Central Department of Biotechnology

Curriculum

Master of Science in Biotechnology

2016 (2073 B.S.)

Institute of Science and Technology
TribhuvanUniversity
Kirtipur, Kathmandu
Nepal

M Sc biotechnology course of study

Introduction

The development of Biotechnology is embracing almost every sector of human civilization. All the developed and developing countries are heading towards this diverse discipline in a very short span of time which has created unique opportunities not only for the exploitation of biological systems for the benefit of mankind, but also for undertaking research to explore the fundamental life processes. Presently it has foAAund wide applications in the areas as diverse as agriculture, animal husbandry, medicine, pharmacology, environmental management, Biosensors, Bioelectronics and diagnostics, Bioinformatics and Computational Biology, Biomedical Engineering, Body's and Cell's Bio-signatures, Microarray Technologies, Prediction and Molecular Simulation, Drug Discovery, Gene Regulation and Transcriptomics, Bioinformatics and computational biology and in industries making biotechnological products. In a country like Nepal, where the concept of biotechnology based industries is limited and biotechnology is immature with limited number of skilled human resources making it difficult to develop biotechnological research and industries.

Tribhuvan University (TU) is the premier university in Nepal, which provides courses in diverse disciplines at various levels. Considering the potentialities of modern biotechnology, TU established Central Department of Biotechnology in 2008,anticipating leading role in the fulfillment of national demand on the manpower and also to start innovative researches in various fields of biotechnology. The course curriculum of master level in biotechnology has been formulated considering the need of the current nation's requirement as well as to meet the international standard in the subject under the Institute of Science and Technology.

The aim of this program is to produce high level manpower in the field of biotechnology required in the country and at global level. Yearly hundreds of biotechnology undergraduates and graduates leave Nepal for higher studies. If the nation or government could make an effort on setting up a biotechnology based laboratory and industry, not only the student but also those who are abroad will be benefited in the sense that they will have enough space to come back here, thus making an attempt in brain gain rather than brain drain and of course the national economy and development will be flash up.

Objectives of the course

Upgrade the Central Department of Biotechnology as an Academic Centre of Excellence for the production of competent postgraduate/higher level human resource in the field of biotechnology.
Establish a sophisticated and well equipped academic Research Laboratory as a model biotechnology laboratory in Nepal.
Conduct innovative national/international research projects in various fields of biotechnology according to specialization of faculties (at least one project-one faculty concept).
Contributein the creation of human resource for the manpower need of the country;develop scientific knowledge and innovative ideasleading to the economic uplift of the nation.

Eligibility for Admission

1.Candidates with Bachelor degree in Biotechnology, Agricultural Science, Biochemistry, medicine, Environmental Science (with chemistry and biological science), Medical Lab Technology (BMLT), Food Technology, and Bachelor degree in science with chemistry and biological sciences (Botany Microbiology, or Zoology), from Tribhuvan University or equivalent degrees from other recognized institutes or universities are eligible for admission.
2. The candidate must have secure at least 50% marks in aggregate in Bachelor level

Selection Criteria

The candidates will be selected for the admission on the basis of merit, which will be assessed by the marks secured in the entrance test taken by the Central Departmentof Biotechnology.

Normal and Maximum Duration of study

Normal duration *24 months (4 semesters)*
Maximum duration *60 months (10 academic semesters)*
Students failing to complete the requirement in 60 months have to be re-enrolling.

Credit calculation

A semester consists of16 weeks.

*Theory***:** One credit is equivalents to 16 teaching hours in a semester or one credit equals to one-teaching hour in a week for one semester.

*Laboratory work***:** One credit is equals to 60 Practical hours in a semester or one credit equals to 4 practical hours in a week.

Evaluation

Different methods of evaluation are to be adapted to assess students' performance.
The in-semester (internal) evaluation shall have a total weight of 40 percent in each course. Students have to obtain 50 percent to pass in the internal exam. Without passing internal exam students will not be qualified to appear in semester exam.
Total weight of internal exam includes internal assessment, project work, class attendance, class talk, home worketc upon the recommendation of departmental committee.
In case a student remains absent in internal examination due to serious illness will given one-time opportunity to appear in the exam if he/she is able to produce an authorized medical certificate. The internal exam notice will be published by the concerned department or campus.

The total evaluation will be done by taking final examination. In total one credit equivalent to 25 marks for both theory and practical papers

Theory paper

Forty percent mark is allocated for Internal Assessment and is assessed by the concerned faculty on the basis of internal examination. 60% mark is allocated for Final examination.

Laboratory work

The laboratory work is evaluated based on the performance of student during the regular lab work (40%) as well as the Examination taken at the end of each semester (60%).

Thesis

The student must prepare a thesis and should submit it within 3 months after the completion of the academic session oAf the fourth semester. The duration can however extended by the head of the department on request from the student and on the recommendation of the supervisor with suitable reason.

Seminar

All studentsmust attend and take active participation in seminars organized by the department. Each student must present at least one research paper or topic provided to him/her with critical assessments and discussion comments. Evaluation will be done by assessing quality of presentation and participation in all the departmental seminars. Each student must get at least satisfactory grade in the Seminar.

I st semester seminar: seminar at the department

IInd semester: seminar outside kathmandu/KTM valley

IIIrd semester: seminar for Project practicaloutside Kathmandu/KTM valley

IVth semester: Seminar related to their thesis work at CDBT/Kathmandu

Departmental Participation in organizing national and International Seminar is important part for upgrading the student's scientific knowledge. The department should organize national /International conference time to time whenever possible by inviting foreign and national scientists.

Talk Program

All students should attend talks delivered by foreign and national scientists invited by the central department of biotechnology. In each semester at least 2 (or more) talks should be attend by the students.

Field Visit

All IIIrd semester students must participate in required field visitsas practicable in each subjects, organized by the department outside the Kathmandu valley/KTM valley. The visit may include Research centers, Biotech-industry, Universities and other organization related to biotechnology.

Project practical /Internship

Project practical can be replaced by internship whenever possible. For which the course code will be same as project practical

Guest Lectures from visiting faculty

There should provision for guest lecture from invited visiting faculties. They will be paid according to the departmental decision/rules.

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Electives

The Department can offer various elective courses. The elective courses are extra credit and are not compulsory, which will not be counted in the last grade of the degree.

Semester examination

Semester exam will be held two times in a year.
Semester exam contains 60 percent weight. Students have to secure at least 50 percent marks in each subject to pass the semester exam.
Semester exam will be conducted by the concerned office of the dean.
All answer books are corrected at the concerned dean's office exam section.

Grading

Students must pass all compulsory and optional papers separately. Students must pass the internal assessment examination in order to appear in the final examination. There will be at least two internal examinations and the average of which will be counted as 40% internal evaluation. The pass mark for both theory and practical papers is 50%. To obtain the M.Sc. Biotechnology degree the student must complete total 60 credit hours (compulsory and optional courses).Grade is given according to the percentage of marks secured in the aggregate.

Second Division	*60% and above*
First division	*70% and above*
Very Good	*80% and above*
Distinction	*90 % and above*

Grade CGPA		***Percentage Equivalent***	***Performance Remarks***
A	4.0	90 and above	Distinction
A-	3.7	80 -89.9	Very good
B+	3.3	70 -79.9	First Division
B	3.0	60 - 69.9	Second Division
B-	2.7	50 — 59.9	Pass in individual subject
F	0	below 50	Fail

Course Structure 2073 (2016) for M.Sc. Biotechnology
First semester

Course Code	Course Title	Credits	Evaluation (40% internal Assessment)
BT 511	Cell Biology and Genetics	3	**75(45+30)**
BT 512	Molecular Biology	3	**75(45+30)**
BT 513	Molecular Biochemistry	2	**50 (30+20)**
BT 514	Microbiology	3	**75(45+30)**
BT 515	Bioprocess &Biochem. Technology	3	**75(45+30)**
	Practical Courses (L) (40% internal)		
BT 511L	Cell Biology and Genetics	1	**25**
BT 512L	Molecular Biology	1	**25**
BT 513L	Biochemistry	1	**25**
BT514L	Microbiology	1	**25**
BT 515L	Bioprocess & BT	1	**25**
Total		**19**	**475**

Second Semester

Course Code	Course Title	Credits	Evaluation (40% internal Assessment)
BT 521	Genetic Engineering	2	**50 (30+20)**
BT 522	Immunology and immunotechnology	3	**75(45+30)**
BT 523	Plant Biotechnology	3	**75 (45+30)**
BT 524	Bioinformatics	2	**50(30+20)**
BT 525	Biophysical Chemistry	2	**50 (30 + 20)**
BT 526	Metabolic Biochemistry and Secondary metabolites	2	**50 (30+20)**
	Practical Courses (L) (40% internal)		
BT 521L	Genetic engineering	1	**25**
BT 522L	Immunology	1	**25**
BT 523L	Plant biotechnology	1	**25**
BT524L	Bioinformatics	1	**25**
BT 526L	Metabolic Biochemistryand Secondary Metabolites	1	**25**
Total		**19**	**475**

Third Semester

Course Code	Course Title	Credits	Evaluation (40% internal Assessment)
Courses 611 to 615 select any three			
BT 611	Food Biotechnology	3	75(45+30)
BT 612	Medical and Pharmaceutical Biotechnology	3	**75** (45+30)
BT 613	Environmental Biotechnology	3	75(45+30)
BT 614	Agriculture Biotechnology	3	75(45+30)
BT 615	Animal Biotechnology	3	**75** (**45**+30)
BT 616	Biostatics and Research methodology	2	**50 (30 + 20)**
BT 617	IPR, Biosafety and Bioethics	1	**25 (15+10)**
BT618	Elective 1 (non credit)Entrepreneurship Development.	2	**50#**
Select any threepractical courses (Courses 611L to 615L) according to the theory courses (40%internal)			
BT 611L	Food biotechnology	Select any three each with 1 credit	25
BT 612L	Medical and pharmaceutical		25
BT613L	Environmental Biotechnology		25
BT 614L	Agriculture Biotechnology		25
BT 615L	Animal biotechnology		25
BT619L	Project practical/internship (3 weeks)	1	25
Total		**16+**	**400**

#All non creditelectives are extra credit

Fourth Semester

Course Code	**Course Title**	**Credits**	**Evaluation (40% internal Assessment)**
BT 621	Thesis	6	150
BT 622	Seminar	0	Attendance
BT 623	Elective 2: Management of Technology	2	50#
Total		**6+**	**150**

M Sc biotechnology course of study

Semester I

Course Title: Cell Biology and Genetics
Course No.: BT 511
Credits: 3

Objectives
At the end of the course the students should be able to:

- explain the evolution of biomolecules and prokaryotic and eukaryotic cells
- describe the membrane structure, roles of phospholipids and other components, and role of cell membrane in intracellular and intercellular transport and various transport procedure
- explain the oxidative- and photo-phosphorylation and mechanism of ATP production
- describe the role of cytoskeleton of cell
- describe the presence of signal molecule in organisms and the role of receptor and secondary messenger molecules of a cell to perform metabolism according to the signal
- describe the role of apoptosis and cancer
- explain the role of interphase in cell division. Describe how mitosis and meiosis occur and explain the control of cell division
- describe how zygote develops into multicellular organism and explain the differential gene activity during development
- understand the multi-disciplinary actions of genes in the inheriting characters
- understand principles and concepts of genetical materials applicability in applied science

Course Description

Cellular Evolution **2 hrs**
Chemical evolution: Chemical elements of living organisms; Synthesis of biomolecules from inorganic molecules and small organic molecules,
Evolution of cell: Evolution of biomolecules to cell. Evolution of prokaryotic cell, evolution of cellular organelles and eukaryotic cells.

Membrane structure and membrane transport **8hrs**
Molecular structure of membrane: lipid bilayer, membrane proteins, models of membrane structure. Membrane compartmentalization and lipid rafts.
Membrane transport: principles, passive and active transport, carrier protein, aquaporin, ion-channel. Intracellular compartment.
Intracellular transport: compartmentalization, Transport of molecules between cellular compartments such as nucleus, mitochondria, chloroplast and other cell organelles.
Vesicular transport: compartmental diversity, transport from ER to cell organelles, Endocytosis and exocytosis

Cytoskeleton **4 hrs**
Structural elements: Components of microtubules and dynamics of microtubule assembly, microfilaments, intermediate filaments, dynamics of cytoskeleton structure, structural support and their role in cell division. Cellular movements: Molecular motors, microtubule dynamics, filament and actin based motility

Energy and biosynthesis **8 hrs**

- Anaerobic synthesis
- Chloroplast: structure, light harvesting complex and photophosphorylation, CO_2-fixation, various types of C4-plants, Photorespiration.
- Mitochondria: Structure and functional dynamics, pyruvate transport, Mechanisms of Kreb's cycle reactions, Oxidative phosphorylation,
- Evolution of electrontransport chain
- Biosynthesis of Chloroplast and Mitochondrial and their genome

Cell aging and Apoptosis **2 hrs**

Function, Extrinsic and intrinsic pathways and their molecular control, role in cancer

Cell to cell signal transduction **6 hrs**

Extracellular and intercellular signaling molecules (Ligands and Receptors); types of extracellular signaling processes; Intracellular second messengers with examples (cyclic nucleotides, phospholipids, calcium and protein kinases as elements of signal transduction); third messengers (DNA binding proteins) and role of signaling molecules in gene activation, Interaction and regulation of signaling pathways as related to G-Protein coupled receptor signaling mechanisms; Receptor tyrosine kinase based signaling mechanisms; Receptor guanylylcyclase based signaling mechanisms; Gated ion channel based signaling mechanisms; Adhesion receptor based signaling mechanisms; and Nuclear receptor based signaling pathways.

Nucleus and Cell division **6 hrs**

- Cycle cycle: Regulating eukaryotic cell cycle. Cyclindependant kinase regulation during Mitosis. Check points in cell cycle regulation.
- Molecular mechanism of cell division. Structure of metaphase chromosome, and cytokinensis
- Variation of chromosome no and arrangement
- Morphology and functional elements of chromosome, Cytogenetic techniques (karyotype and mitotic behavior).

Ferilization and development **4 hrs**

- Fertilization, cleavage , differentiation. Developmental genetics. Activation and deactivation of genes during differentiation. Differential gene regulation and Embryonic development in drosophila, in vitro morphogenesis
- Sex determination in plant, drosophila and human at molecular level
- Stem cell and lineage

Genetics **6 hrs**

- Review of Mendelian and Non-Mendelian genetics
- Chromosome mapping through linkage and molecular basis.
- Extra nuclear Inheritance,
- Epigenetics.

Population Genetics and Breeding **6 hrs**

- Review of basic population genetics (gene pool, gene frequency and Hardy and Weinberg equilibrium) Process of meosis and genetic variability. Gene Action and Effects; Variance and Covariance. Heritability , Repeatability,
- Selection and Mating Design. Conventional breeding methods in plants and animal. Influence of environment on heredity
- Mapping of quantative trait loci (QTL).

Course Title: Practical Cell Biology and Genetics
Course No.: BT 511L
Credits: 1

- Collection of blood from human, blood typing and estimation of gene frequency
- Preparation of media for drosophila culture and sexing. Preparation of reagents and stain. Isolation of polytene chromosome from drosophila
- Smear study of human buccal epithelial cells to observe barr body
- Total human blood cell count including rbc, wbc and platelets. Differential count of wbc.
- Survey of general phenotypic character of human heredity and finding of their gene frequency
- Macroscopic, microscopic and chemical examination and evaluation of spermatocytes and semen
- Isolation of mitochondria from given samples.
- Squash preparation from root tip of viciafaba and study of different stages of mitosis
- Fuelgen stain and squash preparation of root tips of allium cepa and karyotyping.
- Practical 10: techniques for giemsa c- banding and evaluation of karyotyping
- Silver nitrate staining of nucleolus organizing region (nor) of chromosomes
- Culture of white blood cell derived from human and embryo cell derived from chicks.
- Estimation of different statistical parameter including heritabillty and repeatability of given set of data.
- Measurement of o_2 production during photosynthesis
- Demonstration of hill reaction
- Demonstration of a typical monohybrid and dihybrid cross
- Diurnal Acid rhythmus by CAM plants

References

William S. Klug and Michael R. 2003 Cummings Concepts of Genetics., Pearson Education Inc, NJ, USA

2003. David A. Micklos, Gerg A. Freyer with David A. Crotty, DNA Science- A First Course Cold Spring Harbor Laboratory Press, New York, USA.

D. S. Falconer 1997 Introduction to Quantitative Genetics.`., Longman, London and New York, USA

John F. Lasley Latest Edition. Genetics of Livestock Improvement. Prentice –Hall Inc. NJ

Walter A. Becker Manual of Quantitative Genetics. Latest Edition.. McNaughton & Gunn, Inc. Michigan, USA.

Alberts, B. Bray, D. Lewis, J. Raff, M. Roberts, K. Watson, JD: Molecular biology of Cell

Berg, JM, Tymoczko, JL, Stryer, L: Biochemistry, Freeman,

Lodish,H, H. Berk, A. Zipursky, SL, Matsudaira, P Baltimore, D, Darnel J. Molecular cell biology. Wolfe

Lehninger, A.L., Nelson, D.L. and Cox, M.M. Principles of Biochemistry. Worth Publishers, USA or CBS, India.
Buchanan, BB., Gruissem, W and Jones, RL: Biochemistry and molecular biology of plants., Garland Science
Becker, Kleinsmith, Hardin: The world of the cell. Pearson
Watson, JD. Baker, TA. Bell, SP. Gann, A. Levine, M. Losick, R: Molecular biology of the Gene. Pearson
Turner, P.C., McLennan, A.G., Bates, A.D. and White, M.R.H. (2007). Instant Notes Molecular Biology. Routledge.
Karp, G: Cell and Molecular biology-concept and experiment. Wiley

M Sc biotechnology course of study

Course Title:Molecular Biology
Course No.: BT 512
Credits: 3

Objectives
At the end of the course the students should be able to:

- describe NAs and the process of protein synthesis
- explain the mechanism of DNA replication
- explain, how the expression of DNA is controlled inside a cell
- Describe the role of protein structure on its functions
- explain how proteins are synthesized and their intracellular transport

Course Description

Introduction to Molecular Biology. 1 hr

Prelude, Discovery of the role of DNA, biochemistry and genomic revolution, building blocks of DNA, Base-paring of DNA, double helical structure of DNA, DNA has hereditary material-its stability and storage of genetic information, RNA and its basic role in the cell, Genetic code, genetic terminology, and possible of mechanism of evolution, RNA directed polypeptide synthesis, Proteins are cellular functional units.

The Structure of DNA and Genome Organization. 5 hrs

Building blocks of nucleic acids, Chemical structure of DNA, its chemical and physical properties.Organization of cellular DNA in prokaryotes and eukaryotes. Proteins interactions with DNA and chromosomal organization, satellite DNAs, repeated DNA sequence. Heterochromatin and euchromatin, mobile DNA.

RNA structure and the Versatility of RNA. 2 hrs

Chemical difference between DNA and RNA, types of RNA-rRNA, mRNA, tRNA, snRNA, dsRNA, and other RNA, Structure of RNA- modification of bases, RNA folding and its importance, RNA hereditary material, stability of RNA genomes, RNAi- introduction, mechanism and applications.

From Gene to Protein. (Central Dogma) 1 hr

Gene expression in outline: Accessing of genome, Assembly of the transcription initiation complex, synthesis of RNA, Processing of RNA, RNA degradation, Assembly of the translation initiation complex, Protein synthesis, protein folding and protein processing, protein degradation).

Genome replication
Topological problems: 2 hrs

Watson-Crick scheme for DNA replication, topological problem and its solution, Meselson-Stahl experiment, DNA topoisomerase and its types, variations in semiconservative theme

The replication process:

a.Initiation of genome replication (formation of replisome and various components involved in initiation of replication, replication fork formation and its components): Differences in

Initiation of replication between *E. coli,* yeast and higher eukaryotes.

1 hr

b. Elongation of replication: Template dependent synthesis of DNA, DNA polymerase of bacteria and eukaryotes, Priming of DNA synthesis in bacteria and eukaryotes, bacterial replication fork, eukaryotes replication fork and its variations on the bacterial theme, termination of replication, termination of E coli genome,

2 hrs

c. Maintaining the ends of a linear DNA: Okazaki fragments, synthesis of telomeric DNA, Senescence of telomere length, extension of human chromosome by telomerase, shorting chromosomes leading to cancer and aging

2 hrs

d. Regulation of Eukaryotic genome replication: Coordination of genome replication and cell division; control within S phase, **3 hrs**

DNA Mutation, Repair and Recombination.

Mutation:

1. Introduction and causes of mutations: Genomes are dynamics, Difference between mutation and recombination, causes of mutations, Types of mutations, Errors in replication causes the mutations, effects of tautomerism on base-paring, replication slippage, trinucleotide repeat expansion, **2 hrs**
2. Mutation caused by chemical and physical mutagens: base analogs, deaminating agents, Alkylating agents, Intercalating agents, Ionizing radiation, Heat **1 hr**

3. The effects of Mutations: The effects of mutation on genomes, Mutation detection, The effects of mutations on multicellular organisms: loss of function, gain of function; the effects of mutations on microorganisms; Hypermutation and the programmed mutations,

2 hrs

DNA Repair: **2 hrs**

Types of repair: Direct repair; Excision repair: Base excision repair, Nucleotide excision repair in E. coli and eukaryotes; Mismatch repair: single and double-stranded- break repair; Bypassing DNA damage during genome replication, Non-homologous end-joining in humans, SOS response in E. coli; Defects in DNA repair causes human disease including cancer.

Recombination: **3 hrs**

Homologous recombination: Holliday junction; Meselson-Radding modification, RecBCD pathway, Ruv proteins, Site-specific recombination, double strand break model for recombination in yeast, Transposition and its types: replicative and conservative transposition, Transposition of retroelements,

Transcription in Prokaryotes. **3 hrs**

Overview of RNA synthesis, Gene structure and transcription in prokaryotes, *E. coli* RNA polymerase and roles of subunits, functions of σ subunit of RNA polymerase, elongation, mechanism for the termination of transcription (factors involved in termination), post transcriptional processing of RNA, inhibitors of transcription, Elongation and termination.

Transcription in Eukaryotes **4 hrs**

Eukaryotic RNA polymerases and their sub units, Cis and Trans acting elements, Transcription promoters & enhancers, Eukaryotic transcription factors and their roles, hnRNA, Post transcriptional processing of mRNA and modification, alternative processing of mRNA, splicing, Processing of rRNA and tRNA, RNA editing, recently discovered small RNAs, Ribozymes,

Synthesis and Processing of the Proteome. **3 hrs**

(mRNA and Genetic code: standard and variations; codon anti codon interactions), The role of tRNA in protein synthesis Role of Ribosome in Protein synthesis (Ribosome structure, The players... mRNA, tRNA, activating enzymes, initiation of translation in bacteria and eukaryotes, elongation of polypeptide in bacteria and eukaryotes and termination of polypepetide synthesis in bacteria and eukayrotes), Post translation modifications (Protein folding, Proteolysis, Protein chemical modification) Protein trafficking and degradation, inhibition of protein synthesis (antibiotic).

Regulation of gene expression **9 hrs**

Control of protein synthesis in bacteria and eukaryotic cell; Role of promoter; TBPs (TATA-binding proteins) structure/functions, TAFs (TBP-associated factors) structure and functions, Control in transcription level: transcriptional activators and repressors. Structures and functions of activators and repressors, Signal transduction and the control of transcriptional regulators, RNA processing, RNA degradation; antisense RNA. Gene silencing, Regulation of eukaryotic cell cycle. Gene regulation during early stage of development, environment and hormonal regulation.

Course Title: Molecular biology
Course No.: BT 512L
Credits: 1

Laboratory Course

- Laboratory safety and lab operating procedure
- Practicing with micropipettes and testing the micropipettes
- Calibration curve of nucleic acid, and Determination of nucleic acid concentration and its purity
- Plasmid extraction by alkaline lyses method (mini preparations)
- Separation of DNA fragments by agarose gel electrophoresis
- Restriction digestion of plasmid and electrophoresis
- Determination of molecular size of DNA fragments
- In vitro amplification of DNA by PCR and separation of amplified DNA fragment
- The expression of bacterial gene under the control of lac Z promoter, SDS- PAGE and analysis of protein bands
- Extraction of whole blood DNA
- Construction of restriction map of given plasmid by study of restriction fragments
- In vitro transcription of given DNA fragment by T7 RNA polymerase
- Extraction of genomic DNA from plant sample
- *gfp* expression controlled by inducible promoter, GFP production and visualization of GFP by fluorescence analysis
- Isolation of RNA and formaldehyde agarose gel electrophoresis.

Reference Books

Alberts, B., Lewis J., Raff M., Johnson A., Roberts K. (2010).Molecular biology of cell.Garland Publishing Inc.

Ausubel F.M., Brent R., Kingston R.E., Moore D.D., Seidman J.G., Smith J.A., Struhl K (2002).Short Protocols in Molecular Biology.Wiley.

Campbell, N.A. and Reece, J.B. (2002).Biology.Pearson education/Benjamin Cummings.

Grierson, D. and Covey, S.N. (1989).Plant molecular Biology.Chapman or Hall or Blackie

Griffiths, A.J.F., Gelbart, W.M., Miller, J.H., Lewontin, R.C. (2002). Modern Genetic analysis. Freeman.

Griffiths A.J.F., Gelbart, W.M., Lewontin R.C., Wessler S.R., Suzuki D.T., Miller J.H. (2004).An Introduction to Genetic Analysis. Freeman.

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Miesfeld, R. L.(1999): Applied Molecular Genetics. Wiley-Liss.

Sambrook, J. and Russel, D. (2001).Molecular Cloning: A laboratory Manual. CHSL Press.

Shrestha, T. R. (2013). Using DNA barcodes to identify and classify living things, CDP, TU.

Shrestha, T.R. (2013). A text book of experimental molecular biology, CDP, TU.

Stryer L. (recent edition). Biochemistry.Freemean and Co.

Trun, N. and Trempy, J.(2004).Fundamentals of Bacterial Genetics. Blackwell.

Turner, P.C., McLennan, A.G., Bates, A.D. and White, M.R.H. (2007).Instant Notes Molecular Biology.Routledge.

Watson J.D., Baker T.A., Bell S.P., Gann A., Levine M., Losick R. (2004).Molecular Biology of the Gene. Pearson

Central Dogma (Nature, vol. 227, pp. 561-563 (August 8, 1970):http://www.euchromatin. org/Crick01.htm),

Background.Mendel; genetic mapping. Cells and chromosomes.; genetic engineering portion

M Sc biotechnology course of study

Course Title: Molecular Biochemistry
Course No.: MBT 513
Credits: 2

Objectives

- To acquaint students with basic knowledge of biochemistry emphasizing on its importance in biotechnology.
- To provide the students the basic knowledge of biomolecules and their synthesis.
- To provide the students an insight of biochemical techniques, their uses and general applications.
- Synthesis and metabolism
- To expose the students to practical methods used in biochemistry laboratory

Course Description

Water: 2hrs
Water as a molecule of life (Structure, properties and reactivity). Weak acids and bases and buffering in biological systems.

Amino acids and proteins 8 hrs
Structure, properties and classification of amino acids. Biological role of peptides and proteins; Protein structure: primary and secondary structure, Ramachandran's Plot, super-secondary-, tertiary- and quaternary structure; structure of proteins such as keratins, Collagens. Elastin and Hemoglobin; Forces stabilizing of 3-D and quaternary structure of proteins, Protein denaturation and folding; Chemical synthesis of peptides. Peptide sequencing.

Carbohydrates 4 hrs
Biological function. Monosaccharides: classification, structures and reactions, sugar derivatives and their physiological function. Disaccharides: structure and biological role of some common disaccharides. Oligosaccharides and polysaccharides: classification, properties and structures of some common carbohydrates of biological interest. Glycosaminoglycans, Proteoglycans and glycoproteins: structures and biological role..

Lipids 3 hrs
Biological role of lipids. General properties, distribution, classification and nomenclature of lipids. Structure, properties and functions of: fatty acids, waxes, neutral fats, phospholipids, sphingolipids, glycolipids, steroids and its derivatives, eicosanoids and other lipids. Lipoproteins.

Nucleic acids. 3 hrs
Biological role of. General properties, distribution, classification . Structure, properties and functions of: DNA and RNA.

Enzymes and enzyme technology 15 hrs
Nomenclature and classification of enzymes, enzyme specificities, Mechanisms of enzyme action (acid base catalysis, Covalent catalysis, electrostatic catalysis, Proximity and orientation effect, metal ion catalysis), investigation of active site of enzymes, enzyme kinetics: single substrate enzyme catalyzed reaction- Michaelies-Menton kinetics (kintetic constants: Km, Vmax, Kcat, turn over number),

determination of kinetic constants (Lineweaver-burk Plot, Dixon plot, etc.) Mechanism of Bi-substrate enzyme catalyzed reactions. Methods of determination of enzyme activity, Factors influencing the enzyme activity. Enzyme inhibitors and types of enzyme inhibition, Determination of Ki, factors influencing enzyme inhibition. Regulation of enzymes: Cooperative (allostery) effects (KNF and WMC model), Multi enzyme systems (occurrence, properties and importance with appropriate examples), cascade systems (mono- and multi-cyclic, feedback and feed forward regulation with appropriate examples). Isoenzymes: classification, occurrence and clinical applications. Enzyme immobilization: methods of enzyme immobilization, kinetics and applications of immobilized enzymes.

Laboratory work
Course Title: **Laboratory work I: Molecular Biochemistry**
Course No.: BT 513L
Credit: 1

- Preparation of normal, molar and percent solutions of different salts, preparation of different buffer solutions and pH measurements.
- Qualitative analysis and separation of biomolecules: carbohydrates, fats, amino acids, proteins and DNA.
- Quantitative estimation of biomolecules (carbohydrates, amino acids, fats and proteins in different samples provided (at least 5 samples).
- Isolation and purification of proteins - precipitation and chromatographic separation techniques.
- Effects of different factors in enzyme activity.
- Enzyme purification and determination of enzyme kinetics.

Reference Books

Boyer, R. F.(2001). Modern Experimental Biochemistry (3rd edition). Benjamin Cummings Publication.
Delvin, T.(eds) (1997).Textbook of biochemistry with clinical correlations. Willey-Liss Publications.
Herbert, R. B. (1989). The Biosynthesis of Secondary metabolites (2nd edition). Chapman and Hall.
Holme, D. and Peck, H. (1998). Analytical Biochemistry (3rd edition). John Wiley and Sons Inc.
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Morris, C. J. O. R., and Morris, P. (1976). Separation Methods in Biochemistry, John Wiley and Sons Inc., New York.
Murray, R. K., Granner, D. K., Mayes, P. A. and Rodwell V. W. (1999). Harper's Biochemistry (25th edition) (Lange Series). McGraw-Hill Company.
Satyanarayana, U. (2004). Biochemistry (revised reprint). Books and Allied Pvt. Ltd.
Stryer, L., W. H. (1995). Biochemistry (4theditон). Freeman and Company, New York.
Voet, D. and Voet, J. D. (2004). Biochemistry (3rd edition). John Wiley and Sons Inc.
Wilson, K. and Walker, J. (eds.) (2000). Principles and Techniques of Practical Biochemistry. Cambridge University Press.
Zubay, G. L., Wm. C. (1996). Biochemistry(4th edition). Brown Publishers.

M Sc biotechnology course of study

Course Title: Microbiology
Course No.: BT 514
Credits: 3

General objective

- The course is intended to acquaint the students about different forms /fields of microorganisms with their applications

Specific objective

After the completion of the course, the students should be able to:

- describe the morphology and classification of different groups of microorganisms
- explain the factors influencing growth of microorganisms
- apply methods of microbial growth in laboratory conditions
- Identify microbial diseases of human/animals/plants
- identify the unknown microorganisms using conventional and advanced diagnostic techniques
- elucidate microbial mechanism of pathogenicity
- Utilize molecular and immunological tools in disease diagnosis

Course Structure

Bacterial Classification **3hrs**

Basis of classification. Bergey's classification of Bacteria.

Cell structure of Bacteria **3 hrs**

The cell wall structure of Gram positive and Gram negative bacteria, Lipopolysaccharide walls and its significance. Function and importance of capsule, spore and flagella.

Bacterial Nutrition and Growth **5 hrs**

Nutritional requirements, Chemical, physical and energy requirements for growth.Toxic forms of oxygen. Transport mechanism of nutrients

Bacterial growth curve. reproduction, measurement of microbial cell growth in terms of number, volume and biomass, Effect of environmental factors in cell growth. Microbial growth at extreme of environment. Bacteriological media,

Cultivation of Bacteria **2 hrs**

The isolation and cultivation of pure culture. Methods of maintenance and preservation of culture, Major culture collection centre

Microbial Control **4 hrs**

Physical Methods of Microbial Control, Chemical Methods of Microbial Control

Antimicrobics

Methods for Evaluating Disinfectants and Antiseptics, Route of administration, Mechanisms of Antimicrobial Action, Alteration of cell walls, Cytoplasmic membranes

Interference with protein, Nnucleic acid structure, Inhibition of general metabolic pathway

Antibiotic Susceptibility Testing,

Disc diffusion, Minimum Inhibitory Concentration (MIC) and Minimum bactericidal concentration (MBC)Test, Combination therapy

Microbial mechanism of pathogenicity **5 hrs**

Portals of entry of pathogens to the host, penetration of host defense by pathogens penetration into host cell cytoplasm (cytoskeleton), damage of host cell by pathogen.Viral mechanism to invade host defense and cytopathic effects.Molecular mechanisms for origin of new pathogens. Host-pathogen interaction. Evolution of pathogenesis and regulation of virulence, Mechanisms for origin of new pathogens. The development of resistant organisms in populations

Diagnostic microbiology **5 hrs**

Cultivation and identification of microorganism:

Sites of sample collection Culture identification: microscopic examination, Conventional system technique: blood culture, urine culture, sputum, throat swab, stool culture, BACTec technique, cultivation for obligate pathogen, phage typing, antimicrobial susceptibility testing, immunological techniques: antibody based identification, detection of microbial antigen, western blot RIA, ELISA, immunofluorescence, immunolocalization, flow cytometry, PCR based molecular diagnosis PCR, DNA chips (microarray), ribotyping, southern blotting, nucleic acid hybridization, DNA fingerprinting, fatty acid profile, protein profiling

Bacterial disease of human **8hrs**

Disease of skin and eyes, disease of nervous system, disease of cardiovascular and lymphatic system, microbial diseases of the respiratory system (upper and lower), disease of digestive system, disease of urinary and reproductive system,

Microbial Genetics **4 hrs**

Genetic recombination in bacteria, Conjugation, Transformation, Transduction

Fungi, Structure and Physiology **3 hrs**

Morphology, classification, reproduction and cultivation of fungi, medical importance of fungi, Fungal mycotoxins.

General Virology **3 hrs**

Nature of viruses, Isolation and identification of Viruses. Classification of viruses. Mode of replicationcultivation ofviruses, and bacteriophages,

General parasitology **3 hrs**

Classification, cultivation, identification, life cycle of protozoa and helminthes

Course Title: Lab work II: Microbiology
Course No.: BT 514L
Credit: 1

- Microscopic study by simple differential and special staining
- Preparation and use of culture media
- Biochemical tests for identification of bacteria (Voges-proskauer, methyl red test indole production, citrate utilization, carbohydrate utilization test, starch, gelatin, casein and lipid hydrolysis tests, Dextran production test)

- Isolation and Identification of Pathogenic bacteria
- Determination of growth curve of bacteria in broth medium (spectrophotometrically)
- Isolation and identification of mutants of bacteria
- Isolation and identification of antibiotic producer . Tests for antibacterial activity of the antibiotics.
- Isolation of *Bacillus thurengiensis* and staining of their cry protein.
- Culture of obligate anaerobe by using anaerobic jar
- Preservation of important microorganisms
- Determination of MIC and MBC value of the antimicrobial agent against given bacteria
- Isolation of heavy metal resistance bacteria from the polluted environmental sample. Determination MIC of the heavy metal
- Immunological diagnostic technique for identification of microorganisms by using Kits
- Isolation and Identification of Saprophytic fungi from different environment
- Cultivation and storage of Saprophytic fungi in lab media.
- Isolation and characterization of bacteriophage and their phase typing
- Cultivation of new castle disease virus in embryonated chicken egg.
- Isolation and culture of some protozoans
- Study of bacteriological indicators of water pollution

Reference Books

Nester, Anderson, Roberts, Pearsall and Nester. Microbiology, A Human Perspective. MC Graw Hill
J C. Pommerville. Alcamo,s Fundamentals of Microbiology.Jones and Bartlett Publishers
Schaechter, Medoff, Eisenstein. Mechanisms of Microbioal Disease
Brock, T.D. and Madigan, M.T. Biology of Microorganisms, Prentice-Hall International.
Black J.GMicrobiology: Principles and applications. Prentice Hall, New Jersey.
Atlas, R.M. Principles of Microbiology, WMc Brown Publishers USA.
Gerhardt, P. ethods for general and molecular bacteriology, American Society for Microbiology, Washington, D.C.
Prescott, L., Harley, J. and Klein, D. Microbiology. Williams C Brown press.
Gupta, P.K. Elements of biotechnology. Rastogi Publications.
Prasad, B.N. A text book of biotechnology. Budha Academic Enterprises, Kathmandu
Moo-Young, M. Comprehensive biotechnology- the principles, applications, and regulations of biotechnology in industry, agriculture, and medicine. Oxford.
Talaro, K. and Talaro, A. Foundations in Microbiology. Wm C. Brown, Dubuque, IA.
Dubey, R.C. and Maheshwari, D.K. A textbook of Microbiology. New Age International
Lewin, B. Gene IX. Pearson Prentice Hall. New York: Wiley and Sons
Tortora G J, Funke B R, Case C L, (2007) Microbiology an application. Pearson
Malla, R. (2006) Practical manual in Dairy and Meat Microbiology. Applicable to M. Sc Microbiology, Biotechnology and Food technology Students.Ektapublishin
Malla, R. (2011) Sewage Quality Control Monitoring Manual. Applicable to M.Sc. Students of Microbiology and Environmental Sciences. 2011. Published and printed by CDP science and Technology

Books for Laboratory work

R S Burlage, R Atlas, D Stahl.GGeesey, G Sayler. Techniques in Microbial Ecology. Oxford university press
R C Dubey and D K Maheshwari. Practical Microbiology

Cappuccino, J.G., Sherman, N..Microbiology: A Laboratory Manual. BJ PublishingCompany
Delost, M.D.. Introduction to Diagnostic Microbiology. A TM company.
Ghimire, P..Hand book of Practical Microbiology. Pravesh Publication, Kathmandu,Nepal
Harold, J.B.. Microbiological Applications: A laboratory Manual in GeneralMicrobiology. WCB Company Publisher.
Marie, D.D. Introduction to Diagnostic Microbiology. A Text Book and Work Book
Malla, R. (2006) Basics of Laboratory Techniques in General Microbiology- Applications to Microbiology and Biotechnology Students, 2006. Published and printed by CDP science and Technology
Seeley, H.W. and VanDemark, P.J. Microbes in Action: A Laboratory Manual ofMicrobiology.
Malla, R. (2011) Microbiology for Biotechnology students.2011. Published and printed by CDP science and Technology

M Sc biotechnology course of study

Course Title: Bioprocess & Biochemical Techniques
Course No.: BT 515
Credits: 3

General objectives

- The students are expected to learn detail engineering principles of bioprocess technology and several biochemical techniques

Objectives

• To provide broad knowledge on fermentation technology
• To provide knowledge on upstream and downstream processes
• To provide knowledge on production of industrially important bio-products
• To provide knowledge on application of biochemical techniques for analysis of important bio-products

Course Description

Bioprocess Technology **3 hrs**

Introduction to bioprocess technology, Morphology, screening and selection of industrial microorganism Preservation and maintenance of stock culture, Regeneration of stock culture. Inoculum preparation and production. Strain improvement by recombination and mutation for overproduction of metabolites, Improvement other than yield.

Upstream Process **8 hrs**

Media formulation, Natural and synthetic media, Energy source, Source of carbon, nitrogen, vitamins and minerals. Bioreactor and media sterilization, sterilization of processed fluids. Kinetics of cell growth. Role of antifoams, buffers, inhibitors, inducers precursors and chelators. Mass and energy balance, Mass transfer and energy transfer in fermentation process

Bioreactor Design **12 hrs**

Different types of bioreactors: Batch, fed-batch and chemostat with recycle, multistage chemostat and perfusion systems, immobilized cell systems. Solid state and submerged state fermentation.Imperfectly mixed bioreactor system. Specialized bioreactors: Tubular bioreactors, Membrane bioreactors, Tower bioreactor, Fluidized bioreactor, Packed bed bioreactors, Photo-bioreactors etc. Operation and control of bioreactor system: pH, Temperature, Aeration and agitation systems, Impeller design, control of other parameters. Non-mechanically agitated bioreactor systems. Data analysis

Down Stream Process **19 hrs**

Separation of Biomass from culture fluid. Coagulation and flocculation. Disruption of microbial cells
Separation of insoluble solids from fermentation broth: Centrifugation and sedimentation, filtration
Cell processing using tangential flow filtration, Adsorption, Precipitation, Cell processing with hollow fiber membranes. Ultra filtration process in Biotechnology. Liquid-liquid extraction of biopolymers, Aqueous two phase extraction, Supercritical fluid extraction. Different Chromatographic techniques: Affinity chromatography, Ion exchange recovery of antibiotics, Ion exchange recovery of proteins, Gas Chromatography, Size exclusion chromatography , Hydrophobic chromatography, High performance liquid chromatography.Electrophoresis. Dialysis and electro dialysis. Recovery of Biological products by distillation. Crystalization. Drying.

Industrial Production **6 hrs**

- Production of industrially important enzymes (amylase, pectinase etc), organic acids (lactic acid, citric acid)
- Secondary metabolites, production of antibiotics (Penicillin, Streptomycin) and toxins
- Scale up and scale down of bioprocess technology.
- Bioprocess economics
- Safety consideration in Bioprocess.

Title: Labwork II: Bioprocess and enzyme technology
Course No.: BT 515L
Credits: 1

- Fermenter Design
- Determination of doubling time and Z value for Sterilization of fermenter and media
- Isolation of Different industrially important strains (*Saccharomyces cerevisiae*, *Lactobacillus, Aspergillus, Bacillus* spp.)
- Strain improvement by applying mutagenic agents
- Preparation of fermentation pre-culture
- Study of antibiotic producing microorganism of local soil: a) Isolation, b) Screening
- Production of antibiotics by *Penicillium*spp
- Production of ethanol and organic acids.
- Production of single cell protein: a) Yeast cells, b). *Spirilluna*and others
- Enzyme production :extra and intracellular enzymes (amylase, Cellulase, Sucrase, Pectinase, Lipases, Protease, Alkaline and Acid Phosphatase, alcohol dehydrogenase) by microorganisms and other sources.
- Production of vitamins.
- Immobilization of whole cell in gel and assay
- Purification, a) precipitation, b) dialysis, c) column chromatography , d) extraction

Reference Books

- Booth, C. (Ed) (1974). Methods in Microbiology. Vol .IV Academic Press.
- Bull, A.T. and Dalton, H. (Eds.) (1995). Comprehensive Biotechnology. Pergamon Press, Oxford
- Butterworth-Heinemann(1992). Product Recovery in Bioprocess Technology, Elviser.
- Casida, L,E,, Jr. (1997). Industrial Microbiology. New AI. New Delhi
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- Gerhartz, W. (1990). Enzymes in Industry: Production and applications. VCH Publishers, New York Gupta, P,K. (1999). Elements of biotechnology. Rastogi Publication.
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- Malla, R. (2011)Bio-Molecules in Microorganisms and Their Roles to Friendly Environment.
- Michael L Sular and FikretKargi (2002): Bioprocess Engineering, Basic concepts, Prentice Hall.
- WHF and Company. McNeil, B., and Harvey, L.M. (1990). Fermentation a practical approach. IRL press. NY.

- Stanbury, P. F. , Whitaker, A. and Hall, S.J. (1997). Principles of Fermentation Technology. Aditya Books (P) LTD, New Delhi.
- Walsh, G. (2002). Proteins Biochemistry and Biotechnology. JW and Sons LTD.
- Malla, R. (2009) Characterization of p-NPP reactive Acid phosphatase in *Piriformosporaindica.Lambert Academic Publications. Germany.*

Books for Laboratory work

- Bollag, D.M., Rozycki, M.D., Edelstein, S.J. (1996). Protein methods. 2nd Edition, Wiley- Liss. Deutscher, M.P. (1990).
- Methods in Enzymology. Guide to Protein Purification. Academic Press. Sambrook,
- J. and Russell, D. (2001). Molecular Cloning. A Laboratory Manual, Vol. III CHSL Press.
- Walker, J.M. (Eds) (1996). The protein protocols handbook. Humana press, NJ

M Sc biotechnology course of study

Second Semester

Course Title: Genetic Engineering

Course No.: BT 521
Credits: 2

Objectives
At the end of the course the students should be able to:

- explain the various techniques of molecular biology and their uses in genetic engineering.
- know the uses of PCR in various field of molecular biology
- describe the various ways of genetic manipulation and transformation, and explain how the transformation can be proved by molecular techniques.
- describe artificial ways of inducing mutation and explain the role of mutation in molecular biology
- describe the types of DNA-library and explain the various methods of library screening
- explain the methods of DNA sequencing

Course Description

Introduction & Importance of Genetic Engineering **1hr**
Basic techniques of Gene cloning **4 hrs**
Introduction, Basic techniques: Restriction enzymes and restriction digestion, other enzymes used for DNA manipulation: synthesis, joining and modification, gel-electrophoresis: Principal, types, process and uses

PCR techniques **3 hrs**
DNA polymerase and RNA-polymerase used in PCR, Role of Mg^{++} and NTPs., PCR techniques and its multiple uses. The use of PCR in gene assembly: multiplex PCR, Overlap extension PCR. Real time quantitative PCR. PCR in molecular diagnostics, application of RT-PCR in gene expression

DNA cloning and esxpression **10 hrs**
Cloning vectors: plasmid, polylinker, lamda vector (phagemids), cosmid, Artificial chromosomes, marker and reporter gene, genetic transformation of E.Coli and selection, DNA recombination without ligase: topoisomerase, cre-lox recombination, Gate way method etc

DNA library: genomic library, cDNA library, expression library, substraction library
Cloning strategies, cloning in bacteria other than *E.coli*, cloning in yeast and other fungi, gene manipulation of animals and plants, Analysis of transcriptome. expression analysis of protein
Expression systems: Recombinant DNA technology, Synthesis of protein through expression vector, fusion protein, .Prokyaryotic: expression system in *E.coli,Bacillus* expression, eukaryotic : Pichiaexpression system; expression in insects system (Baculovirus expression system); Protein expression in mammalian cells

Identification, isolation and sequencing of cloned DNA **7 hrs**
Direct selection of gene, Oligonucleotide probes (radioactive and nonradioactive) Nucleic acid hybridization: southern blotting, northern blotting,

Library screening by membrane hybridization, Western Blotting and immunoscreening for expression library
Methods of DNA sequencing: Maxam and Gilbert, Sanger and Coulson, improvement in the methods, Pyrosequencing, next generation sequencing, Microarray and sequencing

Method of transformation **3 hrs**
Direct transformation: electroporation, microinjection, microprojectile bombardment, direct uptake of DNA fragment
Indirect method: through Ti-plasmid, conjugation, transduction

Functional genomics **5 hrs**
Mutation and induced mutation, The use of PCR in site directed mutagenesis and protein engineering, knockout mutation, role of transposons in mutation, isolation and analysis of mutants, genetic mapping of mutation, cloning of mutated gene, proteomics and genomics.

Microarray techniques and its uses **1 hr**

Course Title: Practical III: Genetic engineering
Code No.: BT 521L
Credit: 1

A. DNA recombination and transformation
- Plasmid extraction and Construction of chimaeric plasmid
- Production of competent E. coli cell, Pichia
- Transformation of E. coli cells and Pichia and selection of transformant
- Selection of transformant by blue white screening
- Electroporation

B. PCR techniques
- Amplification of particular DNA sequence by normal PCR
- Cloning of PCR product in vector
- Preparation of cDNA by Reverse trasnscriptase PCR (RT-PCR), Other PCR techniques

C. Hybridization Techniques
- Labelling of nucleic acid and preparation of nucleic acid probe
- Southern blotting
- Northern blotting
- Western blotting

D. Production of fusion protein using expression vector (pET) and purification

E. Visualization of GFP

F. DNA sequencing technique

Reference Books

Ausubel F, Bent R (2005). Short Protocols in Molecular Biology. Wiley
Brown, TA (2006): Gene Cloning and DNA analysis. An introductio Blackwell Publishing
Campbell, N.A. and Reece, J.B (2002). Biology Pearson education/Benjamin Cummings
Carson, S and Robertson, D (2006) Manipulation and expression of recombinant DNA Academi Press (AP)
Glick, B.R. and Pasternak, J.J (recent edition). Molecular Biotechnology American Society of Microbiology press
Griffiths A J F., Gelbart, W. M., Miller, J.H., Leontin, R.C. (2002). Modern Genetic analysis. Freeman
Griffiths A J F., Gelbart, W. M., Leontin, R.C, Suzuki, W.M.Miller, J.H., (2004). An Introduction to Genetic Analysis. Freeman
Krenzer, H and Massey, Y (2000) A recombinant DNA and Biotechnology, ASM
Krenzer and Massey (2000). Recombinant DNA and Biotechnology ASM
Kumar Anil and GARG; Neha (2005): Genetic engineering. Nova Science Publication
Lehninger, A.L., Nelson, D.L. and Cox, M.M. (recent edition) Principles of Biochemistry. Worth Publishers, USA or CBS, India
Lodish, H., Berk, A., Zipursky, S.L., Matsudaira, P., Baltimore, D., Darnell, J. (2004): Molecular cell biology. Freeman and Co.
Meesfeld(1999): Applied Molecular Genetics. Wiley-Liss
Primrose S B, Twyman RM, Old RW (2007). Principle of Gene Manipulation and genomics. Blackwell science
Robertson D, Shore S., and Miller DM (1997): Manipulation & Expression of Recombinant DNA AP
Sambrook, J. and Russel, D. (2003). Molecular Cloning. A laboratory Manual. Vol. I to III CHSL Press
Stryer, L. (recent edition). Biochemistry. Freemean and Co.
Trun N&Trempy J (2004). Fundamentals of Bacterial Genetics. Blackwell
Turner, McLennan, Bates and White. Instant note on molecular biologyMolecular Biology
Watson JD, Gilman, M, Witkoski, J, Zoller, M (1993). Recombinant DNA. Freeman
Watson JD, Baker, TA, Bell, SP, Gann, A, Levine, M. Losick, R (2004) Molecular biology of gene. Pearson

Course Title: Immunology and Immunotechnology
Course No.: BT 522
Credits: 3

General Objective
To provide knowledge of the immune system and its medical application

Specific objectives
- Understanding basic knowledge of functional anatomy and physiology of immune organs.
- Conceptualization of immuno-structural Biology and understanding the functional mechanism of immune systems
- Broaden the knowledge of applied immunology in disease prevention, diagnosis and treatment
- Provide information and skills for the utilization of Immunological techniques in biotechnology
- Updating the recent developments/ inventions/ publications concerning immunology course

Introduction on Immunology **2 Hrs**

Brief history of Immunology, Epithelial barrier (First line defense), Innate (non specific second line) and adaptive (specific, third line defense) immunity. Concept of humoral and cell mediated immune response.

Cells, tissues and organs of immune systems **3 Hrs**

Lymphocytes, NK cells, mast cells. Antigen presenting cells: dendritic cells, Macrophages, B cells. Functional anatomy of the immune system: Bone marrow, thymus, lymph node, spleen. Mucosal Immunity:, MALT (Mucosal-Associated Lymphoid Tissues), GALT (Gut Associated LT), BALT (Bronchus Associated LT), Cutaneous Immunity: CALT (Cutaneous-Associated Lymphoid Tissue).

Antigens **3 hrs**

Immunogenicity and antigenicity. Factors influencing immunogenicity. Types and characteristics of antigens:immunogens, Epitopes, haptens, Mitogens, Superantigens.

Humoral Immunity **6 Hrs**

Activation and differentiation of B cell. Germinal centre activity. Structure, classification and function of antibodies. Isotypes, allotypes, ideotypes. Synthesis assembly and expression of immunoglobulin molecules. B cell receptor. Antibody response. Immunoglobulin Genes and Generation of antibody diversities.

Cell Mediated Immunity **8 Hrs**

T cell activation, differentiation and Maturation. Understanding self and non self discrimination. T cell sub types (cytotoxic, helper, regulatory). T cell receptors. Role and structure of MHC molecules. Antigen processing and presentation by MHC I and II molecules. Interaction of T cell receptor with MHC I and II peptides and antigens.

Effecter Mechanism of Immune Response **9 Hrs**

Cytokines and chemokines: structure, type, function and their receptor. Therapeutic use of cytokines and their receptor. Complement system. Phagocytosis and opsonization of antigens. Cell mediated effecter responses. Lymphocyte migration, inflammation and Inflammatory responses. Hypersensitivity reaction. Autoimmunity, immune tolerance.

Immunological techniques **14 Hrs**

Antigen antibody reactions. Avidity and affinity. Specificity, cross reactivity. B cell activity measurement techniques (Ag-Ab reactions): Precipitation, Agglutination, Immunoelectrophoresis. Enzyme Immunoassays:Enzyme linked immunosorbent assay (ELISA), Radioimmunoassay (RIA), Immunofluorescence, Confocal Microscopy, Immunohistochemistry, Immunoblotting, and immunogold techniques. Production of monoclonal and polyclonal antibodies, Purification of antibodies. Immunoaffinity chromatography. T cell activity measurement techniques: Absolute lymphocyte count, DTH test, Fluorescence activated cell sorter (FACS). Therapeutics: Immunotherapy, Immunotoxins. Advances in Immunotechnology: Antibody engineering, Vaccinology.

References

Goldsby, R.A., Kindt, T.J., Osborne, B.A.. Kuby immunology. WH Freeman and Company. New York.

Janeway, C.A., Travers, P., Walport, M., Capra, J.D. Immunobiology (6th Edition). Garland Science, New York.

Abbas, A.K., Lightman, A.K., Pober, J.S. Cellular and molecular immunology (Fifth edition). SC Publication.

Booth, C. (Editor). Methods in Microbiology. Vol .IV, Academic Press.

Paul, W.E. Fundamentals of immunology. Raven Press New York.

Peters J.S, Baumgarten H. Monoclonal antibodies. Springer Verlag.

Roitt, I., Brostoff, J., Male, D. Immunology. HP Limited. NY.

Topley and Wilsons Text book on principles of Bacteriology, Virology and immunology (IX th edition). ASM Press/ Lipincott, London

Walsh, G. Proteins Biochemistry and Biotechnology. JW and Sons LTD.

Syllabi from different universities

Practical: Immunology and Immunotechnology
Course No.: BT 522L
Credit: 1

General Objective

To develop experimental skill on immune system and its diagnostic application

Specific objectives

- Experiment with antigens applying electrophoresis
- Production of antibody in animal model and purification
- Perform experiments on interaction of antigen-antibody by applying immunological techniques: Diffusion, Agglutination, Precipitation, ELISA, Westernblot
- Experiments of cell mediated immune responses: cytokines, DTH

Experimental works
Antigen

- Analysis of protein profile by Sodium Dodecyl Sulphate Polyacrylamide Gel Electrophoresis (SDS-PAGE).
- Quantification of protein concentration by Rocket Immunoelectrophoresis.

Antibody (Humoral immune response)

- Production and collection of polyclonal antisera from animal model against Ag.
- Purification of IgG by column chromatography.

Antigen-Antibody interarctions,

- Study of antigen-antibody interaction by single (Mancini) and double diffusion (Ouchterlony) method.
- Detection of Antibody against hapten carrier conjugate applying ELISA.
- Diagnosis of disease (visceral leishmaniasis) by Direct Agglutinition Test (DAT).
- Detection of targeted Ag/Ab by Western Blot technique.

Immune cell/tissue and culture

- Isolation of Macrophage from peritoneal lavage of animal model and *in vitro* culture of the phagocytic cells.
- Preparation of Giemsa stained dabbed slide of tissue from spleen, an organ of immune system, of animal model (Balb/c mice).
- Study of localized target tissue by Immunohistrochemistry.

Cell mediated immune response

- Comparative quantification of cytokines (IFN_Y) in the serum of infected and normal animal model.
- Study of cell mediated immune response by DTH in mice model.

References

Wilson, K and Walker, J. Practical Biochemistry, Principles and Techniques. Cambridge University Press

Harlow, E.D. and Lane, D. Using Antibodies. A Laboratory Manual. CSH Laboratory Press. NY.

Hay, F.C., Westwood, O.M.R. Practical Immunology (4th Edition). Blackwell Publishing

Walker, J.M. (Editor). The protein protocols handbook. Humana press, NJ

protocols in Immunology

M Sc biotechnology course of study

Title: Plant Biotechnology
Course code: 523
Credits: 3

General objectives

- To acquaint with the principles, techniques, scientific and commercial applications of plant tissue and cell culture
- To expose to methodologies of plant tissue and cell culture, micropropagation techniques and applications of tissue and cell culture to plant improvement
- To make familiar with the molecular biology of plant development
- To acquaint with various methods of plant transformation and their uses.
- To acquaint with the process and genetic control of Plant development

Specific objective

- To introduce tissue culture techniques and demonstrate the principles of tissue culture
- To demonstrate how to initiate and perform tissue culture with a crop of choice.
- To provide knowledge on specialized cell culture techniques and their uses in plant science research and industry.
- To acquaint applications of biotechnology in creating fast- growing and healthy trees
- To acquaint the use of tissue culture in the production of phytochemicals
- To get informed to the potential of genetic engineering in the study of plants and its application in the improvement of plant varieties
- To explain various molecular biotechnology methods used in plants
- To know the basic process of embryo, seed, vegetative organs and reproductive organs development and their genetic control.

Plant Micro-Propagation Technique and Types of Culture 10 hrs

Scope of plant biotechnology and its application. Role of *in vitro* tissue culture in plant biotechnology. Types of in vitro culture, Techniques of Micropropagation: Axillary buds proliferation, Regeneration throughmeristem culture, callus cultures, organogenesis and somatic embryogenesis. Production, preservation and use of somatic embryos as propagules. Artificial synthetic seeds production, Suspension culture: Cell culture, Protoplast isolation and culture**.** Types of cell culture (continuous, discontinuous and semicontinuous culture), automation technology and its application in tissue culture. Cryopreservation and germ plasm storage. Indexing for plant pathogens-Culture indexing for bacterial and fungal contaminant. Micropropagation of woody plant.

Application of Tissue/Cell cultureTechniques 8 hrs

Techniques of Meristem culture and *in vitro* grafting for the production of virus free plants**.** Pollen/ microspore culture for haploid plant production, use of haploids in plant breeding and mutation research. Techniques of Embryo culture and embryo rescue in agricultural and horticultural corps**,**Application of embryo culture in wide hybridization. Endosperm culture.Suspension culture in bioreactor:Secondary metabolite (medicinal and other commercial products) production, Biotransformation, economic aspects of *in vitro* production of secondary metabolite of plants.Induction of somaclonal variation, screening and its applications, Somatic hybridization and production of hybrids. Plant tissue culture as industry, Automation of micropropagation and industrial production of plantlets

Mass scale production **5 hrs**

Molecular farming: novel proteins, carbohydrate and lipids production, enzyme production and Plant derived Vaccine. Culture in bioreactor: Principles and the technology, Carbohydrate and other economic chemicals production. Secondary metabolite production through cell cultures. Pharmaceutical & beverage production.

Single cell culture: media and techniques for algal culture, algae and cyanobacteria as source of nitrogen rich fertilizer, Single cell protein,

Genetic manipulation of plants **15 hrs**

*Techniques of introducing DNA into plant cells: (**10 hrs)***

Marker and reporter genes used for plant transformation, Model plants and their Role in genetic manipulation, Indirect transformation: Genetic transformation of plant tissues with the use of *Agrobacterium,* Ti-plasmid and mechanism of T-DNA transfer (different protein involved and their rolr, vir region and other genes involved), Ti plasmid derived plant vector systems; binary and cointrigative vectors transformation process, regeneration of the transformed lines, Plant Viruses as biological vectors. Direct gene transfer methods in plants (Microprojectile bombardment, Electroporation; polyethylene glycol (PEG)- mediated gene transformation, Silica carbomfibres whiskers). Transformation of protoplasts with naked DNA

Genetically modified plant and their Application (5hrs)

Genetic engineering for plant improvement: Development of Pest resistance, herbicide resistance, resistance against viruses, improving stress tolerance, Protoplast fusion and its implication, Importance of GM plants,

Plant developmental biology **10 hrs**

Life cycle of angiospermic plant, Introduction to developmental biology and morphogenesis in plants, Processes and molecular control mechanisms of different developmental stages: endosperm development, embryo development (radial and axil patterning), Seed and seedling development, dormancy, germination, vegetative growth (Pattern formation during Root and Shoot meristem development), Determination of leaf primordial and differentiation of leaf cells, Vegetative bud development, transition to reproductive growth, formation of floral organs and Floral development, senescence

Laboratory work

Course Title: Laboratory work IV: Plant Biotechnology
Course No.: BT 523L
Credit: 1

Plant Micro-Propagation Techniques (Plant tissue culture)

- Sterilization techniques in plant tissue culture
- Composition of media and media preparation from stock solutions
- Plant propagation by seed culture
- Callus culture and growth of callus
- Callus culture for the *in vitro* production of phytochemicals, analysis of phytochemicals
- Induction of direct and indirect somatic embryogenesis from callus and preparation of synthetic seeds

- Micropropagation of plants by axillary bud/ single node culture proliferation
- Technique of acclimatization of *in vitro*propagated plants
- Cytological and histological analysis of *in vitro* cells
- Production of virus free potato by meristem/shoot tip culture (Virus test by ELISA)
- Haploid plants from anther/microspore culture of rice, wheat (cytological test to show the haploid nature of plant)
- Haploid culture from culture of *B. campestris*
- Protoplast culture and protoplast fusion of Pea or tobacco
- Technique of *in vivo* rooting from stem cuttings (*Gingo or Taxus*)

Genetic transformation of plant

- Isolation of genomic(by CTAB method) and mitochondrial DNA of plants
- Agrobacterium mediated transformation of tobacco*/Arabidopsis* using leaf disc method and production of transgenic plant.
- Molecular biological test of transgenic plants (T_0) by PCR-method Southern blot (Dig-labeling)
- Molecular biological test of expression of introduced gene by Northern Blot (Dig-labeling) and Western Blot
- Transformation of protoplast by PEG-mediated direct gene transfer and regeneration of transgenic plants

Reference Books

Adrian, S.N. **Scot N**and Fowler, M. (2003). Plant Biotechnology: The genetic manipulation of plants. Oxford University Press.

Alberts, B. et al. (2002). Molecular Biology of the cell. Gerland

Bhattarai, T. (2000). Experimental Plant Biochemistry and Plant Biotechnology (Tissue culture). Pub.: BhudipuranPrakashan, Kathmandu.

Bhattarai, T. (2007). Plant Physiology. Pub.: BhudipuranPrakashan, Kathmandu

Bhojwani, S.S. and Razdan, M.K. (1996). Plant Tissue Culture: Theory and Practice, Elsevier Science Publishers

Bhojwani S.S. (1990). Plant Tissue Culture:- Applications and Limitations, Elsevier Science Publishers

Chawla, HS (2008) Introduction to Plant Biotechnology Oxford IBH

Dixon, R.A. and Gonzales, R. A. (1994). Plant Cell Culture. A Practical Approach. IRL Press, Oxford University Press, New York

Gamborg, O.L. (2002). Plant Tissue Culture, Biotechnology, Milestones. In vitro cellular and Developmental Biology- Plant, 38, 84- 92.

Gelvin, S.B. and Schilperoort, R.A. (1998). Plant Molecular Biology Manual, 2nd edition, Kluwer Academic Publishing.

Goddijin, O.J. M. and Pen J. (1995). Plants as bioreactors. Trends in Biotechnology, 13, 379-87.

Hammond J, P McGarve and R. Yuusibov (2000). Plant Biotechnology: New products and applications.

Jha, S. (2010). An Introduction to Genetic Manipulation of Plants. Pub.: KFA Publication and Stores, Kathmandu

Mohr and Schoper. Plant Physiology

Portykens. I Spangenberg, G (1995). Gene transfer to Plants A laboratory manual. Springer, Heidelberg

Raghavan V. Developmental biology of flowering plants

Raghavan V. Molecular embryology of angiosperms

Robert, N. T and Dennis J.G. (2000). Plant Tissue culture Concept and Laboratory Exercises, (2nd edition). CRC Press.

Salater, A. Nigel, S. and Mark, F. (2003). Plant Biotechnology- Genetic manipulation of plants. Oxford University Press, Great Clarendon Street, Oxford, 2 60p.
Scott F. Gilbert (2010) Developmental Biology, Eighth Edition *Sinauer Associates, Inc*

Smith, R.A. (1992). Plant Tissue Culture. Techniques and Experiments. Academic Press, Inc., San Diego, CA
Tiaz and Zeiger ( )Plant Physiology
Watson JD, Gilman, M, Witkoski, J, Zoller, M (1993). Recombinant DNA. Freeman
Watson JD, Baker, TA, Bell, SP, Gann, A, Levine, M. Losick, R (2004) Molecular biology of gene. Pearson

M Sc biotechnology course of study

Course Title: Bioinformatics
Course No.: BT 524
Credits: 2

Objectives. At the end of the course, the students will be able to:

- understand Mol Biology with Information Technology
- to retrieve information from Biological Databases
- understand Algorithms & Statistics for Biological Software's
- analyze & Interpret Biological Data from Biological Databases
- use computational tools needed for wide range of genomic problem
- annotate unknown information through Computational Analysis
- understand creativity and development for Biological Databases, Tools & Software's
- perform Computational Biology modeling

Bioinformatics Basic

1hr

Introduction, Historical overview and Definitions , Bioinformatics Applications , Internet and search engines, database and database management system in Bioinformatics

Information Search and Data Retrieval **4 hrs**

Introduction, Tools for web search, Data retrival Tools (Pubmed, OMIM, Sequences Databases for Nucleotide & Amino Acids, Gene Bank, Entrez, SRS Other Databases (Primary, Secondary, Subsidary, Structural Databases) Data mining of BiologicslDatas, File Formats, Genome & Organism specific Databases. Annotated Sequence Databases.

Computational Method for Sequence alignment **6 hrs**

Local Alignment (Smith-Watermann Algorithm), Global Alignment (Needleman Wunsch Algorithm), Alignment Matrices (Dot Plot, Substitution Matrices PAM & BLOSUM), Alignment with Gap Penalties, Multiple Sequence Alignment, Guide Tree, Application of Sequence alignment, FASTA

BLAST:- Introduction, Types, Scores, E-values.

Computational Approach for Phylogenetic analysis **4 hrs**

Introduction, Distances, Types of Trees, Tree construction Methods (Ultra metric Case, Neighbor-Joining, Parsimony, MLH)**,** Application of Phylogenetic Analysis. Elements of phylogenetic models.

Genomics **5 hrs**

Genome,Structural Genomics, Functional Genomics, Genome Maping, sequencing(Next generation Sequencing), Comparative Genomics analysis, Large scale Genome analysis, Gene Prediction (Prokaryote & Eukaryote), Genome Annotation.

RNA Structure analysis **2 hrs**

RNA Secondary Structure Predictions. Covarience Model-SCFG-based RNA profiles.

Microarray Bioinformatics **2 hrs**

Sequence Databases for Microarrays,
Computer Design of Oligonucleotide Probes, Image
Processing, Analysis of Differentially Expressed Genes.

Introduction to basic Language and Algorithm **2 hrs**

Introduction to Perl, Introduction to Genetic Algorithm,

Structural Bioinformatics **6hrs**

Relationship of Protein three-dimensional Structure to protein Function, Evolution of Protein structure and Function, Obatining viewing & analyzing Structural Data (Rasmol, Chime, Cn3D), Structural alignment, Classification of proteins of known three dimensional Structures (CATH, SCOP), Homology Modelling.

Computer aided Drug Design:-Introduction, Drug Design Approaches and Methods.

Course Title: Laboratory work IV: Lab in Bioinformatics
Course code: BT524L
Credit: 1

Online Practicals will be conducted under the following URL:

- www.ncbi.nlm.nih.gov&www.expasy.org (Proteomics Server) to be familiar with Biological Databases and use freely available Biological Softwares& Tools
- Practical under Biology workbench
- Practicals using different Gene Prediction Tools
- Practicals using different Phylogenetic Tree construction Tools.

Reference Books

Campbell, A. M. and Heyer, L. J. (2004). Discovering Genomics, Proteomics &
Leach, A. R. (2001). Molecular Modelling. Prentice Hall
Andrew, J., Cammon, Mc, Harvey S. (1988). Dynamics of Proteins and Nucleicacids. Cambridge University Press.
Bioinformatics CHSL Press, Pearson Education
Brown, T. A. (1999). Genomes. John Wiley & Sons.
Cotterill, R. (2002). Biophysics: An introduction. John Wiley & Sons Press.
Durbin, R., Eddy, S., Krog, A., and Mitchison, G. (2003). Biological Sequence Analysis, Probablistics Models. Cambridge Press.
Elmasri, R. and Navathe, S.B. Fundamentals of database system. Addison-Wesley.
Ewens ,W. J. (2001). Statistical Methods in Bioinformatics. Springer Publication.
Higgins, D. and Taylor, W. (2000). Bioinformatics: Sequence, Structure, and Databanks. A Practical Approach. Oxford University Press.
Pevsner, J. (2003). Bioinformatics & Functional Genomics. John Wiley and Sons.
Mount, D. W.(2001). Bioinformatics Sequence and Genome Analysis. Cold Spring Harboor Laboratory Press, New York.
Pevzner, P. A.. (`2004). Computational Molecular Biology. An Algorithimic Approach PHI
Perun, T. J., Propst, C.L. (1989).Computer-Aided Drug Design.
Rastogi, S.C, Mendiratta, N., Rastogi, P. (2004).Bioinformatics, Methods and Applications. PHI Publication.
Stekel, D. (2003). Microarray Bioinformatics. Cambridge University Press.
Jin xiong, 2006, Essential Bioinformatics. Cambridge University Press

Course Title: Biophysical Chemistry
Course No.: BT 525
Credits: 2

Objectives

- The objective of this course is to understand the physical principles/properties of biological macromolecules including proteins, DNA, RNA and polysaccharides.
- The physical properties provide a description of their structures at various levels – atomic to multi-subunit assemblies.
- Accordingly this course will explore the interaction of macromolecules with different kinds of radiation, and their behavior in electric, magnetic, and centrifugal fields.
- The course will pay particular emphasis to thermodynamic, quantum mechanics and equilibrium principles.

Description of Biological macromolecules: 7hrs

Description of stoichiometry and geometry in macromolecules and structural complexity; description of configuration and conformation in macromolecules and their relation to small molecules; description of molecular interactions in macromolecules (strong and weak interactions and their distance and energy relationships); Cellular environment and role of water in defining macromolecular structure and biological function of macromolecules (solubility, hydrophobicity, membranes and transport across membrane; osmosis and osmotic pressure);

Symmetry and types of symmetry (mirror; rotational and translational) in macromolecules; Cartesian coordinate system and description of symmetry using simultaneous equations; application of symmetry elements to macromolecules at the molecular, monomeric unit and atomic level; hydropathy index of amino acids and partition coefficients, charge densities; amino acid abundance is proteins; protein sequences and their prediction; application of translational symmetry to polypeptide structure; Ramachandran's map and description of secondary structure in proteins; contact maps and description of secondary structure; supersecondary structure formation; description of 3D structure of proteins at the atomic level using translational symmetry; molecular graphics and their role in modeling macromolecular structure; brief description of quarternary structure of proteins with particular emphasis to symmetry and symmetry elements.

Thermodynamics: 4hrs

Heat, work and energy and molecular interpretation of thermodynamic quantities; entropy, free energy, and equilibrium.

Molecular thermodynamics: 3hrs

Complexities of macromolecular modeling and molecular mechanics; simulating macromolecular structure: molecular dynamic simulation and Monte carlo simulation.

X-ray Crystallography 4hrs

Atomic resolution, crystals, theory of X-ray diffraction; determination of crystal morphology and solving macromolecular structure by X-ray diffraction.

Scan Electron Microscopy, Tunneling Microscopy **2hrs**

Nuclear magnetic resonance (NMR): **3hrs**

Theory and description of small molecular and macromolecular structure by NMR techniques.

Scattering from solutions of macromolecules **2hrs**

Light scattering concepts and measurements; Examples: X-ray, Neutron, and Raman scattering phenomenon.

Absorption, Emission and IR Spectrometry, linear and circular dichroism of biological polymers, Mass Spectrometry (Electron Spray, MALDI-TOF) **7hrs**

Macromolecules in solution **1hr**

Equilibria and membrane potentials.

References:

Andrew, J., Cammon, Mc, Harvey S. (1988). Dynamics of Proteins and Nucleic acids. Cambridge University Press.
Cotterill, R. (2002). Biophysics: An introduction. John Wiley & Sons Press.
Lehninger Principle of Biochemistry 4th edition. David L. Nelson, Michael M. Cox.
Introduction to Spectroscopy by Donald L. Pavia, Gary M. Lampman, George S. Kriz and James A. Vyvyan (2008)

Course Title: Metabolic biochemistry and secondary metabolites

M Sc biotechnology course of study

Course No.: BT 526
Credits: 2

Objectives

- To acquaint students with basic knowledge of metabolism
- To provide the students the basic knowledge of Vitamines and coenzymes,
- To understand Synthesis and metabolism of biomolecules
- To know the various types of secondary metabolites synthesized by plants and animals and their importance.
- To expose the students to practical methods used in biochemistry laboratory

Introduction to metabolism **2hrs**

General characteristics of metabolic pathways: High energy compounds, Organic reaction mechanisms, Metabolic flux and coupled reactions; methods of investigation of metabolic pathways.

Vitamins and coenzymes **3 hrs**

Classification. Role of vitamins, metals and other cofactors in enzyme function. Water soluble vitamins and their coenzymes: thiamin pyrophosphate, pyridoxal-5-phosphate, nicotinamide coenzyme, Flavin, Coenzyme A, lipoic acid, biotin, folate, ascorbic acid, cobalamine. Lipid soluble vitamins: Vit.A, Vit.D, Vit.E and Vit.K.

Carbohydrate metabolism **7hrs**

Synthesis of carbohydrates (Tetrose, Pentose, Heptose, sucrose, glycogen, starch, cellulose), Pentose phosphate pathway, Digestion, absorption and mobilization of carbohydrates. Glycolysis reactions with emphasis on reaction mechanisms, feeder pathways of glycolysis, Gluconeogenesis, Citric acid cycle with emphasis on reaction mechanisms, Glyoxalate pathway, HMP pathway, ED pathway, fermentative pathways, electron transport chain (prokaryotic and eukaryotic), generation of ATP(Oxidative phosphorylation), glycogen metabolism. Regulation of carbohydrate metabolism.

Lipid metabolism **6 hrs**

Digestion, absorption and mobilization of lipid in human. Synthesis and degradation of fatty acids, ketone bodies, triacyl glycerol, eicosanoids, phospholipids and glycolipids. Synthesis and utilization of cholesterol and cholesterol derivatives (bile acids, steroids hormones etc.) Regulation of lipid metabolism.

Integration of metabolism: **2 hrs**

Integration of metabolic pathways, metabolic specialization of organs and hormonal regulation of metabolic pathways with emphasis on Insulin, glucagon, catachol amines.

Nucleic acid metabolism **2hrs**

Synthesis, degradation and regulation of purine and pyrimidine nucleotides.

Amino acid metabolism **4 hrs**

Digestion of proteins, absorption of amino acids. Transamination, deamination, urea cycle. Link between urea cycle and TCA cycle.

Secondary Metabolism **6 hr**

Secondary metabolites of plants, animals and microorganisms. Importance of secondary metabolites, Main types of secondary metabolites

Phenolic metabolism: Structure functions and use of Phenolic compounds, Biosynthesis-shikimate/ aroginate pathway, biosynthesis of important phenolic compounds like coumarins, flavenoides, lignins, tannins, quinones

Isoprenoid metabolism: Mevalonic acid pathway and isopentenyl pyrophosphate synthesis. Structure, uses and biosynthesis of important terpens, steroids and carotenoides

Special nitrogen containing metabolites: Structure, uses and biosynthesis of amines, glycosides and alkaloides.

Laboratory work
Course Title: **Laboratory work I: Metabolic Biochemistry and Secondary Metabolites**
Course No.: BT 526L
Credit: 1

- Isolation and quantitative assay of some metabolically important enzymes.
- Isolation and assay of vitamins from biological samples
- Effect of coenzyme and factors in the enzymatic reactions
- Effects of physical and chemical factors in the enzymatic reactions
- Isolation of some important secondary metabolites of
- Test of some Sec metabolites for medical uses

Reference Books

Boyer, R. F.(2001). Modern Experimental Biochemistry (3rd edition). Benjamin Cummings Publication.
Buchanan, Gruissem and Jones (2005): Biochemistry and molecular biology of plant. American society of Plant Biologists
Dey, PM and Harborne, JB (2000) Plant Biochemistry. Academic Press
Delvin, T.(eds) (1997).Textbook of biochemistry with clinical correlations. Willey-Liss Publications.
Goodwin and Mercer (1998) Introduction to plant biochemistry. Butterworth Heinemann
Herbert, R. B. (1989). The Biosynthesis of Secondary metabolites (2nd edition). Chapman and Hall.
Holme, D. and Peck, H. (1998). Analytical Biochemistry (3rd edition). John Wiley and Sons Inc.
Lehninger, A. L., Nelson, D. L. and Cox, M. M. (2004). Lehninger Principles of Biochemistry (3rd and 4th editions). Palgrave MacMillan Indian Edition.
Morris, C. J. O. R., and Morris, P. (1976). Separation Methods in Biochemistry, John Wiley and Sons Inc., New York.
Murray, R. K., Granner, D. K., Mayes, P. A. and Rodwell V. W. (1999). Harper's Biochemistry (25th edition) (Lange Series). McGraw-Hill Company.
Satyanarayana, U. (2004). Biochemistry (revised reprint). Books and Allied Pvt. Ltd.
Stryer, L., W. H. (1995). Biochemistry (4theditor). Freeman and Company, New York.
Voet, D. and Voet, J. D. (2004). Biochemistry (3rd edition). John Wiley and Sons Inc.
Wilson, K. and Walker, J. (eds.) (2000). Principles and Techniques of Practical Biochemistry. Cambridge University Press.
Zubay, G. L., Wm. C. (1996). Biochemistry (4th edition). Brown Publishers.

Third Semester

Course: Title: Food Biotechnology
Course No.: BT 611
Credits: 3

General objective
To provide scientific knowledge on microbial process of food production in an industrial scale

History and scope **2 hrs**
- History and cope of food biotechnology
- Intrinsic and extrinsic factors that affect microbial growth

Starter cultures **3 hrs**
- Introduction
- Mixed and defined cultures, and microorganisms
- Manufacture of cultures

Production of microbial food ingredients/products **10 hrs**
- Organic acids: citric acid, lactic acid, gluconic acid
- Amino acids: L-glutamic acid, L-lysine, L-tryptophan
- Vitamins: β-carotene, vitamin B_{12}, riboflavin
- Misc.: SCP

Technology of alcoholic beverages **7 hrs**
a) Production of alcoholic non-distilled beverages
- Wine (introduction, types, production)
- Beer (introduction, raw materials, malting, production)
- *Jand, sake*

b) Production of alcoholic distilled beverages
- *Raksi*, whiskey, branby, rum, vodka, gin

Food processing and quality **2 hrs**
- Postharvest operations: raw materials, cleaning, sorting and grading, peeling, blanching
- Concept of HACCP

Food preservation **5 hrs**
a) Principles: physical and chemical and biological methods of food preservation
b) Concept of hurdle technology for food preservation

Indigenous non-alcoholic fermented food products **6 hrs**
a) *Gundruk, sinki, kinema, mesu,* pickle, yoghurt (*dahi*), *jujudhau*
b) Sauerkraut, natto, soyu, miso, tempeh, kimchi, idli, kafir, vinegar

Tea processing technology **3 hrs**
- Introduction, manufacture, chemistry, grading

Functional foods **6 hrs**
a) Pro-biotics — definition, functional properties, interaction with pre-biotics, health benefits, food products (yoghurt, curd, etc.)
b) Pre-biotics — introduction, functions, sources, health benefits
c) Phytochemicals — introduction, active components, health benefits, sources

10. Fermented meat products **3 hrs**

- Introduction
- Starter cultures and their role
- Production of sausage, cured meat, etc.
- Quality and health benefits

Course Title : Practical Food Biotechnology
Course No.: BT 611L
Credit: 1

I. Regular Laboratory

- Screening of wine yeast from grapes
- Production of sauerkraut, kimchi
- Production of malt and beer and their quality evaluation
- Production of wine and their quality evaluation
- Production probiotic yoghurt
- Production and recovery of baker's yeast
- Production of soymilk and tofu
- Production and recovery of amino acids (glutamic acid, lysine)
- Production and recovery of organic acids (citric, lactic, acetic)

II. Project work

Survey on traditional fermented food products (*marcha, jand, raksi, kinema,* etc.)

III. Industrial visit

Visit of beer, wine, dairy industries of Nepal

References

- Gerald Reed (ed). 2004. Prescott & Dunn's Industrial microbiology (4th Ed). CBS Publishers & Distributors, N. Delhi
- Robert W. Hutkins. 2006. Microbiology and Technology of Fermented Foods. Blackwell Publ., IFT Press
- Bruce W. Zeocklein, Kenneth C. Fugelsang, Barry H. Gump and Fred S. Nury. 1995. Wine Analysis and Production. CBS Publishers and Distributors, N. Delhi
- James E. Bailey and David F. Ollis. 1977. Biochemical Engineering Fundamentals. McGraw-Hill Co.
- Murray Moo-Young (ed). 1985. Comprehensive Biotechnology, Vol 1-IV, Pergmon Press
- Aiba Shuichi, A.E. Humphrey and N.F. Mills. 1973. Biochemical Engineering, Academic Press, Inc.
- P.F. Stanbury, A. Whitaker and S.J. Hall. 1984. Principles of Fermentation Technology, Pergmon Press
- R. Malla. 2005. Lab. Manual in Microbiology. Meat and Dairy Technology, Ekta Offset Press

- G.P. Kharel and F. Hashinaga. 2004. Principles of Food preservation, Prasanti Publication, Kathmandu, Nepal
- G.P. Kharel, P.P. Acharya and B.K. Rai. 2010. Traditional Foods of Nepal, Highland Publ. (P) Ltd, Kathmandu, Nepal
- Eden, T. 1976. Tea. 3rd Edn. Longman, London

M Sc biotechnology course of study

Course Title: Medical and Pharmaceutical Biotechnology
Course No: BT 612
Credit: 3

Objectives
On the completion of the course the students should be able to:

- Describe history of molecular biotechnology in relation to health and disease
- Understand the latest concept of gene technology and gene therapy.
- Cloning and gene expression
- Understand concept of fetal and neonatal medicine
- Understand the importance of therapeutics and forensic medicine
- Explain the host and pathogens interactions

Molecular and medical genetics **5 hrs**

Autosomal dominant disorders as example marfan's syndrome, achondroplasia. Autosomal recessive disorders as example cystic fibrosis,spinal muscular atrophy. Sex linked disorders as example muscular dystrophy,x linked hypophosphatemia. Other disorders as example down's syndrome, klinefelters syndrome. Introduction to genetic diseases - Thallasaemia, Haemophiloia, Psoriasis, Parkinson's diseases, Alzheimer's disease. Introduction to Mitochondrial mutation based diseases.

Molecular oncology **6hrs**

Types of tumors, predisposing factors, cellular changes involved in tumor formation, genes associated with cancer, methods of tumor detection, hormone and non hormonal model of cancer, immunotherapy

Microbial diseases in humans **9 hrs**

Molecular biology of pathogenesis of : HIV, flu, Hepatitis viruses, *Mycobacterium tuberculosis, Vibrio cholerae, Plasmodium, Leishmania, Entamoeba*. Mode of action of drug and mechanism of drug resistance in pathogens. Molecular mechanisms for origin of new pathogens.

Therapeutics **7hrs**

rDNA derived drugs. Chemotherapy,immunotherapyandGene therapy: somatic and germ line gene therapy. Monitoring and response to therapy,geneticcounselling

Forensic medicine **6hrs**

Repetative DNA and its application in forensic medicine. Tissue analysis and human relationship.

Drug design and delivery technology **8hrs**

Combinatorial chemistry, Organized Drug discovery and development. Receptor versus enzyme mediated drug action.Rational design of enzyme inhibitors. ACE, Renin and HIV protease inhibitors.

1. **Nanobiotechnology in medical aspects** **2hrs**

Types of drug delivery through nanobiotechnology,types and synthesis of nanomaterials,protein based nanomaterials,DNA based nanomaterials,risk potential of nanomaterial

2. Stem cells and tissue engineering **5 hrs**

Types of human stem cells, properties of stem cells and their applications,Induced pluripotent stem cells and their applications(case study of relevance), introduction to tissue engineering, basic components and tissue engineering of specific tissues and organs

Course Title: Lab in Medical and Pharmaceutical Biotechnology
Course No: BT 612L
Credit: 1

Identification and characterization of blood
PCR in disease diagnosis, paternity determination and criminal investigations.
Detection of semen from given sample
Drug identification by spectrophotometric method
Determination of aspirin concentration in given sample by spectrophotometry.
Drug testing by TLC
Testing of the drug as miotic or mydriatic on rabbit's eye.
Testing the effect of various anesthetics and calculation of its induction time, down time and recovery time on mice.
Phage titration
Pedigree Analysis and genetic counseling.
Inhibitory effect of various drugs on the growth of various diseases causing organisms.

Reference Books

Kaushik D Deb,satish M Totey(2009)Stem cells.Basics and applications
Glick and Pasternak,(2008).Molecular Biology,Principles and applications of recombinant DNA.
Abbas et al. (2001). Cellular and Molecular Immunology. Saunders
Black. (2002). Microbiology principles and exploration. Wiley.
Griffiths et al.(2004). An introduction to genetic analysis. Freeman
Lewin, B. (2004). Gene IX. 2005
Meesfeld**,** (1999). Applied molecular genetics. Wiley-Liss
Streips and Yasbin**.** (2002). Modern microbial genetics. Wiley
Turn and Trempy (2004). Fundamentals of bacterial genetics. Blackwell Publications.
Watson et al. (2004). Molecular biology of gene

Books for Practical work

Alberts, B., Bray, D., Lewis, J. Raff, M., James K. R. D, Watson (1989). Molecular biology of the cell (2nd edition). Garland Publishing Inc, New York and London.
Ausubel F. M., Brent, R., Kingston, R. E., Moore, D. D., Seidman, J. G., Smith, J. A., Struhl, K. (Eds) (1999). Short Protocols in molecular biology (4th edition). John Wiley and Sons, INC. New York, Chichester, Weinheim, Brisbane Singapore, Toronto.
Freifeldes, D. (1987). Molecular Biology (2nd edition). Jones and Bartlet Publishers: Boston, Portola Valley.
Sambrook, J. and Russell, D. (2001). Molecular Cloning: A laboratory manual. Vol. III, CHSL Press.

Course Title: Environmental Biotechnology
Course No.: BT 613
Credits: 3

Objectives

- To familiarize the students with the recent development in the environmental biotechnology in relation to environment research.
- To familiarize Microbial biotechnology applicable in pollution monitoring, bioremediation of polluted environment and solid waste management

Molecular techniques in Environmental research **4 hr**

Molecular genetic and molecular biology approaches to the environmental and ecological research problems. Application of the techniques: their advantages and limitations including organism typing. Biodiversity and biotechnology (with emphasis on conservation Biodiversity technology).

Environmental microbiology **5 hr**

Interaction of microbes with their immediate surroundings, i. e soil and water, and plant and animal hosts. Adaptation of microbes in extreme environments. Properties of microbes exploited for human benefit. Techniques used to track genetically engineered microbes in the environment, Interaction of plant parasitic microbes with their hosts.

Microbial biotechnology **4 hr**

Pollution monitoring (e.g. use of bacterial and viral pesticides, biosensors to detect environmental pollutants), the role of genetic engineering in biomonitoring and bioremediation. Biomineralization (microbially induced metal deposits). MOS in mineral recovery and detection Biological bleaching. Biosensors.

Microbial interaction **7 hr**

Environmental determinants that control microbial growth and activity. Study of organisms that survive and function in physiochemical stress and constrain of the ecosystem (Plant and animal). Extremophile organisms as source of enzymes. Microbial interaction for recovery of production of cometalism product. Roles of these organisms in the transformation of energy and cycling of nutrients in ecosystems. Study of detrivorous organisms. Positive and negative ways of microbial interactions.

Pollution microbiology **6 hr**

Interactions between microorganisms and naturally occurring organic matter. Degradation and persistence of environmental pollutants. Mechanisms of organic matter decomposition and pollutant degradation with particular emphasis in environmental systems. Application of these processes in biological treatment of chemically contaminated ecosystems. Bio-cleaning technologies (degradation of lignin and plastic, removal of spilled oil and grease deposits)

Contaminated Land and Bioremediation **6 hr**

Typical contamination problems. Methodologies for assessing the extent and seriousness of contamination. Bioremediation, Applicability and effectiveness of bioremediation techniques compared to other remediation processes. Biotechnology for pollution abatement. Treatment of solid waste for rapid degrading technology. Hazardous waste control technology. Restoration of soil contaminated with heavy metals by the use of microbes.

Environmental toxicology **4 hr**

Xenobiotic chemicals in the environment. Their sources, effects and exposure of biota. Modes of action accompanied by examples of chemical toxicity in the environment.

Water and Wastewater Engineering **7 hr**

Physical and chemical pretreatment processes. Chemical oxidization and reduction. Biological treatment of sewage and industrial affluent. Immobilized cells and enzymes for waste water treatment. Sedimentation. Precipitation and flocculation. Filtration and membrane processes.

Environmental radioactivity **2 hr**

Origins and behaviour of natural and artificial radionuclides in the environment. Their radiological consequences and the practices required to minimize these. Their application to the understanding of natural processes.

Course title: Laboratory work: Environmental Biotechnology
Course code: BT 613L
Credit 1

Toxicant level determination in environmental samples

- Application of Atomic Absorption Spectrophotometer (AAS) in the analysis of environmental samples
- Determination of toxic metals in samples (soil and plant) from contaminated sites (sample collection, sample preparation and instrumental analysis)
- Study of bioaccumulation and biomagnification of toxic metals in the food chain (producers, herbivores, carnivores) of contaminated ecosystem
- Determination of toxic metals in plants to identify the accumulators and hyperaccumulators for application in bioremediation of contaminated sites

Isolation and identification of microbes from contaminated water and soil

- Isolation of microbes from contaminated water and soil and study of interaction with the surroundings and their use in biomonitoring (microbe species as indicators of contamination)

Isolation and identification of microbes useful for bioremediation.

- Microbial degradation of wastes and pollutants (in solid wastes and waste water)
- Study of autopurification of flowing water (sampling at different parts, isolation and identification of bacteria)

Reference Books

Agarwal, S.K. (1998): Environmental Biotechnology. Vedams Books from India. 389 p.

Rittmann, B, E., McCarty, P, L. (2001). Environmental Biotechnology- Principles and Applications, Amazon.com's.
Rittmann, B, E., (1994)In situ Bioremediation Willium Andrew Publishing
Dubey, R.C. A text book of Biotechnology, S.Chand& Co. Delhi
Wise, D.L. (1996): Global environmental biotechnology, Elsevier Science and Technology Bookstore: http://books.elsevier.com/elsevier/?isbn=0444825347. Proceedings of the Third International Symposium of the International Society for Environmental Biotechnology, Boston, MA USA.
Das Gupta, H.K. (2005): A textbook of Biotechnology. Wiley & Sons
Evans, G M; Furlong, J C Environmental Biotechnology -Theory and Application; ISBN:047084373X
Jördening, H.J., Winter, J. (Editors). Environmental Biotechnology - Concepts and Applications, Wiley VCH.
Purohit, S.S. (2005), Biotechnology - Fundamentals and Applications. S.Chand& Co. Delhi.
Ratledge, C. and Kritinson B. **(……..):** Biotechnology. Cambridge University Press.
Scragg, Alan(.2005). Environmental Biotechnology; nhbsenvironment bookstore ISBN: 0582276829
Shrestha, P.M. (2004). Environmental Microbiology. Books Paradise Enterprises, Kathmandu.
Smith, JE (2004).Biotechnology. Cambridge University Press

M Sc biotechnology course of study

Course Title: Agriculture Biotechnology

Course No.: BT 614
Credits: 3

General Objective
Students are expected to gain knowledge about application of biotechnology in agriculture sector.

Specific objectives:

The students should be able to:

- produce and utilize organic and bio-fertilizers
- know the importance of stresses in plant productivity
- apply methods of plant health testing
- know the use of DNA marker in plant breeding
- produce transgenic crop plant
- produce bio-pesticides
- apply preservation techniques like Cryo-preservation and lyophilization (freeze-drying) techniques for organisms of commercial importance

Organic farming **2 hr**
Soil management and organic fertilizers. Composting and vermicomposting.

Plant-beneficial microbe interaction at molecular level **10 hr**
Nitrogen metabolism, Biochemistry, Genetics, and Physiology of biological nitrogen fixation; Process of nodule formation in Rhizobium-legume Symbiosis, Regulation and functions of rhizobial nodulation genes, Nitrogen-fixation in root nodule. Mycorrhizal association, Use of mycorrhizae for enhancing crop productivity, Phosphate solubilizing microorganisms. PGPR acting via plant hormones (auxins) and enhancement of water and mineral uptake (*Azospirillum*, *Herbaspirillum, and mycrorrhiza*). Nitrogen fixing microorganisms and blue green algae as bio-fertilizer, Azolla as bio-fertilizer in rice field.

Algal biotechnology **2hr**
Mass cultivation of micro-algal species of commercial value: *Spirulina*, *Dunaliella*, *Chlorella*and others,Micro-algae for human and animal consumption; and waste-water treatment.

Plant health **14 hr**
a. Biotic stress **8 hr**
Plant disease: disease epidemic, Plant pathogen interaction, the plant defense system. Phytoalexins and Immune system in plant, Innate immunity: PAMP*-triggered immunity (PTI) and effector-triggered immunity (ETI). The gene-for-gene model and the hypersensitive response (HR). Systemic acquired resistance (SAR). D*isease diagnosis*: Traditional methods, Immunological methods: Diffusion, Agglutination, Enzyme linked immuno sorbent assay (ELISA), Immunofluorescence techniques. Molecular techniques: Polymerase chain reaction (PCR), real time-PCR, Randomly amplified polymorphic DNA (RAPD), Restriction fragment length polymorphism, 16s rDNA. *Crop protection*: Chemical control by Pesticides and its Pros and cons, *Biological control*: Management of plant diseases caused by fungi, Bacteria, virus, nematodes and insects; Microbial herbicides; Bacterial biopesticides;

Production of biopesticides; Fungal biopesticides; Entomo-pathogenic fungi, benefits of biological control, Integrated pest management,Maintainingvirus free plants.
Genetic control:, Making plant resistance by breeding and Genetic engineering.
*Pathogen associated molecular pattern

b. Abiotic stress **5hr**

iEnvironmental factors as stress: Abiotic and biotic stresses, perception to stress and creation of signal, Plant reactions to stress, Structural and physiological adaptation and molecular control to different stresses: light, Temperature, water (drought and flooding), salt and heavy metal, Engineering stress tolerant plant.

c. Post harvest stress **1 hr**

Aspects of plant health related to post-harvest. Biotic and abiotic stresses at storage

Plant as source of energy (Biofuels) **2 hr**

Plant biomass as source of renewable fuel, Cellulose, hemicellulose lignin degrading and bioethanol producing microorganisms. Technology, prospect, pros and cons to use biomass for production of bioalcohol, biodisel and biogas.

Crop Improvement **9 hr**

a. Plant breeding **4 hr**

Methods and use of classical plant breeding. Molecular marker technology,Marker assisted selection in plant breeding. **QTL (Quantitative Trait Loci)**, Genetic analysis and characterization of crops with various DNA markers and isozymes. Application of Biotechnology in plant breeding programs., Testing GM crops

b. Genetic modification **5 hr**

Crop improvement: Genetic engineering for making crop plants resistance to bacteria, fungi, virus and insects (Rice, Tobacco, Bt cotton etc.); herbicide resistance (glyphosate resistance soybean), Modification of phyto-nutrients in crops (Golden rice etc.), tolerance to stresses; Gene subtraction: Antisense technology, Modification of ripening of fruits and vegetables (Tomato). Termination technology, *Molecular farming*: Use plant as chemical and pharmaceutical factories for the production of novel products. *Problem with GMO*: public concern and safety concern.

Mushroom Biotechnology **7hr**

Poisonous andnon poisonous mushroom, Introduction to wild and cultivated mushrooms of Nepal and their economic importance.. *Reproduction*: Mating system in fungi,.Homothallism, Secondary homothallism, Heterothallism (bipolar and tetrapolar). Life cycle of mushroom, *Mushroom cultivation*: Effect of genetic factors, temperature, light, humidity, medium on cultivation of mushrooms. Techniques of Commercial cultivation of some important mushrooms, Single spore isolation/pure culture and spawn production techniques, Present situation and prospect of mushroom cultivation in Nepal. *Medicinal values of mushroom*: Medicinal mushrooms, Medicinal importance chemicals like Polysaccharides, Gluco-peptides. Steriods. Bioactive compounds such as nucleosides, cordycepinetc found in mushroom

Agro Genetic Resources conservation **2 hr**

Phytosanitory aspects of plant germplasm conservation. Cryopreservation. Cataloging, characterization, evaluation and utilization of genetic resources. National seed policy, Seed: seed health, diseases, quality, viability and storage

Course title: Laboratory : Agriculture Biotechnology

Course code: BT 614L
Credit: 1

- Isolation, Identification, inoculation of Bacteria and fungi for crop nutrition (cellulose degrading microorganisms, phosphate solubilizing organisms, fungi of Mycorrhizae)
- Study of isozyme polymorphisms
- Molecular diagnostic tests for plant virus, bacterial and fungal infection
- Biological control of pathogenic bacteria and fungi at the laboratory scale
- Production of biofertilizers in mass scale
- Disease resistance and bio-cidic effect of biopesticides
- Study on pesticide degrading characteristics of microorganisms
- Study of composting microbiology and vermiculture
- Mushroom forays in surrounding areas of Kathmandu Valley.
- Drying and preparation of herbarium specimens of mushrooms
- Preparation of mycological media
- Demonstration on *In vitro* production of mushroom fruiting bodies, preparation of Isolates of mushrooms from spores and tissues
- Demonstration on effect of nutrition on mycelial growth of fungi
- Demonstration on homothallism and heterothallism in agar media
- Mushroom collection and preparation of herbarium specimens.
- Spore and tissue isolations from fresh mushrooms
- Isolation of lignocellulose biomass degrading and bioalcohol producing microorganism

Reference Books

Adhikary, M.K. (1999). Mushrooms of Nepal.
Ainsworth, G.C. and Sussman, A.S. (Eds.). (1965-73). The fungi; an advanced treatise Vol. I-IV. Academic Press, New York.
Agrios, G.N. (2005). Plant Pathology, 5th Ed. Elsevier Academic Press.
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Anke, T. (ed.) (1997). Fungal biotechnology. Chapman & Hall, London, New York.
Bhattarai, T. (2000). Experimental Plant Biochemistry and Plant Biotechnology (Tissue culture). Pub.: BhudipuranPrakashan, Kathmandu.
Bhattarai, T (2007) Plant Physiology, BhudipuranPrakashan, Kathmandu.
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Carlile, M.J., Watkinson, S.C. and Gooday, G. (2001). The fungi (2nd Ed.) Academic Press, San Diego, San Francisco.
Chrispeels, MJ and Sadava, DE (2003) Plants Genes and Crop Biotechnology (Edited Book). American Society of Plant Biology.

Cook, R.J and Baker, K.F (1983). The nature and Practice of Biological Control of Plant Pathogens. APS. Press, St. Paul.
Day, J. G. and McLellan, M.R. (Eds.) (1995). Cryopreservation and freeze-drying protocols. Methods in molecular biology 38. Humana Press.
Elliott, C.G. (1994). Reproduction in Fungi: Genetical and Physiological Aspects. Chapman & Hall
Fincham, J.R.S., Day , P.R. and Radford, A. (1979). Fungal Genetics 4th ed. Blackwell Scientific Publications, Oxford.
Griffin, D.H. (1996) Fungal Physiology (2nd Ed.). John Wiley & Sons, INC, New York.
Hobbs, C. (1995). Mushrooms, An Exploration of Tradition, Healing, and Culture. Botnica Press, Santa Cruz.
Kirakosyan, A. and Kaufman, PB (2009) Recent advances in Plant Biotechnology. (Edited Book) Springer
Kirk, P.M., Cannon, P.F., David, J.C., Staplers, J.A. (Ed.) (2001). Ainsworth and Bisby's Dictionary of the Fungi (9th Ed.) CABI Bioscience, Egham, UK
Kornerup, A. and Wanscher, J.H. (1978). Methuen Handbook of Colour (3rd Ed.). Erye Methuen, London.
McNeil, B. and Harvey, L.M. (1990) Fermentation: A Practical Approach. Oxford University Press, Oxford.
Moore, D. (1998). Fungal Morphogenesis: Developmental and Cell Biology Series No. 35. Cambridge University Press.
Moore-Landecker, E. (1996). Fundamentals of the Fungi (4th Ed.) Prentice Hall International, Inc.
Palaniappan, S. P. and Annadurai, K.. (1999). Organic Farming Theory & Practice. Scientific Publishers India.
Purohit, S.S. (2005). Biotechnogy fundamentals and application. Student edition.
Richmond A. (Ed.) (1986). Hand Book of Micro algal Mass Culture. CCP Press Boca Raton, Fl.
Sastry, M.V.S., Muralidharan, K, and Prasad, G.S.V. (2004).Production and marketing of seed and seed material. Padma Publishers.
Gail L. Schumann , Cleora J. D Arcy 2009 Essential Plant Pathology, Second Edition [Hardcover],. APS Press.
Slater, A., Scott, N., Fowler, M. (2003). Plant Biotechnology: The Genetic Manipulation of PlantsOxford University Press
Smith, J.E. and Berry, D.R. (Eds.) (1975-1983). The Filamentous fungi Vol. I-IV. London.
Stacey, G, Burris, H. and Evans, H. J. (Eds.) (1992). Biological Nitrogen Fixation, Chapman & Hall, New York Sung, J.M. (1996). The Insect-born fungus of Korea. Kyo-Hak Publishing Co. Ltd., Seoul.
Talbot, N. (Ed.) (2001). Molecular and cellular Biology of Filamentous Fungi: A Practical Approach. Oxford University Press, Oxford.
Varma, A. (1997). Mycorrhiza Manual. Springer Verlag.

M Sc biotechnology course of study

Course Title: Animal Biotechnology
Course No. BT 615
Credits: 3

Objectives

- Familiarization to techniques applied for the production of improved animal breeds through bio -molecular technique
- Offering practical knowledge on tissue culture, in situ conservation and vaccine production.
- Understanding the techniques used for animal cloning
- Familiarization to various techniques applied for disease diagnosis
- Providing practical knowledge on animal cell culture and preservation techniques

Animal Reproductive Techniques and Manipulation **10hr**

- Review on comparative anatomy and hormonal regulation of reproductive system. Spermatogenesis, Oogenisesis
- Collection, preservation and extension of liquid semen.
- Frozen semen: processing, preservation and extension
- Estrus /Menstruation synchronization, superovulation (MOET). Artificial Insemination (AI), Collection and Preservation eggs.
- In vitro Fertilization (IVF) Process, Fertilization, Implantation, Placentation
- Pregnancy diagnosis (external and biological method), Intra cytoplasmic sperm Injection (ICSI) Embryo bisection, nuclear transplantation. Advances in embryo manipulation

Animal cell /Tissue Culture **6 hr**

- terminologies of primary and established cell lines, Culture and maintenance of Cell lines, Characterization of cultured cells.
- Measurement of Viability. Cytotoxicity.
- Animal tissue culture
- Stem Cell culture. Embryonic and Adult Stem cell culture and their applications.
- Short term lymphocyte culture. Fibroblast culture from chick embryo.

Transgenic Animals

8hr

- Trangenesis and application of transgenic techniques, techniques of gene manipulation and Gene Transfer,
- Advances in the transgenic animal production in cattle, buffalo, sheep, goat, swine poultry, mouse, rabbit and fish,
- Fish polyploidy , fish chromosome and gene manipulation ,
- Gene knock out technology for animal models ,
- Recombinant Genes for theProduction of entities of pharmacological and commercial values.

Molecular control of Animal embryo Development **10hr**

Cell-cell communication in development (1 hours)

Review of cell signaling, paracrine and endocrine factors cell death pathways, juxtacrine signaling differentiated state, the extracellular matrix, integrins, epithelial-mesenchymal transition

Early development in birds and mammals (3 hours)
Development in birds: cleavage, gastrulationaxis specification. Mammalian development:
Cleavage , gastrulation, axis formation,the dorsal-ventral and left-right axes

Sex determination in mammal (1 hour)
Primary sex determination, secondary sex determination

Medical aspects of developmental biology (3 hours)
Disease of development:genetic errors and human syndromes, genetic and phenotypic heterogeneity, prenatal diagnosis and preimplantationgenetics, teratogenesis, cancer as a disease of development. Developmental therapies:anti-angiogenesis, stem cells and tissue regeneration

Molecular Techniques in animal conservation and improvement of species 7 hr

- Marker assisted technology, identification,
- Selection of farm animals and rear animal species for production and conservation,
- Phylogenic study through molecular technique,
- Use of Gene and Protein polymorphism such as RFLP, SNP, PCR, RAPD
  Quantitative Trait Link (QTL) analysis for animal improvement

Animal disease diagnosis , Vaccine and Antibody Production and Gene Therapy 5 hr

- Immunological and molecular methods of disease diagnosis (ELISA, DNA probes PCR, Western, Northern and Southern blotting).
- Development of live recombinant vaccine, sub unit vaccine and DNA vaccines,
- Animal Model for vaccination, Monoclonal and polyclonal antibody production in animal model and purification,
- Application of Gene Therapy

Animal Microflora 2 hr

- Probiotics, Prebiotics manipulation of rumen/gut microflora

Course Title: Laboratory: Animal Biotechnology
Course No. BT 615L
Credits: 1

1. Preparation of blood tubes for primary culture of protozoan parasite
2. Study of genotoxicity effect of ciprofloxacin in human lymphocytes
3. Study of effect of UV rays by DNA fragmentation assay
4. Antiserum against human RBC in rabbit and evaluation of antibody titre by hemagglutination (HA) test
5. Collection of bull semen and its physical, chemical, microscopic evaluation
6. Cryopreservation of collected semen
7. Thawing and artificial insemination
8. Pregnancy diagnosis in farm animals by rectal palpation and cervix examination
9. Cultivation of new castle disease virus in embryonated eggs and vaccine production against it
10. Detection of new castle disease virus by hemagglutionation test
11. Detection of antibodies to new castle disease virus by hem agglutination inhibition test
12. Cultivation of fowl pox virus in embryonated eggs and vaccine production against fowl pox disease
13. Immunization of animal model (goat) with antigenic peptide for production of polyclonal antibody
14. Serum collection, processing and purification of polyclonal antibody by affinity chromatography
15. Quality control of antibodies by SDS-Page and western blotting

Reference Books

- Legates, J.E.Breeding and improvement of farm animals
- Lastey, J.F. Genetics of Livestock improvements.
- Benzamin L. (2005) Gene IV. Pearson Prentice Hall
- Biotechnology applied to the diagnosis of animal diseases (OIE). June, Vol. 12(2), 1993.
- Sambrook D. and W. Russell. (2001). Molecular cloning. A laboratory Manual (3 Volume set). Cold Spring Harbour Laboratory Press.
- Hafez E.S.E. (2000). Reproduction in Farm Animals (7^{th} Edition). Lea and Febiger, Philadelphia.
- Freshney R.I. (2000). Culture of animal cells. 4^{th} Edition, John Wiley & Sons, Inc., Publication, USA.
- H. K. Das. 2004. Text Book of Biotechnology. Wiley Dreamtech India

M Sc biotechnology course of study

Course title: Biostatistics and Research Methodology
Code No.: BT 616
Credit hour: 2

Objectives
After the completion of this course, students will be able to utilize the knowledge on research methodology and applications of statistical methods in research work that required for a master level biotechnology student. Specifically, student will be able to:

- Solve the problem related probability theory including sampling theory
- Determine the significance of any study by utilizing appropriate tests
- Handle the regression, correlation problems including Multivariate analysis
- Select appropriate experimental design and utilize the statistical software for the researches they are going to conduct
- Develop appropriate scientific writing and communication skill

Concept and Application of Probability 5 hr

- Review of concept of probability, additive and multiplicative probability. Binomial probability and Poisson distribution, Normal and Z distribution and applications, Conditional probability and Bayes rule. Mathematical expectations

General Introduction to Sampling Theory 2 hr

- Principle of Random Sampling, Non Probability Sampling: Purposive, Quota , Convenience and Self selected sampling. Probability sampling: systematic, Stratified and Cluster sampling, Determination of sample sizes

Statistical Test 4 hr

- Test of significance, Test on means, Estimation and test of hypothesis, Type I and Type II error, Confidence Interval. Z, t and F tests, and non parametric test: Chi Square Test

Regression and Correlation and Fitting of Data 3 hr

- Simple Linear correlation and regression for two or more variables, Least Square methods. Fitting of linear, probabilistic , exponential to time series data and making projections.

Multivariate Analysis 3 hr

- Multivariate Analysis, Principle Component Analysis (PCA), Cluster Analysis,

Researches and Experimental Designs 8 hr

- Varieties of researches. Essentials of experimental design. Application of experimental design: CRD, RCBD, Latin Square, Two Factorial, Three Factorial, Split Plot Design, Nested Design. Mean Comparison: LSD and DMRT

Computational Statistics **4 Hr**

- R – Plus, SPSS, Gen Stat, Bayesian methods including Markov Chain Monte Carlo

Scientific Researches communication/Writing **3 Hr**

- . Thesis, Research, Project and Article writingincluding Proposal writing

References

Different Publications of Biotechnology (Journals)
Singh, M.L. Understanding Research Methodology Third edition, Distributor, National book centre, Kathmandu
Singh, M.L, Sing, M.L. Statistical Methods, National Book Centre, Bhotahity
Gurung, C.K**.** A hand book of biostatistics, Makalu Books, Kathmandu (In press)
Different Publications of Biotechnology (Journals)
Ewens, W. J. (2001).. Statistical Methods in Bioinformatics. Springer Publication
RudraPratap(2006). Getting Started with MATLAB 7. OXFORD University Press.

Course Title:IPR, Biosafety and Bioethics
Course No. BT 617
Credits: 1

Objectives

- to determine knowledge on the relevant scientific concepts and on skills necessary to contribute to the ongoing social dialogue about science and society.
- to make students able to evaluate critically the ethical issues related to biotechnology and the positive and negative aspects of biotechnology.
- To provide information on ethical issues in plant, animal and human biotechnology

IPR **8hrs**

Introduction, Categories (Patents, Copyrights, Trademarks, Geographical indications, Industrial designs, Layout design of integrated circuits, Trade secrets, Breeder's rights, Utility models), WTO: As an international agency controlling trade among nations. WTO with references to biotechnological affairs, TRIPs. - General Introduction: WIPO, Patent claims, the legal decision – making process, ownership of tangible and intellectual property. Basic Requirements of Patentability: Special issues in Biotechnology Patents: Disclosure requirements, Collaborative research, Competitive research - Plant biotechnology: Foreign patents, Plant variety protection act, and the strategy of protecting plants. - Patent Litigation: Substatritive aspects of patent litigation, Procedural aspects of patent litigation, different Doctrines. Case studies of patent.

Biosafety **4hrs**

Handling of Biological and radiolabelleled materials. Biosafety regulations in the handling of recombinant DNA processes and products in institutions and industries, biosafety assessment procedures abroad. Biotechnology and food safety: The GM-food debate and biosafety assessment, Ecological safety assessment of recombinant organisms and transgenic crops, case studies of relevance (e.g. Bt cotton), Biosafety assessment of biotech pharmaceutical products such as drugs/vaccines etc. International dimensions in biosafety: Cartagena protocol on biosafety, bioterrorism and convention on biological weapons.

Bioethics **3hrs**

Bioethics: Legality, morality and ethics, the principles of bioethics: autonomy, human rights, beneficence, privacy, justice, equity etc. Biotechnology and Bioethics: The expanding scope of ethics in biotechnology, ethical conflicts in biotechnology - interference with nature, fear of unknown, unequal distribution of risks and benefits of biotechnology, bioethics vs. business ethics, ethical dimensions of IPR, technology transfer and access to techonological .

Reference Books

Adhikari, R., Belbase, N. and Ghale, Y. (2000). Seed of Monopoly: Impact of TRIPs Agreement on Nepal. Forum for Protection of Public Interest (Pro Public) and Action Aid, Nepal.
Chaudhary, R.P. (1998). Biodiversity in Nepal - Status and Conservation. Tecpress Books, Bangkok, pp. 125-127; 252-255.
Chaudhary, R.P. (1999). Intellectual Property Rights (IPRs) - Mechanisms and Issues. BotanicaOrientalis, 2056: 125-129.
Chaudhary, R.P. (1999). Intellectual Property Rights and Farmers Rights. National Conference on Wild Relatives of Cultivated Plants in Nepal, pp. 215-223. Green energy Mission/Nepal.
Eisner, T. (1989). Prospecting for nature's chemical riches. Issues in Science and Technology, 6(2): 31-34.

Gamez, R., Piva, A., Sittenfeld A., Leon, E., Jimenez, J. and Mirabelli, G. (1993). Costa Rica's conservation program and national biodiversity institute (INBio). In: W.V. Reid, S.A. Laird, C.A. Meyer, R. Gamez, A. Sittenfeld, D.H. Janzen, M.A. Gollin and C. Juma (Eds.), Biodiversity Prospecting: Using Genetic Resources for Sustainable Development, pp. 53-67. World Resource Institute, USA.

Geeta Rani, M. (2000). Community gene banks sustain food security and farmers' rights. Monotor, No. 41: 19-22.

Gollin M.A. (1993). An Intellectual Property Rights Framework for Biodiversity Prospecting. In: W.V. Reid, S.A. Laird, C.A. Meyer, R. Gamez, A. Sittenfeld, D.H. Janzen, M.A. Gollin and C. Juma (Eds.), Biodiversity Prospecting: Using Genetic Resources for Sustainable Development, pp. 159-197. World Resource Institute, USA.

Posey, D.A., Dutfield, G. and Plenderleith, K. (1995). Collaborative Research and Intellectual Property Rights. Biodiversity and Conservation, 4: 892-902.

Reid, W.V., Laird, S.A., Gamez, R., Sittenfeld A., Janzen D.H., Gollin, M.A. and Juma C. (1993). A new lease on life . In: W.V. Reid, S.A. Laird, C.A. Meyer, R. Gamez, A. Sittenfeld, D.H. Janzen, M.A. Gollin, and C. Juma (Eds.), Biodiversity Prospecting: Using Genetic Resources for Sustainable Development, pp. 1-52. World Resource Institute, USA.

South Centre (1997). The TRIPs Agreement – a guide for the south. Chemin du Champ-d'Anier, Geneva and Switzerland.

Svarstad, H.andDhillion, S. (2000). Bioprospecting: From biodiversity in the south to medicines in the north. Spartacus Forlag, As, Oslo.

Swanson, T. (1995). Intellectual Property Rights and Biodiversity Conservation. Cambridge University Press, London

Ten Kate, K. and Laird, S.A. (2000). The commercial use of biodiversity: Access to genetic resources and benefit sharing. Earthscan Publications, London.

Watal, J. (2001). Intellectual Property Rights in the WTO and Developing Countries. Oxford, New Delhi.

Biotech Policy Of Nepal published by MOEST

Relevant websites (few):

www.bio.org/ethics - America

www.newscientist.com/hotttopics/cloning

www.webdesk.com/biotechnology-ethics

Course Title : Entrepreneurship Development
Code No. BT 618 E1
Credit Hours : 2

General Objectives
The module aims to prepare the students for the possibility of starting their own entrepreneurial ventures with successful identification of venture opportunities and preparation of a business plan.

Specific Objectives
- Empowering necessary knowledge and skills to start new business venture
- Preparing consultant or facilitator to individual/institution aspiring for business ventures
- Developing expertise in identifying prospective business ventures and preparing business plan
- Promoting self employment and creating new jobs

Course Description
Overview of basics of entrepreneurship, entrepreneurial role in the economy and emerging trends in entrepreneurship (internet and e-commerce). Factors affecting entrepreneurship growth. Entrepreneurial thought, process and approaches. Concept and development of creativity.
Innovation : Concept, types and sources. Entrepreneurial risk and its types. Entrepreneurial stress : Sources and management.
Business opportunity identification : Sources and methods of generating new ideas.
Feasibility studies : Business description, marketing and financial component, development and production, organization and management and forms of ownership. Selection of best option.
Business plan : Concept, benefits and preparation (practical exercise).
Legal provisions for starting new venture.
Need for institutional support to entrepreneurs and its present status (strengths and weaknesses).

Detailed Course Outline

Unit	Course Content	Lecture Hour
I.	Introduction Overview of the basics of Entrepreneurship: Concept and elements of entrepreneurship, entrepreneur and entrepreneurship, entrepreneurial role in the economy, emerging challenge and trends in entrepreneurship (internet and e-commerce).	4
II.	Entrepreneurship Growth: Factors affecting entrepreneurship growth, entrepreneurial thought, process and approaches.	2
III.	Creativity and Innovation: Concept and development of creativity, concept, types, development and sources of innovation.	2
IV.	Entrepreneurial Risk Stress and Management: Entrepreneurial risk and types, entrepreneurial stress, types and sources, management of stress.	3
V.	Business opportunity Identification: Concept, sources and methods of generating new ideas	2
VI.	Feasibility studies: Concept and components, business description, marketing and financial component, development and production,	5

	organization and management and forms of ownership. Selection of best option.	
VII.	Business plan: Concept, benefits and preparation (practical exercise).	4
VIII.	Starting New Venture: Introduction of legal provisions of related laws and regulations.	5
IX.	Institutional Support to Entrepreneurship: Need, institutions (government, non-government and others) involved for entrepreneurial development, support modus, present status of institutional support and its strengths and weaknesses.	5

Recommended Readings

Dollinger, M.J. (2003). *Entrepreneurship:Strategies and Resources.* New Delhi:Pearson Education.

Hisrich, R.D.,Peters, M.P. and Shepherd, D.A. (2007).*Entrepreneurship.*NewDelhi:Tata McGraw Hill Publishing Company.

Kuratko, D.F. and Hodgetts, R.M. (2005). E*ntrepreneurship:Theory,Process and Practice.*Singapore:Thomson Asia Pte. Ltd.

Course title : Project practical/scientific writing

Course no : BT619L

Credit : 1

Objectives

Provide practical knowledge to work independently in a scientific problem

Develop scientific report writing skill.

Each student should work in an independent mini-project. He/she will get a short experimental problem by faculty of CDBT, which he/she should solve by doing experiments. The problem will be given in such a way that the experiments will complete within about 3 weeks. After completion of the project the student should write scientific report of the project and present his results in a seminar. The evaluation of the report and presentation will be done by the concerned faculties.

Fourth Semester
Course Title: Thesis
Course code: BT 621
Credit: 6

Each student should conduct an independent research work under the supervision of a faculty of Tribhuvan University or a research scientist in the related field on a topic of interest agreed upon by the concerned supervisor and the student. The research work should normally be completed within 6 months. On the completion of the work a thesis should be submitted to the department. The evaluation of the thesis will be done jointly by an external examiner and the supervisor. The student must make an oral presentation in the department, which will be evaluated by examination board coordinated by Head of the Department with supervisor, external examiner and internal examiner as members.

Course Title: Seminar
Course code: BT 622
Credit: 0

All students must attend and take active participation at the student seminars organized by the department. Each student must make presentation on at least one research paper or topic provided to him. He should answer questions related to the presentation in the seminar. Evaluation will be done by assessing his quality of preparation and presentation and participation in all the departmental seminars presentation.

Elective courses
All elective courses are extra credit and it will not be counted in overall grade. Two elective courses are offered in enterpreunership and management technology in 3rd and 4th semester to provide managerial skill.

More elective courses will be formulated to provide depth knowledge to the student in a specific subject of biotechnology. The courses will be designed by the faculties according to their expertise. Faculties are requested to formulate such course and to submit the course to subject committee which will be recommended to faculty board of IoST. If such elective course is passed then the concerned faculty will be responsible to conduct such course.

Code. No: BT 623
Types of course: Elective
Course Title : Management of Technology
Credit Hours : 2

Objectives
Generic Objectives
The module aims to impart required knowledge and skills to the students so as to enable them to manage technology effectively in enterprises.

Specific Objectives
- Empowering necessary knowledge and skills for the management of technology in manufacturing enterprises
- Preparing consultant or facilitator to individual/institution in the fields of technology management
- Encouraging research and development in technology
- Developing and supporting technology research and development institutions
- Promoting planning culture for management of technology

Course Description
Conceptualization of Management of Technology:Meaning and focus of technology and technology management. Objectives and issues of technology management.
Technology Transfer: Typology and approaches (economic and engineering) to technologies.
Technology and Transformation: Modes of technical transfer and indicators determining the modes of transfer.
Developing Countries and Technology Transmission: Theory of transfer, criterion for effective technology transfer, Key role factor for effective transfer system and problems in transforming successful technologies. Pros and cons of existing technology transfer policies in Nepal.
Research and Development in Technology: Present status and problems of institutions (government, universities, corporate and individuals) in technology research, development and transfer of technologies in related sectors of the economy.
Emerging issues in the management of technology and developing framework of planning for the management of technology.

Unit	Course Content	Lecture Hour
I.	Introduction: Conceptualization of Management of Technology, meaning and focus of technology and technology management. Objectives and issues of technology management.	4
II.	Technology Transfer: Concept, typology and approaches (economic and engineering) to technologies.	3
III.	Technology and Transformation: Need for technology transfer, modes of technical transfer and indicators determining the modes of transfer.	3
IV.	Developing Countries and Technology Transmission: Features of developing countries, need for technology transmission, and its impact, theory of transfer, criterion for effective technology transfer, Key role factor for effective transfer system and problems in transforming successful technologies. Pros and cons of existing technology transfer policies in Nepal.	8
V.	Research and Development in Technology: Role of research in technology development, present status and problems of institutions (government, universities, corporate and individuals) in technology research, development and transfer of technologies in related sectors of the economy.	7
VI.	Issues in Planning and Management of Technology: Emerging issues and trends in the management of technology and developing framework of planning for the management of technology. Addendum: case studies of Nepal.	7

Recommended Readings

1. Cohen, Goel.(2003). *TechnologyTransfer.* New Delhi:Sage Publication.

Cohen, Goel. Technology Transfer: *Strategic Management in Developing Countries.* New Delhi:Sage Publication.

2. McLaughlin, L. and Harris, M. (eds). (1997). *Innovation, Organization Change and Technology.*Boston: International Thompson Business Press.
3. Narayan, V.K. (2009). *Managing Technology and Innovation for Competitive Advantage.* New Delhi: Pearson Publication.
4. National Planning Commission (NPC), Nepal. *Plan Documents* (recent)