University of Rajasthan
Jaipur

SYLLABUS

M.SC. BIOTECHNOLOGY
2015-2016 (I & II SEMESTER)
2016-2017 (III & IV SEMESTER)
UNIVERSITY OF RAJASTHAN
JAIPUR

M. Sc. BIOTECHNOLOGY
SYLLABUS SEMESTER SCHEME

2015-2017
## M. Sc. Biotechnology Semester Scheme 2015-17

### First Semester

<table>
<thead>
<tr>
<th>Paper</th>
<th>Title of the Paper</th>
<th>Max. Marks</th>
</tr>
</thead>
<tbody>
<tr>
<td>BTH-101</td>
<td>Cell Biology</td>
<td>100</td>
</tr>
<tr>
<td>BTH-102</td>
<td>Genetics</td>
<td>100</td>
</tr>
<tr>
<td>BTH-103</td>
<td>Microbiology</td>
<td>100</td>
</tr>
<tr>
<td>BTH-104</td>
<td>Biotechniques</td>
<td>100</td>
</tr>
<tr>
<td>BTH 111</td>
<td>Based on theory papers I &amp; II</td>
<td>50</td>
</tr>
<tr>
<td>BTH 112</td>
<td>Based on theory papers III &amp; IV</td>
<td>50</td>
</tr>
</tbody>
</table>

### Second Semester

<table>
<thead>
<tr>
<th>Paper</th>
<th>Title of the Paper</th>
<th>Max. Marks</th>
</tr>
</thead>
<tbody>
<tr>
<td>BTH-201</td>
<td>Molecular Biology</td>
<td>100</td>
</tr>
<tr>
<td>BTH-202</td>
<td>Biological macromolecules &amp; Enzymology</td>
<td>100</td>
</tr>
<tr>
<td>BTH-203</td>
<td>Pathogenesis, Virology &amp; Immunology</td>
<td>100</td>
</tr>
<tr>
<td>BTH-204</td>
<td>Computer applications, Biostatistics &amp; Bioinformatics</td>
<td>100</td>
</tr>
<tr>
<td>BTH 211</td>
<td>Based on theory papers V &amp; VI</td>
<td>50</td>
</tr>
<tr>
<td>BTH 212</td>
<td>Based on theory papers VII &amp; VIII</td>
<td>50</td>
</tr>
</tbody>
</table>

### Third Semester

<table>
<thead>
<tr>
<th>Paper</th>
<th>Title of the Paper</th>
<th>Max. Marks</th>
</tr>
</thead>
<tbody>
<tr>
<td>BTH-301</td>
<td>Genetic Engineering</td>
<td>100</td>
</tr>
<tr>
<td>BTH-302</td>
<td>Animal cell science &amp; Technology</td>
<td>100</td>
</tr>
<tr>
<td>BTH-303</td>
<td>Industrial Biotechnology &amp; Bio safety</td>
<td>100</td>
</tr>
<tr>
<td>BTH-304</td>
<td>Bioresource &amp; Environmental Biotechnology</td>
<td>100</td>
</tr>
<tr>
<td>BTH 311</td>
<td>Based on theory papers IX &amp; X</td>
<td>50</td>
</tr>
<tr>
<td>BTH 312</td>
<td>Based on theory papers XI &amp; XII</td>
<td>50</td>
</tr>
</tbody>
</table>

### Fourth Semester

<table>
<thead>
<tr>
<th>Paper</th>
<th>Title of the Paper</th>
<th>Max. Marks</th>
</tr>
</thead>
<tbody>
<tr>
<td>BTH-401</td>
<td>Plant Biotechnology</td>
<td>100</td>
</tr>
<tr>
<td>BTH-402</td>
<td>Bioprocess engineering</td>
<td>100</td>
</tr>
<tr>
<td>BTH-403</td>
<td>Intellectual property rights, Entrepreneurship, Ethics and Research, Methodology</td>
<td>100</td>
</tr>
<tr>
<td>BTH-404</td>
<td>Elective Paper (Seminar)</td>
<td>100</td>
</tr>
<tr>
<td>BTH 411</td>
<td>Based on theory papers XIII &amp; XIV</td>
<td>50</td>
</tr>
<tr>
<td>Project work</td>
<td>Dissertation &amp; Industrial training</td>
<td>50</td>
</tr>
</tbody>
</table>

### Total Marks

2000
- M. Sc. (Biotechnology) semester scheme will be spread over two academic years consisting of four semesters, two semesters each in M. Sc. Previous (Semester I and Semester II) and M. Sc. Final (Semester III and Semester IV). The course of all the four semesters shall be of 136 credits i.e., each semester of PG course shall offer 34 credits. The candidate is required to earn a minimum of 120 credits.

- In theory, 15 hrs of theory teaching will be equivalent to one credit.

- In practical, 45 hrs of laboratory work will be equivalent to 2 credits.

- Practical classes will be of 4 hours duration instead of three hours/day.

- Each semester will have continuous assessment which will include internal assessment in theory and practical by internal examination (70 marks) and overall performance assessed by seminar/ oral examination- viva voce etc. (30 marks) and the maximum marks will be 100.

### FIRST - SEMESTER

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Subject Code</th>
<th>Course title</th>
<th>Course category</th>
<th>Credit</th>
<th>CONTACT HOUR/WEEK</th>
<th>EoSE DURATION (HRS)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>L</td>
<td>T</td>
</tr>
<tr>
<td>1.</td>
<td>BTH 101</td>
<td>Cell Biology</td>
<td>CCC</td>
<td>4.5</td>
<td>4</td>
<td>0.5</td>
</tr>
<tr>
<td>2.</td>
<td>BTH 102</td>
<td>Genetics</td>
<td>CCC</td>
<td>4.5</td>
<td>4</td>
<td>0.5</td>
</tr>
<tr>
<td>3.</td>
<td>BTH 103</td>
<td>Microbiology</td>
<td>CCC</td>
<td>4.5</td>
<td>4</td>
<td>0.5</td>
</tr>
<tr>
<td>4.</td>
<td>BTH 104</td>
<td>Biotechniques</td>
<td>CCC</td>
<td>4.5</td>
<td>4</td>
<td>0.5</td>
</tr>
<tr>
<td>5.</td>
<td>BTH 111</td>
<td>PRACTICAL - I (BTH -101, BTH -102)</td>
<td>CCC</td>
<td>8</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>6.</td>
<td>BTH 112</td>
<td>PRACTICAL-II (BTH -103, BTH -104)</td>
<td>CCC</td>
<td>8</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>
### SECOND – SEMESTER

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Subject Code</th>
<th>Course title</th>
<th>Course category</th>
<th>Credit</th>
<th>CONTACT HOUR/WEEK</th>
<th>EoSE DURATION (HRS)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>L</td>
<td>T</td>
<td>P</td>
</tr>
<tr>
<td>1.</td>
<td>BTH 201</td>
<td>Molecular biology</td>
<td>CCC</td>
<td>4.5</td>
<td>4</td>
<td>0.5</td>
</tr>
<tr>
<td>2.</td>
<td>BTH 202</td>
<td>Biological macromolecules &amp; Enzymology</td>
<td>CCC</td>
<td>4.5</td>
<td>4</td>
<td>0.5</td>
</tr>
<tr>
<td>3.</td>
<td>BTH 203</td>
<td>Pathogenesis, Virology &amp; Immunology</td>
<td>CCC</td>
<td>4.5</td>
<td>4</td>
<td>0.5</td>
</tr>
<tr>
<td>4.</td>
<td>BTH 204</td>
<td>Computer applications, Biostatistics &amp; Bioinformatics</td>
<td>CCC</td>
<td>4.5</td>
<td>4</td>
<td>0.5</td>
</tr>
<tr>
<td>5.</td>
<td>BTH 211</td>
<td>PRACTICAL –III (BTH – 201, BTH – 202)</td>
<td>CCC</td>
<td>8</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>6.</td>
<td>BTH 212</td>
<td>PRACTICAL-IV (BTH-203, BTH-204)</td>
<td>CCC</td>
<td>8</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

### THIRD – SEMESTER

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Subject Code</th>
<th>Course title</th>
<th>Course category</th>
<th>Credit</th>
<th>CONTACT HOUR/WEEK</th>
<th>EoSE DURATION (HRS)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>L</td>
<td>T</td>
<td>P</td>
</tr>
<tr>
<td>1.</td>
<td>BTH 301</td>
<td>Genetic engineering</td>
<td>CCC</td>
<td>4.5</td>
<td>4</td>
<td>0.5</td>
</tr>
<tr>
<td>2.</td>
<td>BTH 302</td>
<td>Animal cell science &amp; Technology</td>
<td>CCC</td>
<td>4.5</td>
<td>4</td>
<td>0.5</td>
</tr>
<tr>
<td>3.</td>
<td>BTH 303</td>
<td>Industrial Biotechnology &amp; Bio safety</td>
<td>CCC</td>
<td>4.5</td>
<td>4</td>
<td>0.5</td>
</tr>
<tr>
<td>4.</td>
<td>BTH 304</td>
<td>Bioresource &amp; Environmental Biotechnology</td>
<td>CCC</td>
<td>4.5</td>
<td>4</td>
<td>0.5</td>
</tr>
<tr>
<td>5.</td>
<td>BTH 311</td>
<td>PRACTICAL –V (BTH – 301, BTH – 302)</td>
<td>CCC</td>
<td>8</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>6.</td>
<td>BTH 312</td>
<td>PRACTICAL-VI (BTH-303, BTH-304)</td>
<td>CCC</td>
<td>8</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>S. No.</td>
<td>Subject Code</td>
<td>Course title</td>
<td>Course category</td>
<td>Credit</td>
<td>CONTACT HOUR/WEEK</td>
<td>EoSE DURATION (HRS)</td>
</tr>
<tr>
<td>-------</td>
<td>--------------</td>
<td>---------------------------------------------------</td>
<td>-----------------</td>
<td>--------</td>
<td>------------------</td>
<td>---------------------</td>
</tr>
<tr>
<td></td>
<td>BTH 401</td>
<td>Plant Biotechnology</td>
<td>CCC</td>
<td>4.5</td>
<td>4 0.5 0</td>
<td>3 0</td>
</tr>
<tr>
<td>1.</td>
<td>BTH 402</td>
<td>Bioprocess engineering</td>
<td>CCC</td>
<td>4.5</td>
<td>4 0.5 0</td>
<td>3 0</td>
</tr>
<tr>
<td>2.</td>
<td>BTH 403</td>
<td>Intellectual property rights, Entrepreneurship, Ethics and Research Methodology</td>
<td>CCC</td>
<td>4.5</td>
<td>4 0.5 0</td>
<td>3 0</td>
</tr>
<tr>
<td>3.</td>
<td>BTH 404</td>
<td>Elective Paper (SEMINAR)</td>
<td>SEM</td>
<td>4.5</td>
<td>4 0.5 0</td>
<td>0 1</td>
</tr>
<tr>
<td>5.</td>
<td>BTH 411</td>
<td>PRACTICAL – VII (BTH – 401, BTH – 402)</td>
<td>CCC</td>
<td>12</td>
<td>0 0 18</td>
<td>0 4</td>
</tr>
<tr>
<td>7.</td>
<td></td>
<td>Project Work</td>
<td></td>
<td>4</td>
<td>0 0 6</td>
<td>0 1</td>
</tr>
</tbody>
</table>

|             |             |                     |                 |        | L    | T   | P   | THY | P   |
|             |             |                     |                 |        |      |     |     |     |     |
M.Sc. Biotechnology: Scheme of examination

1. Each theory paper shall carry 100 marks and will be of 3 hrs duration. Minimum passing marks shall be 36.

2. The theory question paper will be divided into two parts A and B. Part A of question paper shall be compulsory and contain 10 (ten) very short answer type questions of 20 words covering entire syllabus. Each carrying 2 (two) marks, with a total of 20 marks.

3. Part B of question paper will have 4 questions having 100% internal choice. Each question will carry 20 marks, with a total of 80 marks.

4. Each Practical examination will be of four hour duration and involve laboratory experiments/ exercises, and viva- voce examination in ratio of 75: 25 (i.e. 15% for record and 10% for viva).

5. The Elective paper in the M.Sc. IV Semester will be based on detailed review report on one of the courses listed in the syllabus. The student will make a complete report in about 100 pages that shall be evaluated by the course coordinator and one internal teacher. The marks will be awarded internally.

6. The project work will involve in depth practical work on a problem suggested by the supervisor of the candidate. The evaluation of the dissertation will be done by the external examiner and carry 50 marks. The dissertation submitted by the candidate shall be evaluated by one external expert, Head of the department and supervisor of the candidate. The seminars, in-plant training and industrial visit reports will also be submitted by the candidate to the Head of the Department who will submit these to the external examiner. The examination shall be held in the department and the dissertation etc. will NOT be required to be mailed to the external examiner. The distribution of the marks will be as under:

Dissertation 35 marks
Viva voce 15 marks
The Dynamics of cell, shape and motility: Structural organization of the plant, animal & microbial cells, Cytoskeleton, microtubules and microfilaments, motor and flagellar movements.

Cell wall, plasma membrane and plasmodesmata: Structure and functions, biogenesis, growth models and functions, ion carriers, channels and pumps, receptors. Role in movement of molecules and macromolecules across membranes, comparison with gap junctions.

Other Cellular organelles: Structure and functions of micro-bodies, Golgi apparatus, ribosomes, lysosome, endoplasmic reticulum.

Plant vacuole: Structure and function

Chloroplast and mitochondria: Fine Structure and function of the organelles, their electron transport systems, import of nuclear encoded proteins, ATP synthases, structure, organization and function of mitochondrial and chloroplast genomes, mechanism of organelle gene expression, diversity and evolution of organelle genomes.

Nucleus: Structure, nuclear envelope (karyotheca), nuclear pores, nuclear lamina, nucleolous and nuclear matrix.

Chromatin organization: Chromosome structure and packaging of DNA, nucleosome organization, molecular organization of centromere and telomere, nucleolus and ribosomal RNA genes, euchromatin and heterochromatin, specialized types of chromosomes, polytene, lambrush, B-chromosomes , supernumerary chromosomes, molecular basis of chromosome pairing.

Cell Cycle and Mechanics of cell division: Cell cycle control mechanisms -Negative and Positive intra & extra cellular controls, Role of cyclins & cyclin depended kinases (CDKs). Cytokinesis and cell plate formation. The events of m phase, CDK & cyclin B leading to Metaphase. The spindle assembly check points leading to Anaphase. DNA damage check point controlled by P 53 protein. Map & mitogen-activated protein kinase (MAPK) : Erk1 & Erk2, Ras (mitogen activated protein kinases).

Mechanism at different stages of mitosis: Cohesins and condensins in chromosome segregation. Microtubules in spindle assembly, Structure of kinetochore, centromere and its
functions, Sister Chromatid separation. Cytokinesis actin & myosin in the generation of contractile ring, somatic metaphase.

Meiosis—Significance, Chiasma formation- Synaptonemal complex, Recombination during meiosis- Recombination nodules.

Apoptosis (Programmed cell death): Mechanism of apoptosis, Apoptosis triggered by internal & external signals, Apoptosis inducing factors, cancer, oncogenesis & its mutations.

Cell communication and Signal transduction: Overview of extra cellular signaling signal molecules- hormones, neurotransmitter proteins, environmental factors
Second messengers and their role in signal transduction - lipid and phosphatidylinositol derived second messengers & Role of calcium as second messenger

Cell surface receptors in signal transduction: G-protein coupled receptor – structure and function, Ion channel receptors, Tyrosine kinase linked receptors, Receptors with intrinsic enzyme activity (RTK).

Interaction and regulation of cell signaling pathways - bacterial and plant two component signaling system, bacterial chemotaxis and quorum sensing.

Suggested Laboratory Exercises:
1. EM study of cell organelles
2. Fluorescence staining with FDA for cell viability.
3. Cell wall staining with calcofluor
4. Study of stages in cell cycle
5. Mitosis and Meiosis
6. Histochemical localization of protein, carbohydrate, fats, starch, lignin, nucleic acids
7. Isolation of mitochondria and the activity of its marker enzyme, succinate dehydrogenase (SDH).
8. Demonstration of SEM and TEM.
10. Polytenic, lampbrush, B-chromosomes and sex chromosomes,
11. Preparation of Polytenic chromosome from Chironomous larva/Drosophila larva
12. Silver banding for staining nucleolus-organizing region, where 18S and 28S rDNA are transcribed.
14. Characteristics and behavior of B chromosomes using maize or any other appropriate material.
15. Any other practical based on theory syllabus.

Suggested readings:

Gene Structure and expression: Genetic fine structure, Operon concept, Introns and Exons, cis-trans test, fine structure analysis of eukayotes, introns and their significance, Gene family.


Genetic recombination: Homologous and non-homologous recombinations; independent assortment and crossing over; molecular mechanism of recombination, Holiday junction, site-specific recombination, FLP/ FRT and cre / lox recombination, role of Rec A and Rec BCD enzymes and other recombinations.

Mutation and types of DNA damage: Mutagens and their effects – Physical (Radiations) and Chemical (Base analogues, Intercalating agents, Alkylating agents and others), Types of mutation- Spontaneous and induced mutations, lethal, conditional, biochemical, loss and gain of function, base substitution, frame-shift mutation, germinal verses somatic mutation, Mutations induced by transposons.

Repair mechanisms of mutational DNA damages- Direct reversal of damages (Photoreactivation and Dealkylation), Excision Repair mechanisms (NER and BER), Post-replication repair mechanisms (Mismatch repair and Recombination repair), SOS repair. Inherited diseases and defects in DNA repair.


Chromosome mapping: Linkage map, mapping with genetic markers including RAPD, QTL, construction of molecular maps, restriction mapping- concept and technique,
correlation of genetic and physical maps, mapping by using somatic cell hybrids.

(6)

Structural and numerical alterations in chromosomes: Origin, meiosis and breeding behaviour of duplication, deficiency, inversion and translocation heterozygotes. Origin, occurrence, production and meiosis of haploids, aneuploids and euploids; origin and production of autopolyploids; chromosome and chromatid segregation, allopolyploids types; genome constitution and analysis. Evolution of major crop plants, induction and characterization of trisomics and monosomics. (8)

Molecular cytogenetics: Nuclear DNA content, C-value paradox, cot curve and its significance, multigene families and their evolution, in situ hybridization - concept and techniques, computer assisted chromosome analysis, chromosome microdissection and microcloning, flow cytometry and confocal microscopy in karyotype analysis.

(7)

Cancer: Proto-oncogenes, oncogenes and tumor suppressor genes. (3)

Human genetics: Pedigree analyses, lod score for linkage testing, karyotypes and genetic disorders. Population genetics; General account of inherited human diseases

(5)

Suggested Laboratory Exercises:
1. Study of Hardy-Weinberg Law using simulations (seeds).
2. Linear differentiation of chromosomes through banding techniques, such as G-banding, C-banding and Q-banding.
3. Working out the effect of mono- and trisomy on plant phenotype.
4. Induction of polyploidy using colchicine.
5. Different applications of Colchicine.
6. Study of variations in plants due to numerical alterations in chromosomes.
7. Isolation of chlorophyll mutants following irradiation and treatment with chemical mutagens.
8. Numericals based on inheritance and gene interactions.
10. Any other practical based on theory syllabus.

Suggested Readings:

**I Semester – Microbiology (BTH-103)**

**History and Development**: Microbial evolution, systematic and taxonomy; primitive organisms and their metabolic strategies and molecular coding; New approaches to bacterial taxonomy classification including ribotyping, Ribosomal RNA sequencing. (7)
Prokaryotic and eukaryotic diversity: Nomenclature and Bergey's Manual; Prokaryotic Cells: Structure and Function-Cell wall composition of Gram+ve & -ve bacteria; Cell wall and cell membrane synthesis; Flagella and motility; cell inclusions like endospores, gas vesicles. Bacteria: Purple and green bacteria, budding bacteria, Spirochaetes; Sheathed bacteria, Endospore forming rods and cocci; Mycobacteria; Mycoplasma, Archaea: Archaea as earliest life forms; Halophiles, Methanogens; Hyperthermophilic archaea and Thermoplasma.

Eukarya: Algae, Fungi, Slime molds and Protozoa- General characteristics and types

Pathogenic bacteria of medical importance: Nomenclature and Classification; Gram Positive cocci of Medical Importance - Pneumococcus, Staphylococcus, Micrococcus, Streptococcus; Gram negative cocci - Neisseria, Branhamella; Gram positive bacilli - Coryneform organisms, Actinomyces, Clostridium; Gram negative bacilli- Vibrios, Aeromonas, Haemophilus, Bordetella, Enterobacteriaceae, mycobacteria, spirochetes, Chlamydiae, Rickettsiae. Establishment, spread, tissue damage and anti-phagocytic factors.

Microbial Growth: Pure culture technique; Microbial Growth- definition, mathematical expression of growth, growth cure, measurement of growth and growth yields, Synchronous growth, Continuous, Batch and Fed Batch Culture; Factors affecting growth: temperature, acidity, alkalinity, water availability and oxygen; Culture collection maintenance and preservation.

Bacterial genetic system: Recombination - transformation, conjugation, transduction; Bacterial genetic map with reference to E. coli.

Genetic system of yeast and Neurospora


Chemotherapy and Antimicrobial agents: Sufa drugs; Antibiotics; Pencillin and Cephalosporin; Antibiotics from prokaryotes and eukaryotes; Mode of action; Resistance to antibiotics.
Suggested Laboratory Exercises:

1. Preparation of liquid and solid media for growth of microorganisms.
2. Isolation and maintenance of organisms by plating, streaking and serial dilution methods, slants and stab cultures, storage of microorganisms.
3. Isolation of pure cultures of bacteria from soil and water.
7. Staining techniques to observe bacterial structure: Simple staining, Gram staining, Negative staining, Endospore staining, Capsule staining
10. Isolation and identification of pathogenic fungi from plants.
11. Isolation and identification of nonpathogenic fungi from soil.
12. Raising fungal pure cultures by hyphal tip culture & single spore culture.
13. Microbiological examination of milk: By Methylene-blue dye reduction test
14. Other practical based on theory syllabus.

Suggested Readings:

4. Purohit, SS. Microbiology Fundamentals and Applications Published by Agrobios, India.


I Semester – Biotechniques (BTH -104)

General techniques: Preparation of buffers, Evaluation of PKa's, Enzyme immobilization technique.

Chromatography and Spectroscopy: Paper chromatography, TLC, GC/GLC, HPLC, Ion Exchange chromatography, Affinity chromatography, Adsorption chromatography, Spectrophotometry, Spectroscopy, GCMS, NMR.


DNA and RNA: Isolation of DNA and RNA, Estimation of DNA and RNA by chemical means, wavelength scan of DNA and RNA, Melting studies of Calf thymus DNA. Electrophoresis (Paper, Gel, Immunodiffusion etc.).
Genetics and Molecular Biology: Genetic recombination, Techniques and screening of recombinants, Insertion mutation of a cloned gene, Isolation of plasmids and their curing, Restriction analysis of plasmids to locate position of inserts, Restriction mapping of the plasmid, Cloning of restriction fragment containing neomycin phosphotransferase gene, Expression of β-gal under different promoters, with wild type E.coli as control.

(13)


(12)

Suggested Laboratory Exercises:

Practicals based on theory syllabus.

Suggested Reading (for Laboratory Exercises)


II Semester – Molecular Biology (BTH- 201)

Genetic material: The Structures of DNA and RNA / Genetic Material, Types of DNA, Types of genetic material, DNA topology - linking number, topoisomerases; Organization of DNA in Prokaryotes, Viruses, Eukaryotes. (6)

DNA Replication: Genome and its organization; Prokaryotic and eukaryotic DNA replication. Unit of replicon, enzymes involved, mechanisms of DNA replication, origin and replication fork, fidelity of replication, accessory proteins involved in DNA replication. (6)

Antisense and Ribozyme Technology: Molecular mechanism of antisense molecules, Biochemistry of Ribozymes –Hammerhead, hairpin, RNase P and other ribozymes, applications of antisense and ribozyme technology. (6)

Transcription-Prokaryotic, Eukaryotic transcription, transcriptional factors and machinery, RNA polymerases; Regulatory elements and mechanisms of transcription regulation -formation of initiation complex, transcription activators and repressors, capping, elongation and termination, RNA processing, RNA editing, structure and function of snRNA & snprotein, spliceosome, type III intron, splicing of eukaryotic RNA , polyadenylation, structure and function of mRNA; RNA transport, nuclear export of m- RNA, m-RNA stability. catabolite repression, attenuation and antitermination. (11)

Regulation at transcriptional level : Signal transduction- Environmental signals to Cell surface, intracellular communication; Protein DNA interaction, Transcriptional complex and activation of smart gene; Activation of transcription by Gene battery; Processing regulation i.e. splicing in different manner e.g. Troponin gene; Repression of transcription- Gene silencing. (5)
Translation - Prokaryotic and eukaryotic translation, the translation machinery, tRNA structure and function, Genetic code (nuclear and organelle). Ribosome subunits its molecular structure and function; Formation of initiation complex, initiation factors and their regulation, elongation and elongation factors, aminoacylation of t -RNA, aminocyl tRNA synthetase, termination of translation, proof-reading; translational inhibitors; Co- and Post- translational modification of proteins. (12)

Regulation at translational level: Activation and Repression of translation through mRNA binding protein, Phosphorylation of eukaryotic initiation factors of translation; Repressor protein, Cytoplasmic control of mRNA stability. (4)

Regulation of gene expression in prokaryotes and eukaryotes - Panopy of operon; Spatial (Tubulin gene in plants) & temporal (Globin gene in animals) regulation; Tissue specific gene regulation. (4)

Protein Localization: Synthesis of Secretory and membrane proteins, intracellular protein traffic-import into nucleus, mitochondria, chloroplast and peroxisomes, Receptor mediated endocytosis. (6)

Suggested Laboratory Exercises:
1. Preparation of culture medium (LB) for E.coli (both solid and liquid) and raise culture of E.coli.
2. Isolation of genomic DNA. and its quantification
3. Perform DNA amplification by PCR.
4. Isolation of RNA.
5. Demonstration of antibiotic resistance
6. Metabolic labelling of proteins and immunoprecipitation.
7. Any other practical based on theory syllabus.

Suggested Readings:

II Semester – Biological macromolecules & Enzymology (BTH- 202)

Amino acids and peptides:
Classification, chemical reactions and physical properties. Biosynthesis of amino acid (Reductive amination, Transamination, GS-GOGAT system). Protein structure (primary, secondary, tertiary & quartenary), Protein folding, Glyco and lipoproteins -structure and function, Globular, Fibrous proteins; Hydrophobic and hydrophilic interactions, Ramachandran plot, Circular Dichroism., SDS- PAGE, Diagonal Electrophoresis, DNA - protein interactions (Yeast mono hybrid system); Protein sequencing. Biological importance of proteins.

Nucleotides: Biosynthesis of purines & pyrimidene. By denowo and salvage pathways.

Carbohydrate: Classification and reactions, structure and function of mono, disaccharides, and polysaccharides. Methods for compositional analysis.
Lipids: Classification, structure, biosynthesis and functions of glycerol phospholipids, sphingolipids and cholesterol.  


Principles of thermodynamics: First and second law, concept of free energy high energy compounds. 

Enzymes: classification, nomenclature, Structure: concept of holoenzymes, coenzyme, apoenzyme, isoenzymes and prosthetic groups; Allosteric enzymes. Properties: physiochemical and biological properties, role of enzymes as catalysts; substrate specificity, Mechanism of enzyme action (active site, chemical modification) and regulation (Zymogens, Isozymes). 


Suggested Laboratory Exercises: 

Separation and Characterization of macromolecules: molecular shape and size; molecular weight, by liquid chromatography, electrophoresis and spectroscopy

1. Reactions of amino acids, sugars and lipids. 
2. Isolation, purity determination and quantitation of cholesterol. 
3. Electrophoresis of Proteins 
4. Quantification of Proteins and Sugars. 
5. Analysis of oils-iodine number, saponification value, acid number. 
6. UV. Visible and IR Spectroscopy- absorption spectra. 
7. Separation techniques- Centrifugation, Chromatography (Ion exchange,TLC etc.) 
8. Electrophoresis. 
9. Separation techniques : Demonstration of HPLC. 
11. Electrophoresis of DNA-linear, circular
12. Hybridoma technology
13. Any other practical based on theory syllabus

Suggested Readings:

29. Physical biochemistry, D Freifelder, W.H. Freeman & company
30. Laboratory Techniques in Biochemistry and Molecular Biology, Work and work.
33. Tools of Biochemistry by T.G. Cooper.
34. Essentials of Molecular Biology, David Frielfiser Jones and Bartlett publications.
35. Proteins-Structure and Molecular properties TE Creighton, WH freeman and company.
41. Biophysical chemistry, Cantor, WH Freeman.
42. Protein Structure, by Max Perutz Perutz.

II semester: Pathogenesis, Virology and Immunology (BTH-203)

Disease development: Introduction and history, Host parasite relationship, Host colonization and factors predisposing to infection. Types of toxins (exotoxins, endotoxins, entero toxins) and their structures; mode of action (biochemical, physiological); nonspecific and specific defense mechanisms. (5)
**Microbial Diseases**: Infectious disease & transmission. Respiratory infections caused by bacteria and viruses; Tuberculosis; Disease transmitted by animals (rabies), insects (malaria) and ticks (rickettsias). Food and water borne diseases; Emerging and resurgent infectious diseases. Plant diseases caused by microbes.

(10)

**Viruses**: Nomenclature and classification; morphology and ultra-structure; Capsid and their arrangements; Genetics of viruses; distinctive properties of viruses. (5)


(10)

**Effect of viruses on plants**: Symptomatology, histopathology, physiology and pathogenicity. Common viral diseases of plants (TMV, Cauliflower mosaic virus and Potato virus X). Transmission of plant viruses through vectors (insects, nematodes, fungi) and without vectors (contact, seed, pollen transmission). Brief account of diagnostic techniques in plants; infectivity assay of plant viruses, indicator plants, histochemical tests and vector control. (15)

**Immunology**: Brief history, innate responses, innate and acquired immunity, organization and structure of lymphoid organs. Nature, biology and types of antigens and super antigens. Antibody structure and types; theories of antibody production; Antigen antibody interaction. (7)

**Cells of immune system**: Lymphocyte (B-cells, T-cells and natural killer cells); Antigen Presenting cells (Macrophages, B cells, dendritic cells), killer T cells, also called cytotoxic T lymphocytes (CTLs). (3)

Hybridoma technology & monoclonal antibodies and its applications, regulation of immune responses- Hypersensitivity, Autoimmunity, Immune response during bacterial (tuberculosis), parasitic (malaria), and viral (HIV) infections, congenital and acquired immune deficiencies, immune techniques. (5)

**Suggested Laboratory Exercises**:

1. Study of various symptoms produced in plants due to virus infection.
2. Study of viral diseases of plants/animals/human (Specimen/photographs)
3. Different type of viruses (Photographs/sketches).
4. Raising virus free plants through apical meristem culture.
6. Immunization, Collection of Serum.
7. Double diffusion and Immuno-electrophoresis.
10. Separation of mononuclear cells by Ficoll-Hypaque.
11. Con-A induced proliferation of thymocytes (by MTT method).
12. ELISA.
13. Immunodiagnostics (demonstration using commercial kits).
14. Any other practical based on theory syllabus.

Suggested Readings:


II Semester –Computer applications, Biostatistics & Bioinformatics (BTH- 204)

Introduction to computer: Characteristics of Computers, Uses of computers, Types and generations of Computers. Basic Computer Organization: Basic components, CPU, ALU, memory hierarchy, registers, input- output devices (hardware and software) and their functions; User Interface with the Operating System, System Tools.

Data Representation: Basic concepts about data and information, Representation of data in computers in binary of integers and real numbers, 1’s Complement, 2’s Complement, Addition and subtraction of binary numbers, bits and bytes, Computer’s words coding (ASCII, Unicode and EBCDIC). Numeric data. Conceptual understanding of assemblers, compilers, operating system; Introduction to programming languages, C, Perl.

Handling of Data and Statistical Analysis: Brief description, classification and tabulation of data and its graphical representation. Measures of central tendency and dispersion: mean, median, mode, range, standard deviation, variance, idea of two types of errors and level of significance, test of significance ( F test, T test, Z test and chi-square Test). Probability distributions (Binomial, Poisson and normal); sampling distribution; simple linear regression and correlation. Application of computers in Biostatistical problems.
Multimedia: Introduction, Characteristics, Elements, Applications

Information retrieval: LAN, WAN, introduction to internet, WWW, NICNET, ERNET, VSNL, ISDN, E-mail, Publication on worldwide web, online publishing ventures e.g., Biomed, online international database access. Motif analysis and power point presentation, Microsoft doc & Excel.

General Awareness & Applications: IT Act, System Security (virus/firewall etc.)
I-Tax, Reservations, Banking, Proteomics, genomics, metabolomics.


Suggested Laboratory Exercises:

1. Dot-matrix comparison – understanding sliding window – window size (word size) and stringency
2. Familiarizing with the Operating System, Control Panel, Networking Configuration, Firewall setting
4. Pair wise alignment
5. Multiple sequence alignment.
6. Making Patterns (prosite syntax) and consensus sequence from multiple sequence alignments.
7. Spreadsheet Handling, Working with worksheets. Creating a spreadsheet, entering and formatting information, basic functions and formulas, creating charts, tables and graphs.
8. Analysis of data and calculation of standard deviation and variance.
9. Test of significance (F test, T test, Z test and chi-square Test).
10. Searching protein sequence databases with FASTA and BLAST.
12. Understanding ORF and gene prediction.
13. Protein structure visualization.
14. Secondary structure prediction online.
15. Understanding the bioinformatics behind human, rice, yeast and *E. coli* genome projects.
16. Any other practical based on theory syllabus

**Suggested Readings:**

3. Goel, Anita, Computer Fundamentals – Free PDF Downloads
   i. [booksily.net/pdf/anita-goel-computer-fundamentals](http://booksily.net/pdf/anita-goel-computer-fundamentals)
   ii. [booksily.net/pdf/computer-fundamentals-anita-goel-2013-unit-1](http://booksily.net/pdf/computer-fundamentals-anita-goel-2013-unit-1)
   iii. [pu.ibrat.com/./Computer%20Fundamental%20By%20Goe%20An](http://pu.ibrat.com/./Computer%20Fundamental%20By%20Goe%20An)
   iv. [www.e-bookpdf.org](http://www.e-bookpdf.org) ; Download
8. Bioinformatics tools and Resources – free online tools, downloadable free tools, software packages, internet, Bioinformatics books and Journals, Bioinformatics web-portals.

Note: Use of Open Office/Star Office is recommended, as they are freely downloadable. Reference manual for Open Office available at: [http://www.openoffice.org](http://www.openoffice.org)

**III Semester – Genetic Engineering (BTH- 301)**

**Genetic engineering tools and their applications:** Restriction-modification system & enzymes, modification enzymes (methylases and other enzymes needed in genetic engineering), DNA and RNA markers. Gene Cloning Vectors- Plasmids, bacteriophages, phagemids, cosmids. Artificial chromosome vectors (YAC, BAC, MAC); CHEF analysis, virus
derived vectors-SV40, M13, retroviral vectors, and general applications.

(8)

Nucleic Acid Sequencing and Amplification: Sequencing methods and their Applications-Maxim & Gilbert's and Sanger's methods; Pyrosequencing, Thermal PCR, Shot gun sequencing and Automated method. Nucleic Acid purification and Yield Analysis; PCR – Types and applications.

(8)

Gene manipulation: cDNA Synthesis and its Cloning; mRNA enrichment, DNA primers, linkers and adaptors, Library (cDNA and Genomic) construction and screening. Alternative Strategies of Gene Cloning- Two and three hybrid systems, cloning of genes in expression vectors and regulation, DNA microarrays. (10)

Study Gene Regulation and analysis of gene Expression: DNA transfection methods, Northern blot, Primer extension, SI mapping, RNase protection assays, Reporter assays.

(6)

Southern and Western blotting, DNA fingerprinting, Chromosome walking, Southern and Fluorescence in situ hybridization;

(3)

Mutagenesis, Protein Engineering & Processing of Recombinant proteins - Directed Mutagenesis- Oligonucleotide with M13 DNA, PCR amplified oligonucleotide and Random mutagenesis. Protein Engineering: adding disulfide bonds, reducing number of free sulphhydryl residues, changing aminoacids, increasing and modifying enzymatic activity. Processing of Recombinant proteins: Purification and refolding, characterization of recombinant proteins, stabilization of proteins. (6)


(6)

Expression Strategies for Heterologous Proteins: Vector engineering, host engineering, in vitro transcription and translation, expression in bacteria, yeast, insects and insect cells, expression in mammalian cells and plants. (8)


Application of genetic engineering: Uses of Transgenic plants and animals; production of recombinant pharmaceuticals, disease diagnoses and nanotechnology.

Suggested Laboratory Exercises

1. Growth characteristics of E. coli using plating and turbidometric methods.
2. Bacterial culture and antibiotic selection on media.
3. Isolation of plasmid from E. coli by alkaline lysis method and its quantitation spectrophotometrically.
4. Amplification of DNA by PCR process
5. Restriction enzyme digestion of genomic DNA from E.coli.
6. Restriction enzyme digestion (EcoRI) of plasmid DNA
7. Estimation of size of a DNA fragment after electrophoresis using DNA markers.
8. RFLP analysis
9. RAPD analysis

10. Demonstration of DNA fingerprinting.

11. Restriction digestion of the plasmid and estimation of the size of various DNA fragments & Construction of Restriction digestion map.


13. Transformation of the given bacterial population and selection of recombinants.

14. Co-cultivation of the plant material (e.g. leaf discs) with Agrobacterium and study GUS activity histochemically.

15. Any other practical based on theory syllabus.

Suggested Reading:


Ill Semester- Animal cell science & Technology (BTH-302)

Tools and Culture Media: Equipments and materials for animal cell culture technology. Introduction to the balance salt solutions and simple growth medium. Brief account on the chemical, physical and metabolic functions of different constituents of culture medium, Role of carbon dioxide. Role of serum and supplements, Serum & protein free defined media and their application. (5)

Basic understanding for cell culture: Structure and organization of animal cell, Cell physiology. Primary and established cell line cultures. Biology and characterization of the cultured cells and measuring their growth. (5)


Mammalian Cell transformation: Establishment of Immortal cell lines, transfection, selection by selectable markers, gene amplification for high level protein expression. Specialized methods to transfer difficult cell types; Uses of viral vectors, Vaccinia and Baculovirus and Retrovirus in gene transfer; and use of antisense RNA and DNA in controlling gene function. Mice as the experimental material for gene introduction. (10)

Impact of Recombinant DNA on human Genetics: Mapping and cloning human disease genes. Positional cloning, subchromosomal mapping and markers, in situ hybridization to chromosomes and RFLP. (8)
Applications of Animal cell and Recombinant DNA technology: Cell culture based vaccines. Somatic cell genetics. Organ and histotypic cultures. Development of Transgenic animals (Mice, Cattle, Sheep, Goat, Pigs, Birds and Fish) and their uses. DNA-base diagnosis of genetic diseases; Human somatic cell gene therapy for single-gene disorders.

Suggested Laboratory Exercises:

1. Preparation of tissue culture medium and membrane filtration.
2. Preparation of single cell suspension from spleen and thymus.
3. Cell counting and cell viability.
4. Macrophage monolayer from PEC and measurement of pathogenicity activity.
5. Trypsinization of monolayer and subculturing.
6. Cryopreservation and thawing.
8. Role of serum in cell culture.
9. Preparation metaphage chromosome from cultured cells.
10. Isolation of and demonstration of apoptosis of DNA laddering.
11. MTT assay for cell viability and growth.
12. Cell fusion with PEG.
13. Any other practical based on theory syllabus

Suggested Readings:


III Semester: Industrial Biotechnology and Bio safety (BTh -303)


Microorganism as bio-resource for human needs: Mushroom cultivation technology. Biofertilizers and their application, biopesticide in disease management; Rhizobacteria for plant growth promotion and disease management including parasitic nematodes; Bacteria and soil fungi in plant disease management; Reclamation of mining wastelands, Application of fungi for biodegradation of cellulosic waste and ethanol production. Bioplastics and biopolymers. Biosensors- application in industry. (10)

Fermentation process: design- overview of aerobic and anaerobic fermentation process. Fermentor systems- types. Fermentation process and factors affecting fermentation process. Design of fermentation media, Substrates used as carbon and nitrogen sources. (8)

Microbial fermented products: Organic acids (lactic acid, acetic acid & gluconic acid), Amino acid (Aspartic acids), Alcohol and beverages (acetone- butanol, beer, wine). Enzymes (proteases, amylases, lipases, cellulases & pectinases). (8)

Health care products and food additives: Antibiotics- penicillin, streptomycin and erythromycin. Vaccines- BCG, hepatitis- B & recombinant vaccines; Vitamins- B12, D & C; dairy products- cheese, yoghurt and other products, health care and environment. (10)

Metabolic Engineering and industrial Products: Plant secondary metabolites, control mechanisms and manipulation of phenylpropanoid pathway, alkaloids, Industrial enzymes, biodegradable plastics, polyhydroxybutyrate, therapeutic proteins. (10)
Biosafety: Security measures, laboratory information management system (LIMS). Laboratory safety- safety policies, health hazardous compounds, chemicals (xenobiotic compounds), solvents, poisons, isotopes, radioactive materials, explosives and biological strains (bacterial, fungal etc.) and their waste management. Biosafety Cabinets, Storage of hazardous material and disposal of biological and radioisotope wastes.

Suggested Laboratory Exercises:

1. Isolation of industrially important microorganisms for microbial processes.
2. Comparative studies of Ethanol production using different substrates.
4. Microbial production of antibiotics (Penicillin).
5. Cultivation techniques of mushrooms.
6. Selection of efficient PGPR and mycorrhizae and their effect on growth
7. Preparation of list of the hazardous chemicals and their biosafety measures.
8. Any other practical based on theory syllabus

Suggested Readings:


III Semester –Bioresource and Environmental Biotechnology (BTH- 304)

Water : Natural resource and its management, Sources of water pollution and biological treatment processes and their microbiology: Aerobic Processes-Oxidation ponds, Trickling filter, Activated sludge process, rotating discs, rotating drums; Anaerobic processes-Anaerobic digestion, anaerobic filters, Upflow anaerobic sludge blanket reactors.

(15)

Microbiology of degradation of xenobiotics in Environment - Oil pollution, surfactants, pesticides. Solid wastes: Sources and management (composting, vermiculture and methane production), bioremediation of contaminated soils and waste-land and groundwater.

(15)

Global environmental problems: Green house effect and acid rain, their effects and biotechnological approaches for management. Biofuels, Methodology of environmental management-the problem solving approach, its limitations. Biodiversity and its conservation; Plant germplasm collection including of wild species, intraspecific variations in crop plants, molecular characterization of variations.

(15)

Human population growth and global food prospects, food security and availability of food, Molecular basis of genetic modification and crop improvement programmes, GM food crops, plant as chemical and pharmaceutical factories, Biotechnology in controlling crop diseases, weeds, insects and pests. Biopesticides in integrated pest management. Seed- seed banks,
terminator gene technology and implications, International and local regulations.

(15)

**Suggested Laboratory Exercises:**

1. Detection of coliforms for determination of the purity of potable water.
2. Determination of total dissolved solids of water.
3. Determination of dissolved oxygen concentration of water sample.
4. Determination of biological oxygen demand (BOD) of a sewage sample.
5. Determination of chemical oxygen demand (COD) of sewage sample.
7. Isolation of xenobiotic degrading bacteria by selective enrichment technique.
8. Test for the degradation of a aromatic hydrocarbons by bacteria.
10. Effect of Sulphur dioxide on crop plants.
12. Estimation of nitrate in drinking water.
13. Study on biogenic methane production in different habitats.
14. Any other practical based on theory syllabus

**Suggested Readings:**

2. Kocher, SL. Economic Botany.
8. Chere misinoff, N P. (). Biotechnology for waste and wastewater treatment

IV Semester- Plant Biotechnology (BTH- 401)

Plant tissue culture: Principles, Concept, History of development of plant tissue culture, Concept of totipotency, PTC laboratory facilities, operation and management, General methodology. Different PTC media and their nutritional components, media preparation and
sterilisation techniques, aseptic techniques and preparation of explants, histological techniques for plant tissue culture. Cryopreservation and slow growth for germplasm preservation.

Plant tissue culture technology: Shoot morphogenesis and organogenesis, rooting, hardening and field transfer; Micropropagation, production of virus free plants, callus and suspension cultures, single cell culture. Ovary, anther and microspore culture for production of haploid plants. Somatic embryogenesis, synthetic seeds and its cryopreservation. Plant tissue culture as a technique to produce novel plants, somaclonal variations. Overview of Plant Tissue Culture Applications.

Protoplast technology: Protoplast isolation, purification, viability tests, plating efficiency, culture, Somatic cell hybridization, selection of hybrid, cybrids and their regeneration.

Plant transformation (Recombinant DNA) technology: Tools and techniques, Vectors for plant transformation (Viral and Bacterial), Basic molecular characteristics of Agrobacterium, Basis of tumor and hairy-root formation, Characteristic features of vectors (Co-integrative and binary vectors, Ti, Ri plasmids, 35S and other promoters and terminators, selectable markers, reporter genes, origin of replication etc.).


Direct gene transfer methods and storage: Particle bombardment, electroporation and micro injection. Transgenic gene incorporation, stability and expression; gene silencing. Cryopreservation and Genebanks.

Plant breeding: Brief idea about conventional Plant Breeding Methods- Character identification, incorporation (hybridization), selection and release of variety; Role of Molecular markers: RFLP, RAPD, STS, SCAR, SSCP, AFLP in plant breeding applications. Green house and green-home technology.

Transgenic approaches to crop improvement: Resistant against biotic (virus, fungi, bacteria, nematode, insect, weed) and abiotic stress (salinity, drought, herbicide, cold,

(8)

**Manufacture of valuable products:** Industrial applications of plant cell culture; Plant cell culture and biosynthesis of secondary products; Manufacture of - antigens, antibodies, edible vaccines, enzymes, proteins.

(8)

**Suggested Laboratory Exercises:**

1. Preparation of Stock solutions for MS medium.
2. Preparation of medium.
3. Micro propagation technique
4. Surface sterilization and Organ culture.
5. Callus induction, propagation, and differentiation
7. Hardening and transfer of plants to soil.
8. Study of somatic embryogenesis.
10. Ovary culture
11. Somatic embryogenesis using appropriate explants and Preparation of synthetic seeds
13. Demonstration of protoplast fusion employing PEG.
15. Isolation & Identification of Sec. metabolite from Plant Cell Cultures.
16. Agrobacterium culture, selection of transformants, reporter gene(GUS)assays.
17. Any other practical based on theory syllabus

**Suggested Readings:**


IV Semester- Bioprocess Engineering (BTH-402)

Introduction to Bioprocess Engineering: Idea about Bioprocess Engineering; Measurement and control of Bioprocess parameters. Classification of Bioreactor types. (8)

Types of fermentation processes: Analysis of batch, fed batch and continuous bioreactions, biotransformation. Downstream Processing. (8)

(12)

Industrial production of chemicals, utilizing wastes: Alcohol (ethanol), Acids (citric, acetic, and gluconic), Solvents (glycerol, acetone, butanol), Antibiotics (penicillin, streptomycin, tetracycline), Amino acids (lysine, glutamic acid), Single cell protein.

(18)

Introduction to food technology: principles of food processing. Elementary idea of canning and packing, sterilization and pasteurization of food products, technology of typical food products (Bread, cheese, idly); food preservation.

(14)

Suggested Laboratory Exercises:

1. Isolation and preservation of industrially important microorganisms for microbial processes.
2. Determination of thermal death point (TDP) and thermal death time (TDT) of microorganism for design of a sterilizer.
3. Comparative studies of Ethanol production using different substrates.
5. Use of alginate for cell immobilization.
6. Microbial production of single cell protein.
7. Any other practical based on theory syllabus

Suggested Readings:


IV SEMESTER: Intellectual Property Rights, Entrepreneurship, Ethics and Research Methodology (BTH-403)


(15)


(15)

Research Methodology: introduction—Basic research, applied research, need based research. Identification of the problem, defining the problem. Research project planning. Literature search—information sources, library resources—books, journals, abstracts hand books, procedure manuals, encyclopedias, annual reports, data banks, CDROMS, online literature search—internet access, websites, directories of information resources.

(15)

Design of the experimental programme—variables in the experiments, materials and methods, evolution of methods, application of methods.

(4)

Progress of research—evaluation of results, statistical approach, comparison with existing methodologies, validation of findings, research communications, impact factor of journals.

(5)

Ethical issues: introduction—causes of unethical acts, ignorance of laws, codes, policies and procedures, recognition, friendship, personal gains. Professional ethics—professional conduct. Ethical decision making, ethical dilemmas. Teaching ethical values to scientists,
Suggested Readings:

3. Hassan, E., Yaqub, O., Diepeveen, D. (2010). Intellectual Property and Developing Countries: A review of the literature, the RAND Corporation, 1776 Main Street, P.O. Box 2138, Santa Monica, CA 90407-2138
17. Paul B. Thompson (2007). Food biotechnology in ethical perspective. The

IV SEMESTER: Elective Paper (BTH-404)