements and sources of error in measurements, Methods of data collection and record keeping.
   - No. of Hours: 4

4. **Data Processing and Statistical Analysis**
   - Processing operations, tabulation, and graphical representation, Statistics in research: Concepts of sample and population, Measure of central tendency, dispersion, asymmetry (skewness, kurtosis), Normal distribution (p-value), Statistical tests and hypothesis (Standard error, t-test, chi-square test), and regression analysis, Report writing, Writing a research paper - abstract, introduction, methodology, results and discussion.
   - No. of Hours: 8

Based on the teaching above, each student will undertake the following exercises.

1. A teacher (adviser) who would guide the student will discuss with student and identify a topic of mutual interest.
2. The student will collect the literature, collate the information and write the same in the form of a term paper with proper incorporation of references using appropriate software such as EndNote.
3. The student will identify scope of research on the topic and will frame objectives to be addressed in the project through a work plan.
4. The student will write standard operating protocols (SOPs) and identify requirement for equipment and reagents.
5. Each student will be asked to make presentation about the project including literature available, objective sought and work plan including methodologies as described above.

**SUGGESTED READINGS**


## Skill Enhancement Courses

### BCM-A-SEC A1-TH

#### Techniques in Biochemistry

<table>
<thead>
<tr>
<th>Tools and Techniques in Biochemistry</th>
<th>2 Credits; 30 hours</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Basic Lab Practices and preparation of solutions</strong></td>
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<tr>
<td><strong>Exercise:</strong> Preparation of a buffer of given pH and molarity.</td>
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<tr>
<td><strong>Spectrophotometric techniques</strong></td>
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<tr>
<td>Principle and instrumentation of UV-visible and fluorescence spectroscopy.</td>
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<tr>
<td><strong>Exercises</strong></td>
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<tr>
<td>a. Determination of the absorption maxima and molar extinction coefficient (of a relevant organic molecule)</td>
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<tr>
<td>b. Determination of concentration of a protein solution by Lowry/BCA method.</td>
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<tr>
<td>c. ELISA</td>
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<tr>
<td><strong>Introduction and importance of virtual labs in biochemistry:</strong> Video from Youtube</td>
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</tbody>
</table>

### Reference Books

PROTEIN PURIFICATION TECHNIQUES 2 Credits; 30 hours

TOTAL HOURS: 30

1. Purification and characterization of a protein from a complex mixture (native or heterologously expressed) involving the following methods/techniques


Unit 2  Demonstration of High Performance Liquid Chromatography (HPLC)

SUGGESTED READINGS

Clinical Biochemistry

Introduction
Organization of clinical laboratory, Introduction to instrumentation and automation in clinical biochemistry laboratories safety regulations and first aid. General comments on specimen collection, types of specimen for biochemical analysis. Precision, accuracy, quality control, precautions and limitations.

Exercises
  a. Collection of blood and storage.
  b. Separation and storage of serum.
  c. Analysis of Cell Morphology

Evaluation of biochemical changes in diseases


Assessment of glucose metabolism in blood

Clinical significance of variations in blood glucose. Diabetes mellitus.

Exercise: Estimation of blood glucose by glucose oxidase peroxidase method.

Lipid profile

Composition and functions of lipoproteins. Clinical significance of elevated lipoprotein.

Exercise: Estimation of triglycerides.

Liver function tests

Exercise: Estimation of bilirubin (direct and indirect).

Renal function tests and urine analysis

Use of urine strip / dipstick method for urine analysis.

Exercise: Quantitative determination of serum creatinine and urea.

Tests for cardiovascular diseases

Involvement of enzymes in diagnostics of heart disease including aspartate transaminase, isoenzymes of creatine kinase and lactate dehydrogenase and troponin.
Exercise: Assessment of hypertension by blood pressure measurement,

Reference Books


► Hawk's book
1  Work flow for in-silico cloning  No. of Hours : 2

Unit 2  Preparation of media, antibiotic solution, culturing of E. coli, isolation of single colonies  No. of Hours : 6


Unit 3  Overview of plasmid vectors and methods of isolation  No. of Hours : 8

Exercises Isolation of plasmid by alkaline lysis method. Isolation of plasmid DNA using column chromatography (kit).

Unit 4  Characterization of plasmid by gel electrophoresis  No. of Hours : 2

Exercise Digestion of plasmid DNA with restriction enzymes and analysis of the fragments.

Unit 5  Cloning of a gene in a vector and functional analysis  No. of Hours : 12

Polymerases chain reaction (parametric optimization, primer designing), ligation, introduction of DNA construct into host cells, selection of recombinants.

Exercises Amplification of DNA segment/gene of interest by PCR. Purification of PCR product, digestion of insert and vector by restriction enzymes for directional cloning, purification of insert and digested vector by gel extraction. Ligation of vector and insert. Preparation of competent cells of E. coli DH5α and transformation with the ligation mixture. Functional selection of recombinants (blue/white selection and eGFP fluorescence).

B.Sc. (General) BIOCHEMISTRY

(CBCS STRUCTURE)
BIOCHEMISTRY GENERIC ELECTIVES (Semesters 1-4)

[To be chosen by students studying other Hons subjects]

(CBCS STRUCTURE)

Detailed syllabus

BCM-G-1-1-TH GE-1 (CC-1): BIOCHEMISTRY OF CELL (THEORY)

SEMESTER - 1

TOTAL HOURS: 50  CREDITS: 4

Unit 1 Biomolecules in their cellular environment  No. of Hours : 6


Unit 2 Amino acids and peptides  No. of Hours : 10

Types of amino acids and their chemistry, derivatives of amino acids and their biological role. Introduction to biologically important peptides.

Unit 3 Sugars and polysaccharides  No. of Hours : 10

Basic chemistry of sugars, optical activity. Disaccharides, trisaccharides and polysaccharides - their distribution and biological role.

Unit 4 Nucleosides, nucleotides and nucleic acids  No. of Hours : 10

Structures and chemistry, DNA structures and their importance, different types of RNA. Unusual DNA structures, other functions of nucleotides.

Unit 5 Lipids  No. of Hours : 10

Various classes of lipids and their distribution, storage lipids, structural lipids in membranes, lipids as signals, cofactors and pigments.

Unit 6 Vitamins, coenzymes and metal ions  No. of Hours : 8

Occurrence and nutritional role. Coenzymes and their role in metabolism. Metal ion containing biomolecules - heme, porphyrins and cyanocobalamin; their biological significance.

Unit 7 Signalling molecules  No. of Hours : 6

Second messengers - cAMP, cGMP, IP3, diacyl glycerol, Ca^{2+}, NO. Brief account of their importance and role in signalling and signal transduction.
BCM-G-1-1-P GE-1: BIOCHEMISTRY OF CELL (PRACTICALS)

SEMESTER - 1

TOTAL HOURS: 60  CREDITS: 2


• Qualitative tests for biomolecules - carbohydrates, lipids, amino acids, proteins, bases and nucleic acids.

• Separation of amino acids by paper chromatography.
• Separation of sugars/bases by TLC and their identification.
• Estimation of ascorbic acid in fruit juices.

SUGGESTED READINGS


1 Introduction to proteins
Polypeptides and proteins. Subunit structures, conjugated proteins, diversity of function.

2 Isolation and analysis of proteins
Techniques to isolate and analyze proteins- salt fractionation, ion-exchange chromatography, gel permeation, HPLC, SDS-PAGE, IEF. Protein primary structure - sequencing by Edman degradation, use of enzymes and chemical reagents to obtain overlap peptides. Synthesis of peptides using Merrifeld method.

3 Introduction to protein three-dimensional structures

4 Myoglobin and haemoglobin - structure and function
Oxygen binding curves, cooperativity models for haemoglobin.

5 Introduction to enzyme catalysis
Features of enzyme catalysis, superior catalytic power. General mechanisms of catalysis. Nomenclature.

6 Enzyme kinetics

7 Mechanisms of enzyme action and regulation

8 Enzymes in medicine and industry
Enzymes used in clinical biochemistry as reagents, diagnostics and therapy. Role of immobilized enzymes in industry.
BCM-G-2-2-P  GE-2: PROTEINS AND ENZYMES (PRACTICALS)

SEMESTER-2

Total Hours: 60  CREDITS: 2

- Protein estimation by UV absorbance and Biuret method.
- Protein microassay by Lowry/Bradford method.
- Ammonium sulphate fractionation of crude homogenate from germinated mung bean.
- Setting up assay for acid phosphatase and activity measurements of the ammonium sulphate fractions (progress curve and effect of pH).
- Determination of Km and Vmax of enzyme enriched fraction.
- Inhibition of acid phosphatase activity by inorganic phosphate.

SUGGESTED READINGS


BCM-G-3-3-THGE-3 (CC-3): INTERMEDIARY METABOLISM (THEORY)

SEMESTER-3

Total Hours: 50  
CREDITS: 4

1 Basic concepts and design of metabolism  
No. of Hours : 4

The nature of metabolism. Role of oxidation and reduction and coupling of these. ATP as energy currency.

2 Glycolysis and gluconeogenesis  
No. of Hours : 6

Glycolysis a universal pathway, fructose and galactose oxidation, anaerobic glycolysis, fermentation, gluconeogenesis, reciprocal regulation of glycolysis and gluconeogenesis.

3 The citric acid cycle  
No. of Hours : 6

Pantoyl dehydrogenase complex, oxidation of acetyl CoA, amphibolic role, regulation and glyoxylate pathway.

4 Oxidative phosphorylation  
No. of Hours : 6

The respiratory chain in mitochondria, proton gradient powering ATP synthesis, glycerol-3-phosphate and malate-aspartate shuttle, regulation of oxidative phosphorylation.

5 Photosynthesis, Calvin cycle and pentose phosphate pathway  
No. of Hours : 8

The light reaction, chlorophyll, accessory pigments, reaction centres, two photo systems, generation of proton gradient and NADPH, Calvin cycle, synthesis of glucose, starch, sucrose, regulation, C4 pathway. Pentose phosphate pathway, importance and regulation.

6 Glycogen metabolism  
No. of Hours : 6

Glycogenolysis, phosphorylase regulation, role of epinephrine and glucagon for glycogenolysis, glycogenesis; reciprocal regulation of glycogenesis and glycogenolysis.

7 Fatty acid synthesis and degradation  
No. of Hours : 6

TAG as energy source, β oxidation of fatty acids in mitochondria and peroxisomes, ketone bodies. Biosynthesis of fatty acids - elongation and unsaturation of fatty acids. Regulation of fatty acid oxidation and synthesis.

8 Amino acid catabolism and anabolism  
No. of Hours : 6

Protein degradation to amino acids, urea cycle, feeder pathways into TCA cycle. Nitrogen fixation, synthesis of non-essential amino acids.
9 Nucleotide metabolism

Biosynthesis - *de novo* and salvage pathways, regulation of nucleotide synthesis by feedback inhibition, degradation and excretion.

10 Integration of metabolism

Brief role of hormones - catecholamines, insulin, glucagon; metabolic shifts to provide fuel to brain during fasting and starvation, role of cortisol in signalling stress - increase in gluconeogenesis and muscle protein breakdown.
1. Alcohol fermentation by yeast.

2. H2S production, indole production and ammonia production by bacteria.

3. Urea estimation.

4. Uric acid estimation.

5. Nitrogen fixation by cyanobacteria.

SUGGESTED READINGS

1 Structure of genes and chromosomes

Definition of a gene, chromosomal organization of genes in viruses, bacteria and eukaryotes. Supercoiling of DNA.

2 Replication of genomes

General features of DNA replication, properties of prokaryotic and eukaryotic DNA polymerases. Replication of DNA and telomeres in linear chromosomes. Replication of RNA genomes.

3 Recombination of DNA

Homologous genetic recombination, Holliday model, proteins and enzymes mediating recombination.

4 Gene mutations and repair

Molecular basis of mutations, multiple repair systems, mismatch repair, base excision repair, nucleotide excision repair, direct repair and translesion DNA synthesis.

5 Transcription of genes

General features of gene transcription, procaryotic and eukaryotic RNA polymerases, stages of transcription, initiation, elongation and termination. Inhibitors of transcription.

6 RNA processing

Processing of eukaryotic mRNA, splicing of introns, alternate splicing and editing, ribosomal and tRNA processing.

7 Protein synthesis

Features of the genetic code, amino acylation of tRNAs, structure and assembly of ribosomes; three stages of protein synthesis - initiation, elongation and termination. Inhibitors of protein synthesis.

8 Regulation of gene expression

Regulation of transcription in prokaryotes, concept of operons. Lac operon - control by negative and positive regulatory proteins, Trp operon - control by attenuation. Regulation of transcription in eukaryotes, regulatory sequences - enhancers, silencers response elements, nucleosome alterations, DNA-protein interactions and RNA interference.
• Quantitative determination of DNA and RNA by absorbance at 260 nm and using A260/A280 ratio to distinguish between them.
• To study the viscosity of DNA solutions.
• Isolation of chromosomal DNA from *E. coli*.
• Isolation of total RNA from yeast cells.

SUGGESTED READINGS

**Structure of B.Sc. (General) under CBCS**

<table>
<thead>
<tr>
<th>Semester</th>
<th>CORE COURSE (CC) (12)</th>
<th>Ability Enhancement Compulsory Courses (AECC) (2)</th>
<th>Skill Enhancement Courses (SEC) (4)</th>
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TH: Theory, P: Practical, TU: Tutorial

- CC/DSE: Each Theory and Practical Course have 4 and 2 credits respectively. Each Theory and Tutorial Course have 5 and 1 credits respectively.
- CC: 4 courses each from three subjects (e.g. X, Y & Z) viz. Zoology, Biochemistry & Botany.
- DSE: 2 courses each from 3 subjects (one course from each subject under each semester (5 & 6)).
- AECC & SEC: Each course has 2 credits.
- AECC-1: Communicative English/MIL; AECC-2: Environmental studies.
- SEC: 4 courses; two courses each from any two subjects.
- DSE/SEC: Group (A & B) for specified semesters.
Overall Scheme of B.Sc. (General) in Life Sciences with Biochemistry as one of the three (3) core subjects under CBCS

Core Course Biochemistry (General) (one out of three subjects)

CC-1 (GE) BIOCHEMISTRY OF CELL (Semester 1)

CC-2 (GE) PROTEINS AND ENZYMES (Semester 2)

CC-3 (GE) INTERMEDIARY METABOLISM (Semester 3)

CC-4 (GE) GENE ORGANIZATION, EXPRESSION AND REGULATION (Semester 4)

- DSE-Biochemistry (2 courses each from 3 subjects [one course from each subject under each semester (5 & 6)])

DSE-A (Semester 5; any one may be chosen)

A1. NUTRITIONAL BIOCHEMISTRY

A2. BASIC MICROBIOLOGY

DSE-B (Semester 6; any one may be chosen)

B1. MOLECULAR BASIS OF INFECTIOUS DISEASES

B2. MOLECULAR BASIS OF NON-INFECTIOUS HUMAN DISEASES

SEC (any four (total); two courses each from any two subjects) (SEMESTERS 3 & 4)

Biochemistry

SEC-A1. TOOLS AND TECHNIQUES IN BIOCHEMISTRY

SEC-A2. CLINICAL BIOCHEMISTRY

SEC-B1. PROTEIN PURIFICATION TECHNIQUES

SEC-B2. RECOMBINANT DNA TECHNOLOGY
### Detailed Scheme of B.Sc. (General) in Life Sciences with Biochemistry as one of the three (3) core subjects under CBCS

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Detailed Syllabus
Core Course (General)

BCM-G-1-1-TH  B.Sc. (General) BIOCHEMISTRY (CBCS STRUCTURE)
CC-1: BIOCHEMISTRY OF CELL (THEORY)

SEMESTER - 1
TOTAL HOURS: 50        CREDITS: 4

1 Biomolecules in their cellular environment No. of Hours: 6

2 Amino acids and peptides No. of Hours: 10
Types of amino acids and their chemistry, derivatives of amino acids and their biological role. Introduction to biologically important peptides.

3 Sugars and polysaccharides No. of Hours: 10
Basic chemistry of sugars, optical activity. Disaccharides, trisaccharides and polysaccharides - their distribution and biological role.

4 Nucleosides, nucleotides and nucleic acids No. of Hours: 10
Structures and chemistry, DNA structures and their importance, different types of RNA. Unusual DNA structures, other functions of nucleotides.

5 Lipids No. of Hours : 10
Various classes of lipids and their distribution, storage lipids, structural lipids in membranes, lipids as signals, cofactors and pigments.

6 Vitamins, coenzymes and metal ions No. of Hours : 8
Occurrence and nutritional role. Coenzymes and their role in metabolism. Metal ion containing biomolecules - heme, porphyrins and cyanocobalamin; their biological significance.

7 Signalling molecules No. of Hours : 6
Second messengers - cAMP, cGMP, IP3, diacyl glycerol, Ca2+, NO. Brief account of their importance and role in signalling and signal transduction.

BCM-G-1-1-P  BIOCHEMISTRY OF CELL (PRACTICALS)
SEMESTER-1
TOTAL HOURS: 60         CREDITS: 2

2. Qualitative tests for biomolecules - carbohydrates, lipids, amino acids, proteins, bases and nucleic acids.
5. Estimation of ascorbic acid in fruit juices.

SUGGESTED READINGS


BCM-G-2-2-TH  B.Sc. (General) BIOCHEMISTRY (CBCS STRUCTURE)
CC-2: PROTEINS AND ENZYMES (THEORY)

SEMESTER-2
Total Hours: 50         CREDITS: 4

1 Introduction to proteins No. of Hours: 4
Polypeptides and proteins. Subunit structures, conjugated proteins, diversity of function.

2 Isolation and analysis of proteins No. of Hours : 12
Techniques to isolate and analyze proteins- salt fractionation, ion-exchange chromatography,
gel permeation, HPLC, SDS-PAGE, IEF. Protein primary structure - sequencing by Edman degradation, use of enzymes and chemical reagents to obtain overlap peptides. Synthesis of peptides using Merrifield method.

3 Introduction to protein three-dimensional structures No. of Hours : 10

4 Myoglobin and haemoglobin - structure and function No. of Hours : 4
Oxygen binding curves, cooperativity models for haemoglobin.

5 Introduction to enzyme catalysis No. of Hours : 8
Features of enzyme catalysis, superior catalytic power. General mechanisms of catalysis. Nomenclature.

6 Enzyme kinetics No. of Hours : 10

7 Mechanisms of enzyme action and regulation No. of Hours : 6

8 Enzymes in medicine and industry No. of Hours : 6
Enzymes used in clinical biochemistry as reagents, diagnostics and therapy. Role of immobilized enzymes in industry.

BCM-G-2-2-P  PROTEINS AND ENZYMES (PRACTICALS)
SEMESTER-2

Total Hours: 60
CREDITS: 2

1. Protein estimation by UV absorbance and Biuret method.
2. Protein microassay by Lowry/Bradford method.
3. Ammonium sulphate fractionation of crude homogenate from germinated mung bean.
4. Setting up assay for acid phosphatase and activity measurements of the ammonium sulphate fractions (progress curve and effect of pH).
5. Determination of Km and Vmax of enzyme enriched fraction.
6. Inhibition of acid phosphatase activity by inorganic phosphate.

SUGGESTED READINGS

BCM-G-3-3-TH  B.Sc. (General) BIOCHEMISTRY (CBCS STRUCTURE)
CC-3: INTERMEDIARY METABOLISM (THEORY)
SEMESTER-3

Total Hours: 50         CREDITS: 4

1 Basic concepts and design of metabolism No. of Hours : 4
   The nature of metabolism. Role of oxidation and reduction and coupling of these. ATP as energy currency.

2 Glycolysis and gluconeogenesis No. of Hours : 6
   Glycolysis a universal pathway, fructose and galactose oxidation, anaerobic glycolysis, fermentation, gluconeogenesis, reciprocal regulation of glycolysis and gluconeogenesis.

3 The citric acid cycle No. of Hours : 6
   Pyruvate dehydrogenase complex, oxidation of acetyl CoA, amphibolic role, regulation and glyoxylate pathway.

4 Oxidative phosphorylation No. of Hours : 6
   The respiratory chain in mitochondria, proton gradient powering ATP synthesis, glycerol-3-phosphate and malate-aspartate shuttle, regulation of oxidative phosphorylation.

5 Photosynthesis, Calvin cycle and pentose phosphate pathway No. of Hours : 8
   The light reaction, chlorophyll, accessory pigments, reaction centres, two photo systems, generation of proton gradient and NADPH, Calvin cycle, synthesis of glucose, starch, sucrose, regulation, C4 pathway. Pentose phosphate pathway, importance and regulation.

6 Glycogen metabolism No. of Hours : 6
   Glycogenolysis, phosphorylase regulation, role of epinephrine and glucagon for glycogenolysis, glycogenesis; reciprocal regulation of glycogenesis and glycogenolysis.

7 Fatty acid synthesis and degradation No. of Hours : 6
   TAG as energy source, β oxidation of fatty acids in mitochondria and peroxisomes, ketone bodies. Biosynthesis of fatty acids - elongation and unsaturation of fatty acids. Regulation of fatty acid oxidation and synthesis.

8 Amino acid catabolism and anabolism No. of Hours : 6
   Protein degradation to amino acids, urea cycle, feeder pathways into TCA cycle. Nitrogen fixation, synthesis of non-essential amino acids.
9 Nucleotide metabolism No. of Hours : 6
Biosynthesis - *de novo* and salvage pathways, regulation of nucleotide synthesis by feedback inhibition, degradation and excretion.

10 Integration of metabolism No. of Hours : 6
Brief role of hormones - catecholamines, insulin, glucagon; metabolic shifts to provide fuel to brain during fasting and starvation, role of cortisol in signalling stress - increase in gluconeogenesis and muscle protein breakdown.

BCM-G-3-3-P  INTERMEDIARY METABOLISM (PRACTICALS)
SEMESTER-3
Total Hours: 60  CREDITS: 2

1. Alcohol fermentation by yeast.
2. H2S production, indole production and ammonia production by bacteria.
3. Urea estimation.
4. Uric acid estimation.
5. Nitrogen fixation by cyanobacteria.

SUGGESTED READINGS
BCM-G-4-4-TH  B.Sc. (General) BIOCHEMISTRY (CBCS STRUCTURE)
CC-4: GENE ORGANIZATION, EXPRESSION AND REGULATION
(THEORY)

SEMESTER-4
Total Hours: 60 CREDITS: 4

1 Structure of genes and chromosomes No. of Hours: 8
Definition of a gene, chromosomal organization of genes in viruses, bacteria and eukaryotes.
Supercoiling of DNA.

2 Replication of genomes No. of Hours : 12
General features of DNA replication, properties of prokaryotic and eukaryotic DNA polymerases. Replication of DNA and teleomeres in linear chromosomes. Replication of RNA genomes.

3 Recombination of DNA No. of Hours : 4
Homologous genetic recombination, Holliday model, proteins and enzymes mediating recombination.

4 Gene mutations and repair No. of Hours : 6
Molecular basis of mutations, multiple repair systems, mismatch repair, base excision repair, nucleotide excision repair, direct repair and translesion DNA synthesis.

5 Transcription of genes No. of Hours : 10
General features of gene transcription, procaryotic and eukaryotic RNA polymerases, stages of transcription, initiation, elongation and termination. Inhibitors of transcription.

6 RNA processing No. of Hours : 4
Processing of eukaryotic mRNA, splicing of introns, alternate splicing and editing, ribosomal and tRNA processing.

7 Protein synthesis No. of Hours : 10
Features of the genetic code, amino acylation of tRNAs, structure and assembly of ribosomes; three stages of protein synthesis - initiation, elongation and termination. Inhibitors of protein synthesis.

8 Regulation of gene expression No. of Hours : 6
Regulation of transcription in prokaryotes, concept of operons. Lac operon - control by negative and positive regulatory proteins, Trp operon - control by attenuation. Regulation of transcription in eukaryotes, regulatory sequences - enhancers, silencers response elements, nucleosome alterations, DNA-protein interactions and RNA interference.

BCM-G-4-4-P GENE ORGANIZATION, EXPRESSION AND REGULATION (PRACTICALS)
SEMMESTER-4
Total Hours: 60 CREDITS: 2
1. Quantitative determination of DNA and RNA by absorbance at 260 nm and using A260/A280 ratio to distinguish between them.
2. To study the viscosity of DNA solutions.
3. Isolation of chromosomal DNA from *E. coli*.
4. Isolation of total RNA from yeast cells.
SUGGESTED READINGS
B.Sc. (General) BIOCHEMISTRY (CBCS STRUCTURE)

Discipline Specific Electives (DSE)
(DSE-A in 5th Semester & DSE-B in 6th Semester)
(Any one from A1 & A2; any one from B1 & B2)

BCM-G-DSE-A1-TH: NUTRITIONAL BIOCHEMISTRY (THEORY)

TOTAL HOURS: 50        CREDITS: 4
1 Introduction to Nutrition and Energy Metabolism        No. of Hours: 8
Defining Nutrition, role of nutrients. Unit of energy, Biological oxidation of foodstuff.
measurement of energy content of food, Physiological energy value of foods, SDA.
Measurement of energy expenditure. Direct and Indirect Calorimetry, factors affecting
thermogenesis, energy utilization by cells, energy output – Basal and Resting metabolism,
physical activity, factors affecting energy input - hunger, appetite, energy balance Energy
expenditure in man. Estimating energy requirements, BMR factors Recommended
Nutrient Intakes (RNI) and Recommended Dietary Allowances for different age groups.

2 Dietary carbohydrates and health        No. of Hours: 8
Review functions of carbohydrates. Digestion, absorption, utilization and storage,
hormonal regulation of blood glucose. Dietary requirements and source of carbohydrates, Dietary
fiber, role of fibre in lipid metabolism, colon function, blood glucose level and GI tract functions.

3 Dietary lipid and health        No. of Hours: 8
Review of classification, sources, functions, digestion, absorption, utilization and storage.
Essential Fatty Acids; Functions of EFA, RDA, – excess and deficiency of EFA. Lipotropic
factors, role of saturated fat, cholesterol, lipoprotein and triglycerides. Importance of the
following: a) Omega – fatty acids. Omega 3/ omega 6 ratio b) Phospholipids c) Cholesterol
in the body d) Mono, Polyunsaturated and Saturated Fatty Acids. Dietary implications of fats
and oils, Combination ratios of n6 and n3, MUFA, PUFA and SFA.

4 Dietary Proteins and health        No. of Hours: 8
Review of functions of proteins in the body, Digestion and absorption. Essential and Nonessential

5 Fat and water soluble Vitamins        No. of Hours: 8
Vitamin A, C, E, K and D Dietary sources, RDA, Adsorption, Distribution, Metabolism and
excretion (ADME), Deficiency. Role of Vitamin A as an antioxidant, in Visual cycle,
dermatology and immunity. Role of Vitamin K in Gamma carboxylation. Role of Vitamin E
as an antioxidant. Extra-skeletal role of Vitamin D and its effect on bone physiology. Hypervitaminosis. Vitamin C role as cofactor in amino acid modifications. Niacin-Metabolic interrelation between tryptophan, Niacin and NAD/ NADP. Vitamin B6-Dietary source, RDA, conversion to Pyridoxal Phosphate. Role in metabolism, Biochemical basis for deficiency symptoms. Vitamin B12 and folate; Dietary source, RDA, absorption, metabolic role Biochemical basis for deficiency symptoms.

6 Minerals
Calcium, Phosphorus and Iron - Distribution in the body digestion, Absorption, Utilization, Transport, Excretion, Balance, Deficiency, Toxicity, Sources, RDA. Calcium: Phosphorus ratio, Role of iron in prevention of anemia. Iodine and iodine cycle. Iodine, Fluoride, Mg, Cu, Zn, Se, Manganese, Chromium, Molybdenum Distribution in the human body, Physiology, Function, deficiency, Toxicity and Sources

7 Assessment of Nutritional status
Anthropometric measurements; Z scores, BMI, skinfold, circumference ratios. Biochemical assessment; Basal metabolic panel, Comprehensive metabolic panel, CBC, Urine Analysis, Assessment of Anemia, ROS assessment, GTT and glycosylated Hb, Differential diagnosis of B12 and folate.

8 Food and drug interactions and Nutriceuticals
Nutrient interactions affecting ADME of drugs, Alcohol and nutrient deficiency, Antidepressants, psychoactive drugs and nutrient interactions, Appetite changes with drug intakes and malnutrition. Food as medicine.

DSE-A1-P: NUTRITIONAL BIOCHEMISTRY (PRACTICALS)
TOTAL HOURS: 60 CREDITS: 2
2. Homocystiene estimation.
4. Anthropometric identifications for Kwashiorkor, Marasmus and Obesity.
5. Determination of oxidative stress: TBARS, antioxidant enzymes in hemolysate.
7. Bone densitometry /bone ultrasound test demonstration (visit to a nearby clinic)

SUGGESTED READINGS
BCM-G-DSE-A2-TH: BASIC MICROBIOLOGY (THEORY)

SEMESTER –5

Total Hours: 50         CREDITS: 4

1 History of Development of Microbiology
   No. of Hours: 12
   Development of microbiology as a discipline, Spontaneous generation vs. biogenesis.
   Contributions of Anton von Leeuwenhoek, Louis Pasteur, Robert Koch, Joseph Lister,
   Alexander Fleming. Role of microorganisms in fermentation, Germ theory of disease,
   Development of various microbiological techniques and golden era of microbiology,
   Establishment of fields of medical microbiology and immunology through the work of Paul
   Ehrlich, Elie Metchnikoff, Edward Jenner

2 Diversity of Microbial world
   No. of Hours: 8
   Binomial Nomenclature, Whittaker’s five kingdom and Carl Woese’s three kingdom
   classification systems and their utility. Difference between prokaryotic and eukaryotic
   microorganisms. General characteristics of different groups: acellular microorganisms
   (Viruses, Viroids, Prions) and Cellular microorganisms (Bacteria, Algae, Fungi and
   Protozoa) with emphasis on distribution and occurrence, morphology, mode of
   reproduction and economic importance.

3 Viruses, viroids and prions
   No. of Hours: 10
   An introduction to viruses with special reference to the structure and replication of the
   following: Poxvirus, Poliovirus, HIV, T4 and λ phage, lytic and lysogenic cycles.

4 Bacteria
   No. of Hours: 10
   An account of typical eubacteria, chlamydiae & rickettsiae (obligate intracellular
   parasites), mycoplasma, and archaebacteria (extremophiles). Applications of bacteria in
   industry, environment and food.

5 Algae
   No. of Hours: 6
   History of phycology; General characteristics of algae including occurrence, thallus
   organization, algae cell ultra structure, pigments, flagella, eyespot food reserves and
   vegetative, asexual and sexual reproduction. Applications of Algae in agriculture, industry,
   environment and food.

6 Fungi
   No. of Hours: 6
   Historical developments in the field of Mycology, significant contributions of eminent
   mycologists. General characteristics of fungi including habitat, distribution, nutritional
   requirements, fungal cell ultra- structure, thallus organization and aggregation, fungal wall
   structure and synthesis, asexual reproduction, sexual reproduction, heterokaryosis,
   heterothallism and parasexual mechanism. Economic Importance of Fungi in Agriculture,
   environment, Industry, medicine, food, biodeterioration, mycotoxins

7 Protozoa
   No. of Hours: 4
   General characteristics with special reference to Amoeba

DSE-A2-P: BASIC MICROBIOLOGY (PRACTICALS)
Total Hours : 60   CREDITS: 2
1. Microbiology Laboratory Practices and Biosafety.
2. To study the principle and applications of important instruments (biological safety cabinets, autoclave, incubator, BOD incubator, hot air oven, light microscope, pH meter)
3. Preparation and sterilization of culture media for bacterial cultivation
4. Study of different shapes of bacteria, fungi, algae, protozoa using permanent slides/pictographs
5. Staining of bacteria using Gram stain
6. Isolation of pure cultures of bacteria by streaking method.

SUGGESTED READINGS
BCM-G-DSE-B1-TH: MOLECULAR BASIS OF INFECTIOUS DISEASES (THEORY)
Semester 6

Total Hours: 50          CREDITS: 4
1 Classification of infectious agents      No. of Hours: 12
Bacteria, Viruses, protozoa and fungi. Past and present emerging and re-emerging
infectious diseases and pathogens. Source, reservoir and transmission of pathogens,
Antigenic shift and antigenic drift. Host parasite relationship, types of infections
associated with parasitic organisms. Overview of viral and bacterial pathogenesis.
Infection and evasion.

2 Overview of diseases caused by bacteria      No. of Hours: 18
Detailed study of tuberculosis: History, causative agent, molecular basis of host specificity,
infection and pathogenicity, Diagnostics, Therapeutics, inhibitors and vaccines. Drug
resistance and implications on public health. Other bacterial diseases including Typhoid,
Diphtheria, Pertussis, Tetanus, Typhoid and Pneumonia.

3 Overview of diseases caused by Viruses      No. of Hours: 12
Detailed study of AIDS, history, causative agent, pathogenesis, Diagnostics, Drugs and
inhibitors. Other viral diseases including hepatitis, influenza, rabies, chikungunya and
polio.

4 Overview of diseases caused by Parasites      No. of Hours: 8
Detailed study of Malaria, history, causative agents, Vectors, life cycle, Host parasite
interactions, Diagnostics, Drugs and Inhibitors, Resistance, Vaccine development. Other
diseases including leishmaniasis, amoebiasis.

5 Overview of diseases caused by other organisms      No. of Hours: 10
Fungal diseases, General characteristics. Medical importance of major groups,
pathogenesis, treatment.

DSE-B1-P: MOLECULAR BASIS OF INFECTIOUS DISEASES (PRACTICALS)
Total Hours: 60          CREDITS: 2
1. Permanent slides of pathogens. Mycobacterium tuberculosis, Leishmania, Plasmodium
falciparum
2. WIDAL test (Tutorial & demo)
3. Gram staining (Not to be set in the examinations)
4. Acid fast staining (Not to be set in the examinations)
4. PCR based diagnosis (Tutorial & demo)
5. Dot Blot & ELISA (Tutorial & demo)

SUGGESTED READINGS
126727.
2. Mandell, Douglas and Bennett.S, Principles and practices of Infectious diseases, 7th
3. Sherris Medical Microbiology: An Introduction to Infectious Diseases by Kenneth J. Ryan, C. George Ray, Publisher: McGraw-Hill
4. Medical Microbiology by Patrick R. Murray, Ken S. Rosenthal, Michael A. Pfaller, Elsevier Health Sciences
BCM-G-DSE-B2-TH: MOLECULAR BASIS OF NON-INFECTIONOUS HUMAN DISEASES (THEORY)
SEMESTER –6

Total Hours: 60      CREDITS: 4

1 Nutritional disorders  No. of Hours: 10
Overview of major and minor nutrient components in the diet. Balanced diet and the concept of RDA. Nutrient deficiencies; Kwashiorkor and Marasmus, Scurvy, beri beri, pellagra and B12 deficiency, Xerophthalmia and Night blindness, Vitamin D deficiency, Vitamin K deficiency. Discuss with relation to biochemical basis for symptoms.

2 Metabolic and Lifestyle disorders  No. of Hours: 12
Obesity and eating disorders like Anorexia nervosa and Bullemia. Diabetes mellitus A metabolic syndrome and the relationship with hypertension, obesity, hypothyroidism and stress. Cardio vascular disorders and Atherosclerosis-defining the broad spectrum of ailments that fall in this category, understanding the factors that contribute to the syndrome, stages of disorder and the management of the condition. Irritable bowel syndrome- biochemistry behind the disorder and the influence of diet, stress and environment on the condition.

3 Multifactorial complex disorders and Cancer  No. of Hours: 20
Understanding the definition of multifactorial diseases. Polygenic diseases and the relationship of environmental factors and genetic makeup in the onset of diseases. Cancer: characteristics of a transformed cell, causes and stages of Cancer, molecular basis for neoplastic growth and metastasis, Proto-oncogenes and tumor suppressor genes; Cancer causing mutations; Tumor viruses; Biochemical analysis of cancer; Molecular approaches to cancer treatment.

4. Diseases due to misfolded proteins  No. of Hours: 8
Introduction to protein folding and proteosome removal of misfolded proteins; etiology and molecular basis for Alzheimer’s, Prion diseases, Huntington’s Chorea, Polycystic ovarian syndrome, Parkinson’s disease, ALS.

5 Monogenic diseases  No. of Hours: 10

DSE-B2-P: MOLECULAR BASIS OF NON-INFECTIONOUS HUMAN DISEASES (PRACTICALS)
SEMESTER – II/VI
Total Hours: 60      CREDITS: 2

1. Anthropometric measurements for normal and high risk individuals and identifications for Kwashiorkor, Marasmus and Obesity
2. Estimation of homocysteine levels in serum
3. Estimation of glycosylated hemoglobin
4. Permanent slides for different types of cancer
5. Diagnostic profile for assessment of CVS and Diabetes mellitus using case studies.
6. Bone densitometry test demonstration (visit to a nearby clinic)

SUGGESTED READINGS
3. The World of the cell, 7th edition (2009)
4. Genetics (2012) Snustad and Simmons,
Skill Enhancement Courses (SEC)
Biochemistry (General)
(Any two of the following courses may be chosen)

BCM-G-SEC-A1-TH: TOOLS AND TECHNIQUES IN BIOCHEMISTRY
SEMESTER–3

TOTAL HOURS: 30        CREDITS: 2

1 Biochemical reagents and solutions
Exercise:
Preparation of a buffer of given pH and molarity.

2 Spectrophotometric techniques
Principle and instrumentation of UV-visible and fluorescence spectroscopy.
Exercises:
Determination of the absorption maxima and molar extinction coefficient (of a relevant organic molecule).
Measurement of fluorescence spectrum.
Determination of concentration of a protein solution by Lowry/BCA method.

3 Introduction and importance of virtual labs in biochemistry

SUGGESTED READINGS
Unit 1: Purification and characterization of a protein from a complex mixture (native or heterologously expressed) involving the following methods/techniques

No. of Hours: 24

Exercises:
Preparation of the sample.
Ion-exchange chromatography.
Gel filtration chromatography.
Affinity chromatography.
Electrophoresis.

2 Demonstration of High Performance Liquid Chromatography (HPLC)

No. of Hours: 6

SUGGESTED READINGS
BCM-G-SEC-B1-TH: CLINICAL BIOCHEMISTRY
SEMESTER-3

TOTAL HOURS: 30        CREDITS: 2

1 Introduction No. of Hours: 4
Organization of clinical laboratory, Introduction to instrumentation and automation in clinical biochemistry laboratories safety regulations and first aid. General comments on specimen collection, types of specimen for biochemical analysis. Precision, accuracy, quality control, precautions and limitations.
Exercises:
Collection of blood and storage.
Separation and storage of serum.

2 Evaluation of biochemical changes in diseases No. of Hours: 4

Unit 3 Assessment of glucose metabolism in blood No. of Hours: 4
Clinical significance of variations in blood glucose. Diabetes mellitus.
Exercises:
Estimation of blood glucose by glucose oxidase peroxidase method.

4 Lipid profile No. of Hours: 4
Composition and functions of lipoproteins. Clinical significance of elevated lipoprotein.
Exercises:
Estimation of triglycerides.

5 Liver function tests No. of Hours: 4
Exercises
Estimation of bilirubin (direct and indirect).

6 Renal function tests and urine analysis No. of Hours: 6
Use of urine strip / dipstick method for urine analysis.
Exercises:
Quantitative determination of serum creatinine and urea.

7 Tests for cardiovascular diseases No. of Hours: 4
Involvement of enzymes in diagnostics of heart disease including aspartate transaminase, isoenzymes of creatine kinase and lactate dehydrogenase and troponin.
Exercises:
Estimation of creatine kinase MB.

SUGGESTED READINGS
BCM-G-SEC-B2-TH: RECOMBINANT DNA TECHNOLOGY

SEMESTER-4

TOTAL HOURS: 30  CREDITS: 2

1 Work flow for in silico cloning  No. of Hours: 2

2 Preparation of media, antibiotic solution, culturing of E. coli, isolation of single colonies  No. of Hours : 6

Exercises:
Preparation of LB broth and agar.
Inoculation of medium.
Preparation of glycerol stocks of bacterial strains.
Obtaining isolated colonies by streak plate method.
Preparation of stock solutions.

3 Overview of plasmid vectors and methods of isolation  No. of Hours: 8

Exercises:
Isolation of plasmid by alkaline lysis method.
Isolation of plasmid DNA using column chromatography (kit).

4 Characterization of plasmid by gel electrophoresis  No. of Hours: 2

Exercise:
Digestion of plasmid DNA with restriction enzymes and analysis of the fragments.

5 Cloning of a gene in a vector and functional analysis  No. of Hours: 12

Polymerases chain reaction (parametric optimization, primer designing), ligation, introduction of DNA construct into host cells, selection of recombinants.

Exercises:
Amplification of DNA segment/gene of interest by PCR.
Purification of PCR product, digestion of insert and vector by restriction enzymes for directional cloning, purification of insert and digested vector by gel extraction.
Ligation of vector and insert.
Preparation of competent cells of E. coli DH5α and transformation with the ligation mixture.
Functional selection of recombinants (blue/white selection and eGFP fluorescence).

SUGGESTED READINGS