Scheme of Examination and Syllabus

Affiliated Colleges

(W.E.F. 2020-21)

M.Sc. (Biotechnology)

BASED ON
CHOICE BASED CREDIT SYSTEM

Department of Bio and Nano Technology
Guru Jambheshwar University of Science & Technology, Hisar-125 001, Haryana

REVISED SCHEME OF EXAMINATION M.Sc. BIOTECHNOLOGY
(2020-21 w.e.f. Sem-I)

FIRST SEMESTER

Sr. No.	Course No.	Title	Type	L	P	Credit
1.	BTL-511	Introductory Biotechnology	PC	4	0	4
2.	BTL -512	Biomolecules and Metabolism	PC	4	0	4
3.	BTL-513	Cell Biology	PC	4	0	4
4.	BTL-514	General & Applied Microbiology	PC	4	0	4
5.	BTP-515	Lab I (Biochemistry)	PC	0	6	3
6.	BTP-516	Lab II (Microbiology)	PC	0	6	3
		TOTAL		**16**	**12**	**22**

SECOND SEMESTER

Sr. No	Course No.	Title	Type	L	P	Credit
1	BTL -521	Theory & Applications of Biotechniques	PC	4	0	4
2	BTL -522	Molecular Biology	PC	4	0	4
3	BTL -523	Fundamentals of Immunology	PC	4	0	4
4	BTL -524	Plant Cell, Tissue and Organ Culture	PC	4	0	4
6	BTP -525	Lab III (Immunology)	PC	0	6	3
7	BTP -526	Lab IV (Plant Cell, Tissue and Organ Culture)	PC	0	6	3
8	Open Elective	Open Elective offered by other department/ Any MOOC through SWAYAM/NIPTEL	OE	4	0	4
		TOTAL		**20**	**12**	**26**

THIRD SEMESTER

Sr. No.	Course No.	Title	Type	L	P	Credit
1.	BTL-531	Genetic Engineering	PC	4	0	4
2.	BTL-532	Enzymology & Enzyme Technology	PC	4	0	4
3.	BTL-533	Molecular Genetics	PC	4	0	4
4.	BTL-534	Introductory Bioinformatics	PC	4	0	4
5	BTP-535	Lab V (Genetic Engineering)	PC	0	6	3
6	BTP-536	Lab VI (Bioinformatics)	PC	0	6	3
7	BTT-595	In Plant/Summer Training	PC	0	6	3
		TOTAL		**16**	**18**	**25**

FOURTH SEMESTER

Sr. No.	Course No.	Title	Type	L	P	Credit
1.	BTL-541	Agriculture Biotechnology & IPR	PC	4	0	4
2	BTL-542	Fermentation Technology	PC	4	0	4
3	BTL-543	Genomics and Proteomics	PC	4	0	4
4	BTL 544-547	Program Elective	PE	4	0	4
5	BTP-548	Lab. VII (Fermentation Technology)	PC	0	6	3
6	BTT-600	Industrial Training/ Research Training	PC	0	6	3
		TOTAL		16	6	**22**

Program Elective (PE): Choose any one course
BTL-544 Bioentrepreneurship
BTL-545 Food Biotechnology
BTL- 546 Medical Biotechnology
BTL-547 Environmental Biotechnology

Semester	Credit
1st	22
2nd	26
3rd	25
4th	22
TOTAL	**95**

Note:**Program core (PC). L=Lecture, P=Practical T=Tutorial**

Program core (PC)	Program Elective (PE)	Open Elective (OE)	Total Credit
87	**4**	**4**	**95**

General Instructions:

1. The minimum credit requirement for the M.Sc. (Biotechnology) for Affiliated Colleges is 95 credits including 04 credits for Open Elective Courses and 04 for Program Elective. As per MHRD guidelines student (M.Sc. Biotechnology) may opt one MOOC course through SWAYAM to earned total credit. List of offered MOOC course will be notified by the department in the start of semester.
2. Among the Program Electives Courses the student is required to opt only one from out of the four courses
3. No Program Elective Course will run unless a number of students registered for the Program Elective Course is less than five.
4. For theory courses, one hour per week per semester is assigned as one credit excluding tutorial. For practical courses six hours per week accounts for 3 credits. One hour per week per semester is assigned as half credit.
5. Each theory paper examination will be of 3 hours duration and practical examination will be of 4 hours duration.

6. After the completion of second semester the students are required to undertake an In-Plant Training /Summer Training BTT-595 comprising of 4-6 weeks in any industry/research organization/institute and shall be required to submit an In-Plant/Summer Training Report for which viva-voce and evaluation examination will be conducted internally.
7. In the fourth semester, the students are required to undertake Industrial/ Research Training BTT-600 comprising of 6-8 weeks in any industry/research organization/institute and shall be required to submit a report for which seminar, presentation and viva-voce examination will be conducted.

BTL 511: INTRODUCTORY BIOTECHNOLOGY (Credits: 4+0)

Max Marks: 80
Internal Marks: 20
Time: 3 Hours

Note: The examiner is requested to set nine questions in all, selecting two questions from each UNIT and one compulsory question (Question No.1 based on entire syllabus will consist of seven short answer type questions each of two marks). The candidate is required to attempt five questions in all selecting one from each UNIT and the compulsory Question No.1.

UNIT I

Biotechnology: An overview-definition, scope and importance of Biotechnology, Concept of Recombinant DNA technology and Gene Cloning.

Microbial Biotechnology: A brief account of microbes in industry and agriculture, Metabolic engineering for over production of metabolites.

UNIT II

Plant Biotechnology: Introduction to plant tissue culture and its applications, Gene transfer methods in plants, Transgenic plants (A brief introduction), Chloroplast and mitochondria engineering.

Animal Biotechnology: *In-vitro* fertilization and embryo transfer in humans and livestock, Transfection techniques and transgenic animals, Animal Cloning.

UNIT III

Medical Biotechnology: (A brief account) Biotechnology in medicine, Vaccines, Diagnostic, Forensic, Gene therapy, Nano Medicine & Drug Delivery Cell & Tissue Engineering, Stem Cell therapy.

Environmental Biotechnology: (A brief account) Role of biotechnology in pollution control, Sewage treatment, Energy management, Bioremediation, Restoration of degraded lands and Conservation of biodiversity.

UNIT IV

Nano Science & Technology: An Overview, Insights and intervention into the Nano world, Important Developments, Societal implications & Ethical issues in Nanotechnology, Applications of Nanobiotechnology in different areas.

Bioinformatics: (A brief account) Importance, Scope of Bioinformatics, world wide web as a tool, Bioinformatics institutes and databases, Bioinformatics training & limitations.

Bio-business and Bio-safety, Biotechnology for developing countries and IPR

Recommended Books:

1. Das, H.K., Textbook of Biotechnology, Willey Dreamtech. Pvt. Ltd, New Delhi. 2004.
2. Natesh S., Chopra V.L. & Ramachandran S., Biotechnology in Agriculture Oxford & IBH, New Delhi. 1987.
3. Kumar, H.D., A Text Book of Biotechnology, Eastern Willey Press, New Delhi. 2004.
4. Tizard, I.R., Immunology- An introduction, 5th Edition, Philadelphia Saunders College press. 2013.
5. Bharat, B., Handbook of Nanotechnology. Springer. 2010.
6. Gupta, P.K., Biotechnology & Genomics, 5th Reprint, Rastogi Publications Meerut. 2010.

7. Singh, B.D., Biotechnology, 4th Edition, Kalyani Publication. 2010.
8. Black, J.G., Microbiology- Principles and Explorations, 7th Edition, John Wiley & Sons. 2008.

BTL 512: BIOMOLECULES AND METABOLISM

(Credits: 4+0)
Max Marks: 80
Internal Marks: 20
Time: 3 Hours

Note: The examiner is requested to set nine questions in all, selecting two questions from each UNIT and one compulsory question (Question No.1 based on entire syllabus will consist of seven short answer type questions each of two marks). The candidate is required to attempt five questions in all selecting one from each UNIT and the compulsory Question No.1.

UNIT I

Biomolecules: An introduction, General structure of biomolecules, Fundamental principles governing structure of biomolecules, Importance of covalent and non covalent bonds.

Carbohydrates: Structure and function of biologically important mono, di and poly-saccharides, glycoproteins & glycolipids. Metabolism of carbohydrates-Glycolysis, Feeder pathways, Citric acid cycle, Gluconeogenesis, Glyoxylate and Pentose phosphate pathways and their regulations.

UNIT II

Proteins: Structure of amino acids, non-protein and rare amino acids. A brief account of amino acid biosynthesis and degradation, Urea cycle. Structural organization of proteins, Reverse turns and Ramachandran plot, Supra-molecular complexes of proteins. Chemical synthesis of peptides and small proteins. Protein sequencing.

UNIT III

Lipids: Structure of fatty acids, Classification of lipids, Structure and functions of major lipid subclasses- Acylglycerols, Phospholipids, Glycolipids, Sphingholipids, Waxes, Terpenes and Sterols. Fatty acids biosynthesis, degradation and their regulations, Ketone bodies synthesis. Biosynthesis of TAG, Cholesterol, Phospholipids and Glycolipids.

UNIT IV

Nucleic Acids: Structure and properties of nucleic acid bases, nucleosides and nucleotides. Biosynthesis and degradation of purines and pyrimidines, Salvage pathway.

Vitamins: Structure and biochemical roles of fat and water-soluble vitamins and their co-enzymes.

Recommended Books:

1. Stryer, L., Biochemistry, 8th Edition. New York: Freeman. 2015.
2. Nelson, D.L., Cox, M.M. & Lehninger, A.L. Lehninger Principles of Biochemistry, 7th Edition, New York, NY: Worth. 2017.
3. Voet, D. & Voet, J.G., Biochemistry, 5th Edition, Hoboken, NJ: J. Wiley & Sons.
4. Dobson, C.M., Protein Folding and Misfolding. Nature, 426(6968), 884-890. doi:10.1038/nature02261. 2016.
5. Richards, F.M., The Protein Folding Problem. Scientific American, 264(1), 54-63. doi:10.1038/scientificamerican0191-54. 1991.

BTL 513: CELL BIOLOGY (Credit 4+0)

Max Marks: 80
Internal Marks: 20
Time: 3 Hours

Note: The examiner is requested to set nine questions in all, selecting two questions from each UNIT and one compulsory question (Question No.1 based on entire syllabus will consist of seven short answer type questions each of two marks). The candidate is required to attempt five questions in all selecting one from each UNIT and the compulsory Question No.1.

UNIT I

Structural organization and function of intracellular organelles: Cell wall, nucleus, mitochondria, Golgi bodies, lysosomes, endoplasmic reticulum, peroxisomes, plastids, vacuoles, chloroplast, structure &function of cytoskeleton and its role in motility.

Membrane structure and function: Structure of model membrane, lipid bilayer and membrane protein diffusion, osmosis, ion channels, active transport, membrane pumps, mechanism of sorting and regulation of intracellular transport, electrical properties of membranes.

UNIT II

Cell division and cell cycle: Mitosis and meiosis, their regulation, steps in cell cycle, regulation and control of cell cycle.

Cell signaling Hormones and their receptors, cell surface receptor, signaling through G-protein coupled receptors, signal transduction pathways, second messengers and regulation of signaling pathways

UNIT III

Cellular communication: general principles of cell communication, cell adhesion and roles of different adhesion molecules, gap junctions, extracellular matrix, integrins. Neurotransmission and its regulation.

Cancer Genetic rearrangements in progenitor cells, oncogenes, tumor suppressor genes, cancer and the cell cycle, virus-induced cancer, metastasis, interaction of cancer cells with normal cells, apoptosis, therapeutic interventions of uncontrolled cell growth.

UNIT IV

Photosynthesis and Respiration: Photosynthetic apparatus, light reaction, cyclic and noncyclic photoinduced electron flow, C3 and C4 cycle and their regulation and CAM pathway, Photorespiration, dark phase of photosynthesis.

Recommended Books:

1. Gilbert S F (2002), Developmental Biology, SF Sinauer Associates Inc. 2002.
2. Freedman L.P., Molecular Biology of Steroid and Nuclear Hormone Receptors, Birkhuser. 1998.
3. Hardin J., Bertoni G. & Kleinsmith, L.J, Becker's world of Cell. 8th Edition, Pearson. 2012.
4. Karp, G., Iwasa, J. & Marshall, W., Karp's Cell and Molecular Biology (9th Ed.). John Wiley & Sons. 2020.
5. Lodish, H., Berk, A., Kaiser, C.A., Krieger, M., Bretscher, A., Ploegh, H., Amon, A. & Martin, K.C., Molecular Cell Biology (8th Ed.). W. H. Freeman & Co. 2016.
6. Alberts, B., Johnson, A.D., Lewis, J., Morgan, D., Raff, M., Roberts, K., & Walter, P. (2014). Molecular Biology of the cell (6th Ed.). Garland Science.

BTL 514: GENERAL AND APPLIED MICROBIOLOGY

(Credits: 4+0)
Max Marks: 80
Internal Marks: 20
Time: 3 Hours

Note: The examiner is requested to set nine questions in all, selecting two questions from each UNIT and one compulsory question (Question No.1 based on entire syllabus will consist of seven short answer type questions each of two marks). The candidate is required to attempt five questions in all selecting one from each UNIT and the compulsory Question No.1.

UNIT I

Introduction to Microbiology: Historical background and scope of Microbiology. Ubiquitous nature of microorganisms. Impact of microbes on human affairs. Structure of prokaryotic and eukaryotic cell. Differences between Eubacteria, Archaebacteria and Eukaryotes. Salient features of different groups of microorganisms such as bacteria, fungi, protozoa and algae including their morphological features, mode of reproduction and cell cycle.

UNIT II

Nutrition and Classification: Principles of microbial nutrition- Chemoautotrophs, chemoheterotrophs, photoautotrophs and photoheterotrophs. Basic principles and techniques used in bacterial classification. Phylogenetic and numerical taxonomy. New approaches of bacterial classification including DNA hybridization, ribosomal RNA sequencing and characteristics of primary domains. Major groups of bacteria based on latest edition of Bergey's manual.

UNIT III

Viruses: General characteristics, structure, and classification of plant, animal and bacterial viruses, Replication of viruses. Lytic and lysogenic cycle in bacteriophages. A Brief account of Retroviruses, Viroid's, Prions and emerging viruses such as HIV, Avian and swine flu viruses.

Microbial Growth: The definition of microbial growth. Growth in batch culture. Mathematical representation of bacterial growth, Bacterial generation time. Specific growth rate. Monoauxic, Diauxic and synchronized growth curves. Measurement of microbial growth. Factors affecting microbial growth. Brief account of growth in fungi. Culture collection and maintenance of microbial cultures.

UNIT IV

Control of Microorganism: Control of Microorganism by physical and chemical agents. Antiseptics and disinfectants. Narrow and broad spectrum antibiotics. Antifungal antibiotics, Mode of action of antimicrobial agents. Antibiotic resistance mechanisms.

Microbial Ecology: Microbial flora of soil, Interaction among microorganisms in environment. Symbiotic associations- types, functions and establishment of symbiosis. Brief account of biological nitrogen fixation.

Recommended Books:

1. Pelczar, M.J., Reid, R.D. & Chan, E.C. Microbiology (5th Ed.). New York: McGraw-Hill. 2001.
2. Matthai, W., Berg, C.Y. & Black, J.G. Microbiology, Principles and Explorations. Boston, MA: John Wiley & Son. 2005.
3. Willey, J.M., Sherwood, L., Woolverton, C.J., Prescott, L.M. & Willey, J.M., Prescott's Microbiology. New York: McGraw-Hill. 2011.
4. Madigan, MT, Bender, K.S., Buckley, D.H., Sattley, W.M. & Stahl, D.A., Brock Biology of Microorganisms (15th Ed.). Pearson/ Benjamin Cummings. 2018.
5. Pommerville, J.C., Alcamo's Fundamentals of Microbiology (10th Ed.) Jones and Bartlett Learning. 2013.

BTP 515: Lab I (Biochemistry) (Credits: 0+3)

Max Marks: 80
Internal Marks: 20
Time: 3 Hours

List of Experiments:

1. Preparing various stock solutions and working solutions that will be needed for the course.
2. To prepare an Acetic-Na Acetate Buffer and validate the Henderson-Hasselbach equation.
3. To determine an unknown protein concentration by plotting a standard graph of BSA using UV-Vis Spectrophotometer and validating the Beer- Lambert's Law.
4. Separation and identification of amino acids by paper chromatography.
5. Separation and identification of amino acids / lipids by thin layer chromatography.
6. Purification and characterization of an enzyme from a recombinant / natural source (such as Alkaline Phosphatase or Lactate Dehydrogenase or any enzyme of choice).
    a) Preparation of cell-free lysates
    b) Ammonium Sulfate precipitation
    c) Ion-exchange Chromatography
    d) Gel Filtration Chromatography
    e) Affinity Chromatography
    f) Dialysis of the purified protein solution against 60% glycerol as a demonstration of storage method.
    g) Assessing purity of samples from each step of purification by SDS-PAGE Gel Electrophoresis
    h) Enzyme Kinetic Parameters: Km, Vmax and Kcat.
7. Experimental verification that absorption at OD_{260} is more for denatured DNA as compared to native double stranded DNA. Reversal of the same following DNA renaturation. Kinetics of DNA renaturation as a function of DNA size.
8. Identification of an unknown sample as DNA, RNA or protein using available laboratory tool.

Recommended Textbooks and References:

1. Sawhney, S.K. & Singh, R., Introductory Practical Biochemistry, Narosa Publishing House. 2009.
2. Plummer, D., An Introduction to Practical Biochemistry (3rd Ed.). McGraw Hill Education.2017.
3. Sadasivam, S., Biochemical Method (3rd Ed.). New Age International Pvt Ltd Publishers. 2018.
4. Jayaraman, J., Laboratory Manual in Biochemistry. New Age International Private Limited. 2011.

BTP 516: Lab I (Microbiology) (Credits: 0+3)

Max Marks: 80
Internal Marks: 20
Time: 3 Hours

List of Experiments:

1. Sterilization, disinfection and safety in microbiological laboratory.
2. Media Preparation for cultivation of microorganisms.
3. Isolation of bacteria in pure culture by streak plate method.
4. Study of colony and growth characteristics of some common bacteria: *Bacillus, E. coli, Staphylococcus*etc.
5. Preparation of bacterial smear and Gram's staining
6. Light compound microscope and its handling
7. Microscopic observation of bacteria (Gram +ve bacilli and cocci, Gram –ve bacilli), cyanobacteria, algae, and fungi.
8. Calibrations of microscopic measurements (Ocular, stage micrometers)
9. Measuring dimensions of fungal spores
10. Simple and differential staining (Gram staining).
11. Spore staining, capsule staining and negative staining.
12. Enumeration of bacteria: standard plate count.
13. Growth curve of bacteria in batch culture.
14. Antimicrobial sensitivity test and demonstration of drug resistance.
15. Maintenance of stock cultures: slants, stabs and glycerol stock cultures.
16. Determination of phenol co-efficient of antimicrobial agents.
17. Determination of Minimum Inhibitory Concentration (MIC)
18. Isolation of Rhizobium from root nodules

Recommended Books:

1. Cappuccino, J.G., & Welsh, C., Microbiology: a Laboratory Manual. Benjamin-Cummings Publishing Company. 2016.
2. Collins, C.H., Lyne, P.M., Grange, J.M., & Falkinham III, J. Collins and Lyne's Microbiological Methods (8th Ed.). Arnolds. 2004.
3. Tille, P.M., Bailey & Scott's Diagnostic Microbiology (14th Ed.). Elsevier. 2017.
4. Kapoor, K.K. & Paroda, S., Experimental Soil Microbiology. CBS Publishers. 2007.
5. Garg, F.C., Experimental Microbiology. CBS Publishers & Distributors. 2005.

BTL 521: THEORY & APPLICATIONS OF BIOTECHNIQUES

(Credits: 4+0)
Max Marks: 80
Internal Marks: 20
Time: 3 Hours

Note: The examiner is requested to set nine questions in all, selecting two questions from each UNIT and one compulsory question (Question No.1 based on entire syllabus will consist of seven short answer type questions each of two marks). The candidate is required to attempt five questions in all selecting one from each UNIT and the compulsory Question No.1.

UNIT I

Microscopic Techniques: Principles and applications of light, Phase contrast, Fluorescence microscopy, Scanning and Transmission Electron Microscopy, Confocal Microscopy. Flow Cytometry.

Centrifugation: Preparative and analytical Centrifuges, Sedimentation analysis, RCF, Density Gradient Centrifugation.

UNIT II

Chromatography Techniques: Theory and Application of Paper Chromatography, TLC, Gel Filtration, Ion Exchange Chromatography, Affinity Chromatography, GLC and HPLC.

Electrophoresis Techniques: Theory and Application of PAGE, Agarose Gel Electrophoresis, Iso-electric Focusing, Blotting techniques- Southern, Northern and Western Blotting.

UNIT III

Spectroscopic Techniques: Theory and Application of UV and Visible Spectroscopy, FTIR Spectroscopy, MS, NMR, Atomic Absorption Spectroscopy, X- ray diffraction, Raman Spectroscopy.

UNIT IV

Radio-isotopic Techniques: Introduction to Radioisotopes and their biological applications, Radioactive Decay – Types and Measurement. Principles and Applications of GM Counter, Solid and Liquid Scintillation Counter, Autoradiography, Radiation Dosimetry.
Other Techniques: Particle Size Analyzer, Circular Dichroism.

Recommended Books:

1. Banwell, C., Fundamentals of Molecular Spectroscopy (4th Ed.) McGraw Hill. 2017.
2. Lakowicz, J. & Joseph, R., Principles of Fluorescence Spectroscopy (3rd Ed.) Springer. 2006.
3. Valeur, B., Molecular Fluorescence: Principles and Applications (2nd Ed.) Wiley. 2013.
4. Rupp, B., Biomolecular Crystallography: Principles, Practice and Application to Structural Biology (1st Ed.). Garland Science. 2009.
5. Wilson, K. & Walker, L., Principles and Techniques in Practical Biochemistry (5th Ed.). Cambridge University Press. 2000.
6. Dash, U.N., Textbook of Biophysical Chemistry. Macmillan Publishers India. 2006.
7. Cantor, C.R. Schimmel, P.R., Biophysical Chemistry: Part 2: Techniques (1st Ed.). W.H Freeman and Co. 2008.
8. Campbell, I.D., Biophysical Techniques. Oxford: Oxford University Press. 2012.
9. Serdyuk, I.N., Zaccai, N.R., & Zaccai, G., Methods in Molecular Biophysics: Structure, Dynamics, Function. Cambridge: Cambridge University Press. 2007.
10. Chakravarty, R., Goel, S. & Cai, W., Nanobody: The "Magic Bullet" for Molecular Imaging? Theranostics, 4(4), 386-398. doi:10.7150/thno.8006. 2014.

BTL 522: MOLECULAR BIOLOGY (Credits: 4+0)

Max Marks: 80
Internal Marks: 20
Time: 3 Hours

Note: The examiner is requested to set nine questions in all, selecting two questions from each UNIT and one compulsory question (Question No.1 based on entire syllabus will consist of seven short answer type questions each of two marks). The candidate is required to attempt five questions in all selecting one from each UNIT and the compulsory Question No.1.

UNIT I

DNA Structure: DNA as genetic material, Chemical structure and base composition of nucleic acids, Double helical structures, Different forms of DNA, Forces stabilizing nucleic acid structure, Super coiled DNA, Properties of DNA, Renaturation and denaturation of DNA. Tm and Cot curves, Structure of RNA.

UNIT II

DNA Replication: General features of DNA replication, Enzymes and proteins of DNA replication, Models of replication, Prokaryotic and eukaryotic replication mechanism. Replication in phages, Reverse transcription

Transcription: Mechanism of transcription in prokaryotes and eukaryotes, RNA polymerases and promoters, Post-transcriptional processing of tRNA, rRNA and mRNA (5' capping, 3' polyadenylation and splicing), RNA as an enzyme- Ribozyme.

UNIT III

Translation: Genetic code, General features, Deciphering of genetic code, Code in mitochondria. Translational mechanism in prokaryotes and eukaryotes. Post transnational modification and transport, Protein targeting (signalling), Non ribosomal polypeptide synthesis, Antibiotic inhibitors and translation.

UNIT IV

Regulation of Gene Expression in Prokaryotes and Eukaryotes: Operon concept, Positive and negative control, lac, trp and arb operon, Regulation of gene expression in eukaryotes (a brief account), Anti-sense RNA, RNAi.

Recommended Books:

1. Adams, R.L.P., Knowler, J.T. & Leader, D.P., The Biochemistry of Nucleic Acids (11th Ed.), Chapman and Hall, New York. 1992.
2. Kreb, J.E. & Goldstein, E.S., Lewin's GENE XII, Jones and Bartlett Publishers. 2017.
3. Karp, G., Iwasa, J. & Marshall, W., Karp's Cell and Molecular Biology (9th Ed.). John Wiley & Sons. 2020.
4. Lodish, H., Berk, A., Kaiser, C.A., Krieger, M., Bretscher, A., Ploegh, H., Amon, A. & Martin, K.C., Molecular Cell Biology (8th Ed.). W. H. Freeman & Co. 2016.
5. Malacinski, G.M., Freifelder's Essentials of Molecular Biology (3rd Ed.). John and Bartlett Publishers. 2015.
6. Buchanan, B.B., Gruissem, W. & Jones, R.L., Biochemistry and Molecular Biology of Plants. Wiley. 2015.
7. Watson, J.D., Baker T.A., Bell, S.P., Gann, A., Levine, M., & Losick, R., Molecular Biology of the Gene (7 Ed.). Pearson Pub. 2013.

8. Klug, W.S., Cummings, M.R., Spencer C.A., Palladino, M.A. & Killian, D., Concept of Genetics (12th Ed.). Pearson Education, Singapore. 2019.
9. Krebs, J.E., Lewin, B., Kilpatrick, S.T. & Goldstein, E.S., Lewin's Genes XII. Burlington, MA: Jones & Bartlett Learning. 2017.
10. Alberts, B., Johnson, A.D., Lewis, J., Morgan, D., Raff, M., Roberts, K., & Walter, P. (2014). Molecular Biology of the cell (6th Ed.). Garland Science.

BTL-523: FUNDAMENTALS OF IMMUNOLOGY

(Credits: 4+0)
Max Marks: 80
Internal Marks: 20
Time: 3 Hours

Note: The examiner is requested to set nine questions in all, selecting two questions from each UNIT and one compulsory question (Question No.1 based on entire syllabus will consist of seven short answer type questions each of two marks). The candidate is required to attempt five questions in all selecting one from each UNIT and the compulsory Question No.1.

UNIT I

Immunology- fundamental concepts and anatomy of the immune system

Components of innate and acquired immunity; Phagocytosis; Complement and Inflammatory responses; Haematopoesis; Organs and cells of the immune system- primary and secondary lymphoid organs; Lymphatic system; Lymphocyte circulation; Lymphocyte homing; Mucosal and Cutaneous associated Lymphoid tissue. (MALT & CALT); Mucosal Immunity; Antigens - immunogens, haptens; Complement system.

UNIT II

Immune responses generated by B and T lymphocytes

Immunoglobulins-basic structure, classes & subclasses of immunoglobulins, Hybridoma technology and its application, antigenic determinants; Multigene organization of immunoglobulin genes; B-cell receptor; Immunoglobulin superfamily; Principles of cell signaling; Basis of self, non-self-discrimination; Kinetics of immune response, memory; Generation of antibody diversity.

Processing and presentation of antigen: Antigen processing and presentation- endogenous antigens, exogenous antigens, non-peptide bacterial antigens and super-antigens, Major Histocompatibility Complex - MHC genes, MHC and immune responsiveness and disease susceptibility, HLA typing.

UNIT III

Antigen-antibody interactions

Precipitation, agglutination and complement mediated immune reactions; Advanced immunological techniques- RIA, ELISA, Western blotting, ELISPOT assay, immunofluorescence, flow cytometry and immune electron microscopy; Surface plasmon resonance, Biosenor assays for assessing ligand –receptor interaction, CMI techniques- lymphoproliferation assay, Mixed lymphocyte reaction, Cell Cytotoxicity assays, Apoptosis.

UNIT IV

Clinical Immunology

Immunity to Infection: Bacteria, viral, fungal and parasitic infections (with examples from each group); Hypersensitivity – Type I-IV; Autoimmunity; Types of autoimmune diseases; Mechanism and role of CD4+ T cells; MHC and TCR in autoimmunity; Treatment of autoimmune diseases; Cytokines-properties, receptors and therapeutic uses; Vaccines

Tumor immunology –Tumor antigens; Immune response to tumors and tumor evasion of the immune system, Cancer immunotherapy; Immunodeficiency Primary immune deficiencies, Acquired or secondary immune deficiencies.

Recommended Books:

1. Punt, J., Stranford, S., Jones, P. & Owen, J.A., Kuby Immunology (8th Ed.). Macmillan International Higher Education. 2018.
2. Delves, P.J., Martin, S.J., Burton, D.R. & Roitt, I.M., Roitt's Essential Immunology (13th Ed.). Wiley-Blackwell. 2017.
3. Kenneth, M. & Weaver, C., Janeway's Immunobiology (9th Ed.). Garland Science. 2016

BTL-524: PLANT CELL, TISSUE AND ORGAN CULTURE

(Credits: 4+0)
Max Marks: 80
Internal Marks: 20
Time: 3 Hours

Note: The examiner is requested to set nine questions in all, selecting two questions from each UNIT and one compulsory question (Question No.1 based on entire syllabus will consist of seven short answer type questions each of two marks). The candidate is required to attempt five questions in all selecting one from each UNIT and the compulsory Question No.1.

UNIT I

Introduction: Historical background**,** Concepts and basic techniques in tissue culture, Media preparation, Cell, Tissue and organ culture, Organogenesis.

Callus Culture: Induction, Maintenance, Growth characteristics, Suspension cultures.

Micropropagation: Techniques, Clonal propagation of elite germplasm, Factors affecting morphogenesis and proliferation rate, Technical problem in micropropagation, Meristem culture for the production of pathogen free plants, Applications of micropropagation.

UNIT II

Protoplast Culture: Protoplast isolation, Fusion and culture, Somatic hybridization, Selection systems for hybrids, Asymmetric hybrids, Production of hybrids and organellic recombinants, Role of protoplast culture and somatic hybridization in the improvement of crop plants.

Haploid Production: Haploid production and its significance, Anther and pollen culture, Monoploid production through chromosome elimination, Production of triploids through endosperm culture, Role of haploids, Monoploids and triploids in agriculture.

UNIT III

Cytodifferentiation: Cytodifferentiation in cell and tissue cultures, Origin of nuclear variations, Factors affecting variations, Ploidy levels and variations in plants from Anther culture, Control of regeneration.

Variability in Plant Systems: Somaclonal variations and *in-vitro* selection for biotic and abiotic stresses, Isolation of useful mutants at cellular level (disease resistant, herbicide resistant and salt tolerant) Practical applications of variability in tissue cultures.

UNIT IV

Cryopreservation and Germplasm Storage: Cryopreservation and germplasm conservation, Production of synthetic and artificial seeds, Cryobiology of plant cell cultures and establishment of plant banks, Freeze preservation technology, Factors affecting revival of frozen cells, Future prospects.

Practical Application of Plant Tissue Culture: Role of tissue culture in the improvement of crop plants, Plant cell culture for the production of useful secondary metabolites- pigments, perfumes, flavours and pharmacologically important compounds. Automation in plant tissue culture for its commercial application.

Recommended Books:

1. Bhojwani, S.S. & Razdan, M.K. Plant Tissue Culture and Practice. Elsevier. 2004.
2. Reinert, J. & Bajaj, Y.P.S., Applied and Fundamental Aspects of Plant Cell, Tissue and Organ Culture. Narosa Publishing House. 1997.
3. Slater, A., Scott, N.W. & Fowler, M.R., Plant Biotechnology- The genetic manipulation of plants, 2nd Edition by Oxford Univ Press. 2008
4. Chawla, H.S., Plant Biotechnology, Oxford and IBH, 2009.
5. Singh, B.D., Plant Biotechnology. Kalyani publisher, 2003.
6. Altman, A., Agricultural Biotechnology, Marcel Dekker Inc. 2001.
7. Buchanan, B.B., Gruissem, W. & Jones, R.L., Biochemistry and Molecular Biology of Plants: Edited. 2000.

BTP 525: Lab III (Immunology) (Credits: 0+3)

Max Marks: 80
Internal Marks: 20
Time: 4 Hours

List of Experiments:

1. Selection of animals, preparation of antigens, immunization and methods of blood collection, serum separation and storage.
2. Antibody titre by ELISA method.
3. Double diffusion, Immuno-electrophoresis and Radial Immuno diffusion.
4. Complement fixation test.
5. Isolation and purification of IgG from serum or IgY from chicken egg.
6. Immunoblotting, Dot blot assays.
7. Blood smear identification of leucocytes by Giemsa stain.
8. Separation of leucocytes by dextran method.
9. Demonstration of Phagocytosis of latex beads and their cryopreservation.
10. Separation of mononuclear cells by Ficoll-Hypaque and their cryopreservation.
11. Demonstration of ELISPOT.
12. Demonstration of FACS.

Recommended Books:

1. Punt, J., Stranford, S., Jones, P. & Owen, J.A., Kuby Immunology (8th Ed.). Macmillan International Higher Education. 2018.
2. Delves, P.J., Martin, S.J., Burton, D.R. & Roitt, I.M., Roitt's Essential Immunology (13th Ed.). Wiley-Blackwell. 2017.
3. Kenneth, M. & Weaver, C., Janeway's Immunobiology (9th Ed.). Garland Science. 2016

BTP 526: Lab IV (Plant Cell, Tissue and Organ Culture) (Credits: 0+3)

Max Marks: 80
Internal Marks: 20
Time: 4 Hours

List of Experiments:

1. Basic laboratory layout for plant tissue culture.
2. Preparation and sterilization MS stock and culture media.
3. General procedure for tissue culture (explant preparation, sterilization, transfer to tissue culture medium, incubation of plant-culture in growth room/chamber)
4. Effect of plant growth regulator on seed germination.
5. Production of callus and suspension culture.
6. Shoot induction from callus culture
7. Effect of plant growth regulator on shoot tip culture
8. Effect of plant growth regulator on nodal culture
9. Effect of plant growth regulator on root culture
10. Effect of plant growth regulator on root induction of cultured plantlet.
11. Agrobacterium mediated genetic transformation (co-cultivation) of plant culture.

Recommended Books

1. Bhojwani S.S. & Rajdan M.K., Plant Tissue Culture: Theory and Practice: A Revised Edition, Reed Elsevier, India, New Delhi. 2004.
2. Chawla, H.S., Plant Biotechnology: Laboratory Manual for Plant Biotechnology Oxford and IBH Publishing,2004
3. Green, M.R. & Sambrook, J., Molecular Cloning: a Laboratory Manual. Cold Spring Harbor, NY: Cold Spring Harbor Laboratory Press. 2012.

BTL 531: GENETIC ENGINEERING (Credits: 4+0)

Max Marks: 80
Internal Marks: 20
Time: 3 Hours

Note: The examiner is requested to set nine questions in all, selecting two questions from each UNIT and one compulsory question (Question No.1 based on entire syllabus will consist of seven short answer type questions each of two marks). The candidate is required to attempt five questions in all selecting one from each UNIT and the compulsory Question No.1.

UNIT I

Introduction: Historical background, Restriction enzymes and modifying enzymes, Restriction mapping, Construction of chimeric DNA- staggered cleavage, Addition of poly dA and dT tails, Blunt end ligation, Gene cloning.

Cloning and Expression Vectors: Vehicles for gene cloning, Plasmids, Bacteriophages, Cosmids and Phagemids as vectors, P1 vectors, F- factor based vectors, Plant and animal viruses as vector, Artificial chromosomes as vectors (YAC, BAC, PAC and MAC vectors), Expression vectors- use of promoters and expression cassettes, Bacculoviruses as expression vectors, Virus expression vectors, Binary and shuttle vectors.

UNIT II

Isolation Sequencing and Synthesis of Genes: Methods of gene isolation, Construction and screening of genomic and cDNA libraries, Chromosome walking, Chromosome jumping, Transposone tagging, Map based cloning, DNA sequencing Techniques (Maxam Gilbert's chemical degradation methods and Sanger's dideoxy chain termination method), Automated DNA sequencing, Organochemical gene synthesis.

UNIT III

Molecular Probes and PCR: Molecular probes**,** Labeling of probes, Radioactive vs Non-radioactive labeling, Uses of molecular probes. Polymerase Chain Reaction- basic principle, Modified PCR (Inverse PCR, Anchored PCR, PCR for mutagenesis, asymmetric PCR, RT PCR, PCR walking), Gene cloning Vs. Polymerase chain reaction, Applications of PCR in biotechnology, Ligase chain reaction.

UNIT IV

Molecular Markers and DNA Chip Technology: Molecular Markers- types and applications, Construction of molecular maps (genetic and physical maps), DNA chip Technology & Microarrays (a brief account).

Genomics and Proteomics: Whole genome sequencing and functional genomics (a brief account), Applications of genomics and Proteomics with special reference to Arabidopsis and Rice.

Recommended Books

1. Clark DP and Pazdernik NJ. (2009). Biotechnology-Applying the Genetic Revolution. Elsevier Academic Press, USA.
2. Brown T.A., Gene Cloning & DNA Analysis (6th Ed.) Wiley-Blackwell, New York. 2010.
3. Watson J.D., A Passion for DNA: Genes, Genomes & Society, Cold Spring Harbor Laboratory press (CSHL). 2009.
4. Primrose, S.B. & Twyman, R.M. Principles of Gene Manipulation and Genomics (7th Ed.). Malden, MA: Blackwell Publisher. 2006.
5. Green, M.R. & Sambrook, J., Molecular Cloning: a Laboratory Manual. Cold Spring Harbor, NY: Cold Spring Harbor Laboratory Press. 2012.
6. Alcamo, I.E., DNA Technology: The Awesome Skill. Harcourt Academic Press. 2001.

BTL 532: ENZYMOLOGY AND ENZYME TECHNOLOGY **(Credits: 4+0)**

Max Marks: 80
Internal Marks: 20
Time: 3 Hours

Note: The examiner is requested to set nine questions in all, selecting two questions from each UNIT and one compulsory question (Question No.1 based on entire syllabus will consist of seven short answer type questions each of two marks). The candidate is required to attempt five questions in all selecting one from each UNIT and the compulsory Question No.1.

UNIT I

Introduction: Historical background, Enzymes vs Chemical catalyst, Enzyme nomenclature and classification, Units of activity, Methods for enzyme assays, Extraction and purification of enzymes, Cofactors and coenzymes.

UNIT II

Enzyme Specificity: Substrate and reaction specificity, Lock & key hypothesis, Induced Fit hypothesis, Wrong way binding hypothesis, Three point attachment hypothesis, Mechanism of action of selected enzymes i.e. chymotrypsin, trypsin, papain, Iysozyme, ribonuclease.

UNIT III

Enzyme Kinetics: Factors affecting velocity of enzyme catalyzed reactions, Michaelis-Menten hypothesis, Transformation of Michaelis- Menten equation and determination of Km and Vmax, Haldane relationship, Multireactant enzymes, Enzymes inhibition i.e., reversible and irreversible inhibition, Competitive, Non-competitive and uncompetitive inhibition.

UNIT IV

Regulatory Enzymes: Allosteric enzymes, Sequential and symmetry models, covalently regulated enzymes.

Enzyme Technology: Large scale production of enzymes, Uses of isolated enzymes in food and chemical industries, Therapeutic & medicinal use of enzymes.

Protein Engineering: Concept and Methods, Site directed mutagenesis, Active site mapping, Nature of the active site, Identification of functional groups at the active site, Immobilized enzymes–methods and applications.

Recommended Books:

1. Palmer, T. & Bonner, P., Enzymes: Biochemistry, Biotechnology and Clinical Chemistry (2nd Ed.). Howood Publishing Chishester, England. 2008.
2. Okotore, R.O. (2015) Essentials of Enzymology Xlibris, USA. 2015.
3. Marangoni, A.G., Enzyme Kinetics-A Modern Approach. 2003.
4. Engel, P.C., Enzyme Kinetics: The Steady State Approach, Springer Illustrated Edition. 2014.
5. Bisswanger, H., Enzyme Kinetics: Principles and Methods (3rd Ed.). Willey-VCH. 2017.
6. Rocha-Martin, J., Immobilization of Enzymes and Cells: Methods and Protocols, Springer US. 2020.
7. Price, N.C. & Stevens, L., Fundamentals of Enzymology (3rd Ed.). Oxford University Press, New York. 1999.
8. Phillips, J., Fundamentals of Enzymology Ed-Tech Press, United Kingdom. 2019.
9. Dixon, M. & Webb, E.C., Enzyme (3rd Ed.). Academic Press, New York. 1979.
10. Uhlig, H., Industrial Enzymes and Their Applications, Jone Wiley, New York. 1998

BTL533: MOLECULAR GENETICS (Credits: 4+0)

Max Marks: 80
Internal Marks: 20
Time: 3 Hours

Note: The examiner is requested to set nine questions in all, selecting two questions from each UNIT and one compulsory question (Question No.1 based on entire syllabus will consist of seven short answer type questions each of two marks). The candidate is required to attempt five questions in all selecting one from each UNIT and the compulsory Question No.1.

UNIT I

Inheritance: Historical background, Extra chromosomal inheritance, Inheritance of quantitative traits, Sex linked, Sex influenced and sex limited traits.

Molecular Organizations of Chromosomes: Viral and bacterial chromosomes, Nucleosome and chromatin structure, Structure of centromere and telomere, Euchromatin and heterochromatin, Polytene and lamp brush chromosomes, Genome complexity.

UNIT II

Linkage, Crossing over and Gene mapping in Eukaryotes: Linkage and recombination of gene, Gene mapping by three point test cross, Tetrad analysis, Positive and negative interference, Molecular mechanism of recombination, Post-meiotic segregation, Mapping through somatic cell hybridization.

UNIT III

Mutation: Molecular mechanism of spontaneous mutations, Molecular mechanism of mutations induced by known chemical mutagens, Types of DNA repair, Molecular mechanism of suppression, Somatic mutations.

UNIT IV

Gene Concept: Classical concept, Fine structure of the gene, Molecular concept of the gene, Pseudogenes, Overlapping genes, Oncogenes, Repeated genes, Gene amplification.

Bacterial and Viral Genetics: Transformation, Conjugation and Transduction, Molecular mechanism of recombination in bacteria, IS and Tn elements in bacteria, *E.coli* recombination system, Bacterial plasmids, Lytic cascade and lysogenic repression.

Recommended Books:

1. Hartl, D.L. & Jones, E.W., Genetics: Principles and Analysis. Sudbury, MA: Jones and Bartlett. 1998.
2. Pierce, B.A., Genetics: a Conceptual Approach. New York: W.H. Freeman. 2005.
3. Tamarin, R.H. & Leavitt, R.W., Principles of Genetics. Dubuque, IA: Wm. C. Brown. 1991.
4. Klug, W.S., Cummings, M.R., Spencer, C.A., Palladino, M.A. & Killian, D., Concepts of Genetics (12th Ed.). Pearson Education Limited: London. 2019.
5. Gardner, E.J. Simmonns, M.J. Snustad, D.P., Principles of Genetics (8th Ed.). Wiley India. 2008.

BTL 534: INTRODUCTORY BIOINFORMATICS (Credits: 4+0)

Max Marks: 80
Internal Marks: 20
Time: 3 Hours

Note: The examiner is requested to set nine questions in all, selecting two questions from each UNIT and one compulsory question (Question No.1 based on entire syllabus will consist of seven short answer type questions each of two marks). The candidate is required to attempt five questions in all selecting one from each UNIT and the compulsory Question No.1.

UNIT I

Introduction to Bioinformatics: Definition, role, scope and limitation of bioinformatics. Different branches of bioinformatics. Terminologies: Internet browser, software, hardware, database, Network, NicNet, Inflibnet, EMBnet, Operating System, algorithm.

UNIT II

Biological Data Banks: An introduction to data mining and data security, Data warehousing, Data capture, Data Analysis, Data Banks, Gene banks, EBTL nucleotide sequence data bank, Sequence data bank, rRNA data Bank, Peptide data bank., Data Bank similarity searches (BLAST, FASTA, PSI-BLAST algorithms multiple), Structural Data Bank (Cambridge small molecules crystal structure data Bank), Calculation of conformational energy of Bio-molecules.

UNIT III

Biodiversity Data Bases: Organizing Biological SPP information, Data sets in Biodiversity informatics (Spp 2000, Tree of life, ATCC, NCBI Spp analyst collaboration. (ICTV, Animal virus information system) a brief account.

Sequence Analysis: Computational methods and significance, homology algorithms (BLAST) for proteins and nucleic acids, open reading frames, annotations of genes, conserved protein motifs related structure / function. Phylogenetic analysis: Introduction and importance, phylogenetic tree, methods of phylogenetic analysis.

UNIT IV

Application of Bioinformatics and Scientific Documentation: Virtual library searching-Medline, Science citation indexes, Electronic Journals, Grants and finding information. Research documentation- preparation of research report, settling up of a laboratory, seminar, paper preparation and presentation. How to write dissertation? Guidelines for writing of literature, materials and method, result, discussion, Presentation and references

Recommended Books:

1. Lesk, A.M., Introduction to Bioinformatics. Oxford: Oxford University Press. 2002.
2. Mount, D.W. (2001). Bioinformatics: Sequence and Genome Analysis. Cold Spring Harbor, NY: Cold Spring Harbor Laboratory Press. 2001.
3. Baxevanis, A.D. & Ouellette, B.F., Bioinformatics: a Practical Guide to the Analysis of Genes and Proteins. New York: Wiley-Interscience. 2001.
4. Pevsner, J., Bioinformatics and Functional Genomics. Hoboken, NJ: Wiley-Blackwell. 2015.
5. Bourne, P. E. & Gu, J., Structural Bioinformatics. Hoboken, NJ: Wiley-Liss. 2009.
6. Lesk, A.M., Introduction to Protein Science: Architecture, Function, and Genomics. Oxford: Oxford University Press. 2004.
7. Mount, D.W., Bioinformatics: Sequence and Genome Analysis (2^{nd} Ed.). CSHL Press. 2004.
8. Bloomfield, V., Computer Simulation and Data Analysis in Molecular Biology and Biophysics. Springer. 2009.

BTP 535: Lab V (Genetic Engineering) (Credits: 0+3)

Max Marks: 80
Internal Marks: 20
Time: 3 Hours

List of Experiments:

1. Concept of lac-operon:
   a) Lactose induction of β-galactosidase.
   b) Glucose Repression.
   c) Diauxic growth curve of *E.coli*
2. Phage titre with epsilon phage/M13
3. Genetic Transfer-Conjugation, gene mapping
4. Plasmid DNA isolation and DNA quantitation
5. Restriction Enzyme digestion of plasmid DNA
6. Agarose gel electrophoresis
7. Polymerase Chain Reaction and analysis by agarose gel electrophoresis

8 Vector and Insert Ligation

9 Preparation of competent cells

10. Transformation of *E.coli* with standard plasmids, Calculation of transformation efficiency

11. Confirmation of the insert by Colony PCR and Restriction mapping

12. Expression of recombinant protein, concept of soluble proteins and inclusion body formation in *E.coli*, SDS-PAGE analysis

13. Purification of His-Tagged protein on Ni-NTA columns

a) Random Primer labeling

b) Southern hybridization.

Recommended Textbooks and References:

1. Green, M. R., & Sambrook, J., Molecular Cloning: a Laboratory Manual. Cold Spring Harbor, NY: Cold Spring Harbor Laboratory Press. 2012.

BTP 536: Lab VI (Bioinformatics) (Credits: 0+3)

Max Marks: 80
Internal Marks: 20
Time: 3 Hours

List of Experiments:

1. Using NCBI and Uniprot web resources.
2. Introduction and use of various genome databases.
3. Sequence information resource: Using NCBI, EMBL, Genbank, Entrez, Swissprot/ TrEMBL, UniProt.
4. Similarity searches using tools like BLAST and interpretation of results.
5. Multiple sequence alignment using ClustalW.
6. Phylogenetic analysis of protein and nucleotide sequences.
7. Use of gene prediction methods (GRAIL, Genscan, Glimmer).
8. Using RNA structure prediction tools.
9. Use of various primer designing and restriction site prediction tools.
10. Use of different protein structure prediction databases (PDB, SCOP, CATH).
11. Construction and study of protein structures using Deepview/PyMol.
12. Homology modeling of proteins.
13. Use of tools for mutation and analysis of the energy minimization of protein structures.
14. Use of miRNA prediction, designing and target prediction tools.

Recommended Books:

1. Lesk, A.M., Introduction to Bioinformatics. Oxford: Oxford University Press. 2002.
2. Mount, D.W. (2001). Bioinformatics: Sequence and Genome Analysis. Cold Spring Harbor, NY: Cold Spring Harbor Laboratory Press. 2001.
3. Baxevanis, A.D. & Ouellette, B.F., Bioinformatics: a Practical Guide to the Analysis of Genes and Proteins. New York: Wiley-Interscience. 2001.
4. Pevsner, J., Bioinformatics and Functional Genomics. Hoboken, NJ: Wiley-Blackwell. 2015.
5. Bourne, P. E. & Gu, J., Structural Bioinformatics. Hoboken, NJ: Wiley-Liss. 2009.
6. Lesk, A.M., Introduction to Protein Science: Architecture, Function, and Genomics. Oxford: Oxford University Press. 2004.
7. Mount, D.W., Bioinformatics: Sequence and Genome Analysis (2^{nd} Ed.). CSHL Press. 2004.
8. Bloomfield, V., Computer Simulation and Data Analysis in Molecular Biology and Biophysics. Springer. 2009.

BTL 541: AGRICULTURAL BIOTECHNOLOGY & IPR

(Credits: 4+0)
Max Marks: 80
Internal Marks: 20
Time: 3 Hours

Note: The examiner is requested to set nine questions in all, selecting two questions from each UNIT and one compulsory question (Question No.1 based on entire syllabus will consist of seven short answer type questions each of two marks). The candidate is required to attempt five questions in all selecting one from each UNIT and the compulsory Question No.1.

UNIT I

Agricultural Biotechnology: An overview, Concept of Sustainable Agriculture, Role of biofertilizers and bio-pesticides in sustainable agriculture.

Biological N_2 Fixation: Diazotrophic microorganism, Free living and symbiotic nitrogen fixing microbes, Structure, function and regulation of nitrogenase enzyme, Molecular basis of legume *Rhizobium* symbiosis.

UNIT II

Intellectual Property Rights and Protection: The GATT & TRIPs, Concept of Patents, Copyrights, Trademarks; Patenting – need for patents. Patenting of biological materials, Patenting of life forms−plant, animals, microbes, gene, process and products, Regulatory issues and challenges to food products. Patent process, protection of knowledge, knowledge consortia and databases. Procedure for patent application, International harmonization of patent laws. Implications of intellectual property rights on the commercialization of biotechnology products.

Plant Variety Protection Act: TRIPS and WTO. Plant breeders' rights, and farmers' rights. International conventions on biological diversity.

UNIT III

Agricultural Biotechnology and the Society. Transgenic plants, commercial status and public acceptance. Bio-safety guidelines for research involving GMO's, Benefits and risks, Socio-economic impact and ecological considerations of GMO's. Gene flow. ; National biosafety policies and law, WTO and other international agreements related to biosafety, cross border movement of germplasm; risk management issues – containment, transgenic animals, Aquaculture, Sericulture and transgenic fish.

Regulatory Practices: Financing R&D capital and market outlook, IP, BP, SP.Government regulatory practices and policies, FDA perspective. Reimbursement of drugs and biologicals, legislative perspective.

UNIT IV

General Principles for the Laboratory and Environmental Biosafety: Health aspects; toxicology, allergenicity, Sources of gene escape, creation of superbugs etc. Quality Assurance and validation**.** Good Manufacturing Practices (GMP) and Good laboratory practices (GLP) in pharmaceutical industry. Regulatory aspects of quality control. Quality assurance and quality management in pharmaceuticals ISO, WHO and US certification. Sterilization control and sterility testing (heat sterilization, D value, z value, survival curve, Radiation, gaseous and filter sterilization). Design and layout of sterile product manufacturing unit, (Designing of Microbiology laboratory), Safety in microbiology laboratory.

Recommended Books:

1. Shrivastava, P.S., Narula, A. & Shrivastava, S.S., Plant Biotechnology and Molecular Markers, Anamaya Publisher, New Delhi. 2004.
2. Altman, A., Agricultural Biotechnology, Marcel Dekker. 1998.
3. Caldentey, K.M.O. & Barz, W.H., Plant Biotechnology and Transgenic Plants, Marcel Dekker. 2002.
4. Slater, A., Scot, N. & Fowler, M., Plant Biotechnology: The Genetic Manipulation of Plants, Oxford University Press. 2004.
5. Brian, C., Legal Aspect of Gene Technology, Thomson Severt Maxwell. 2004.
6. Sarad R.P., The GMO Hand Book: Genetically Modified Animals, Microbes and Plants, Humana Press, New Jersey. 2004.
7. Valpuseta V., Food and Vegetable Biotechnology, CRC Press, New Delhi. 2004.

BTL 542 : FERMENTATION TECHNOLOGY

(Credits:4+0)
Max Marks: 80
Internal Marks: 20
Time: 3 Hours

Note: The examiner is requested to set nine questions in all, selecting two questions from each UNIT and one compulsory question (Question No.1 based on entire syllabus will consist of seven short answer type questions each of two marks). The candidate is required to attempt five questions in all selecting one from each UNIT and the compulsory Question No.1.

UNIT I

Introduction to Fermentation Technology: Fermentation overview, Introduction to fermentation processes, industrially important microorganisms-Isolation, screening, and preservation of industrially important microorganisms.

Strain Improvement: Natural selection, mutation and screening of improved cultures, random and strategic screening methods, Use of recombinant DNA technology, protoplast fusion etc. **Principles of overproduction of primary and secondary metabolites with relevant examples.**

UNIT II

Fermentation Systems: Batch and Continuous system, Fed batch culture, Multistage systems, Feedback systems, Solid substrate fermentation. Instrumentation and control of fermentation processes.

Production and Recovery of Primary and Secondary Metabolites: Industrial Alcohol, Beer, Wine, Citric Acid, Acetic acid, lactic acid, Acetone- Butanol fermentation, Amino acids- Lysine & Glutamic acid production, Industrial enzymes, Antibiotics- Penicillin and Tetracycline, Bioinsecticides, Biopolymers, vitamins and steroids.

UNIT III

Fermentation raw materials: Media for industrial fermentation, Criteria used in media formulation, sterilization, raw materials and process control. Downstream processing- Separation processes and recovery methods for fermentation products.

UNIT IV

Fermenter Design: Bioreactor configuration, design features, Criteria in Fermenter design, Requirement for aeration and mixing, Energy Transfer. Other fermenter designs- Tube reactors, packed bed reactors, fluidized bed reactors, cyclone reactors, trickle flow reactors.

Waste Treatment: Waste Treatment systems, Aerobic and anaerobic waste treatment systems for waste treatment in fermentation industry.

Recommended Books:

1. Stanbury, P.F., Hall, S., Whitaker, A., Principles of Fermentation Technology (3rd Ed.). Butterworth Heinemann Ltd., Elsevier. 2016.
2. Ward, O.P., Fermentation Biotechnology - Principles, Process and Products. Prentice Hall Publishing, New Jersey. 1999.
3. Rehm, H.J., Reed, G.B., Puehler, A. & Stadler, Biotechnology, Vol. 1-8, VCH Publication. 1993.

4. Prescott, S.C. & Dunn, G.C., Prescott and Dunn's Industrial Microbiology (4th Ed.). CBS Publication, New Delhi. 1992
5. Demain, A.I. & Davies, J. E., Manual of Industrial Microbiology and Biotechnology (2nd Ed.), ASM Press, Washington D.C. 1999.
6. Glazer, A.N. & Nikaido, H., Microbial Biotechnology: Fundamentals of Applied Microbiology. WH Freeman & Company, New York. 1998.
7. Cruger, W. & Kruger, A., Biotechnology -A Textbook of Industrial Microbiology (2nd Ed.). Panima Publishing Corporation, New Delhi. 2002.
8. Clarke, W., Industrial Microbiology. CBS Publisher and Distributors PVT .LTD New Delhi. 2016.

BTL 543: GENOMICS & PROTEOMICS (Credits: 4+0)

Max Marks: 80
Internal Marks: 20
Time: 3 Hours

Note: The examiner is requested to set nine questions in all, selecting two questions from each UNIT and one compulsory question (Question No.1 based on entire syllabus will consist of seven short answer type questions each of two marks). The candidate is required to attempt five questions in all selecting one from each UNIT and the compulsory Question No.1.

UNIT I

Introduction to -omes and –omics

Genomics: Organization of genomes: main features of bacterial and eukaryotic genome organization. Strategies for genome sequencing: Chain termination method, automated sequencing, Next Generation Sequencing, 454 pyrosequencing, Illumina Sequencing, Sequence asseBTLy - Clone contig and shotgun approaches. Model plant genome project and its applications. Locating the genes: ORF scanning, homology searches.

UNIT II

Functional Genomics: Functions analysis of genes, candidate gene identification in crop plants, deciphering the function of gene in plant secondary metabolism, gene inactivation (knock-out, anti-sense and RNA (interference) and gene over expression. Approaches to analyze global gene expression: transcriptome, Serial Analysis of Gene Expression (SAGE), Expressed Sequence Tags (ESTs), Massively Parallel Signature Sequencing (MPSS), microarray and its applications, gene tagging, Metagenomics: Prospecting for novel genes from metagenomes and their biotechnological applications

UNIT III

Proteomics: Introduction to proteomics, Analysis of proteome-2D PAGE, Mass Spectrometry based methods for protein identification: De novo sequencing using Mass spectrometric data, use of MALDI TOF and related methods for protein mass determination, protein microarrays; protein interactive maps; structural proteomics: protein structure determination, prediction and threading, software and data analysis/ management, etc.

UNIT IV

Metabolomics: Techniques in metabolomics (HPLC, GC-MS, LC-MS), Nuclear Magnetic Resonance Spectroscopy and Mass Spectrometry in metabolomics. Application of metabolomics in elucidating metabolic pathways, metabolic pathways resources: KEGG, Biocarta etc., Nutrigenomics and metabolic health

Recommended Books:

1. Leister, D., Plant Functional Genomics. Taylor & Francis. 2005.
2. Weckwerth, W., Metabolomics: Methods and Protocols , Humana Press. 2006.
3. Lodish, H., Berk, A., Kaiser, C.A., Krieger, M., Bretscher, A., Ploegh, H., Amon, A. & Martin, K.C., Molecular Cell Biology (8th Ed.). W. H. Freeman & Co. 2016.
4. Primrose, S.B. & Twyman, R.M. Principles of Gene Manipulation and Genomics (7th Ed.). Malden, MA: Blackwell Publisher. 2006.
5. Dubitzky W., Granzow M. & Berrar D.P., Fundamentals of Data Mining in Genomics and Proteomics. Springer Science- Business Media. 2007.
6. Lovric, J., Introducing Proteomics: From concepts to sample separation, mass spectroscopy and data analysis. John Willey and Sons Ltd. 2011.
7. Mine Y., Miyashita K. & Shahidi F., Nutrigenomics and Proteomics in Health and Disease: Food Factors and Gene Interaction. Wiley Blackwell. 2009.

BTL 544: BIOENTREPRENEURSHIP **(Credits: 4+0)**

Max Marks: 80
Internal Marks: 20
Time: 3 Hours

Note: The examiner is requested to set nine questions in all, selecting two questions from each UNIT and one compulsory question (Question No.1 based on entire syllabus will consist of seven short answer type questions each of two marks). The candidate is required to attempt five questions in all selecting one from each UNIT and the compulsory Question No.1.

UNIT I

Innovation and Entrepreneurship in Bio-business: Introduction and scope in Bio-entrepreneurship, Types of bio-industries and competitive dynamics between the sub-industries of the bio-sector (*e.g.* pharmaceuticals *vs.* Industrial biotech), Strategy and operations of bio-sector firms: Factors shaping opportunities for innovation and entrepreneurship in bio-sectors, and the business implications of those opportunities, Alternatives faced by emerging bio-firms and the relevant tools for strategic decision, Entrepreneurship development programs of public and private agencies (MSME, DBT, BIRAC, Make In India), strategic dimensions of patenting & commercialization strategies.

UNIT II

Bio Markets - Business Strategy and Marketing: Negotiating the road from lab to the market (strategies and processes of negotiation with financiers, government and regulatory authorities), Pricing strategy, Challenges in marketing in bio business (market conditions & segments; developing distribution channels, the nature, analysis and management of customer needs), Basic contract principles, different types of agreement and contract terms typically found in joint venture and development agreements, Dispute resolution skills.

UNIT III

Finance and Accounting: Business plan preparation including statutory and legal requirements, Business feasibility study, financial management issues of procurement of capital and management of costs, Collaborations & partnership, Information technology.

UNIT IV

Technology Management: Technology – assessment, development & upgradation, Managing technology transfer, Quality control & transfer of foreign technologies, Knowledge centers and Technology transfer agencies, Understanding of regulatory compliances and procedures (CDSCO, NBA, GCP, GLA, GMP).

Recommended Books :

1. Adams, D.J. & Sparrow, J.C., Enterprise for Life Scientists: Developing Innovation and Entrepreneurship in the Biosciences. Bloxham: Scion. 2008.
2. Karhad, P., How to Patent an Idea in India: From Idea to Granted Patent in Quickest Time, Saving Costs and Making Money with Your Patented Invention; A Step by step guideline on Intellectual Property in India. 2018.
3. Chopra, R.K., Indian Patent System. Himalaya Publishing House. 2010.

4. Patzelt, H. & Brenner, T., Handbook of Bioentrepreneurship: 4 (International Handbook Series on Entrepreneurship). Springer. 2010.
5. Shimasaki, C.D. Biotechnology Entrepreneurship: Starting, Managing, and Leading Biotech Companies. Amsterdam: Elsevier. Academic Press is an imprint of Elsevier. 2014.
6. Jordan, J.F., Innovation, Commercialization, and Start-Ups in Life Sciences. London: CRC Press. 2014.
7. Desai, V., The Dynamics of Entrepreneurial Development and Management. New Delhi: Himalaya Pub. House. 2009.
8. Ganguli, P., Intellectual Property Rights: Unleashing the Knowledge Economy. New Delhi. 2001.

BTL 545: FOOD BIOTECHNOLOGY

(Credits: 4+0)
Max Marks: 80
Internal Marks: 20
Time: 3 Hours

Note: The examiner is requested to set nine questions in all, selecting two questions from each UNIT and one compulsory question (Question No.1 based on entire syllabus will consist of seven short answer type questions each of two marks). The candidate is required to attempt five questions in all selecting one from each UNIT and the compulsory Question No.1.

UNIT I

Food Biotechnology - An overview, importance and scope.

Prokaryotic and Eukaryotic based Products: Fermented meats, Fermented milk products-kefir, koumiss, acidophilus milk, yoghurt, cheese, Fermented cereals and vegetable products - sauerkraut, soy sauce, tempeh, miso, olive, kimchi, Baker's yeast production, Single cell protein, Wine, Beer.

UNIT II

Biotechnology and Food Safety: Impact of Biotechnology on microbial testing of foods-current/traditional methodology and new approaches, Use of gene probes, Recombinant DNA techniques, Bioluminescence, PCR based methods, BAX system, Riboprinter and Real Time PCR based approaches; Safety evaluation of genetically engineered enzyme/novel food products/ transgenic organisms used in food industry.

UNIT III

Natural Control of Microorganisms and Preservation: Bacteriocins of lactic acid bacteria, Applications of bacteriocins in foods, Aflatoxin-production, Control and molecular reduction strategy, Preservation technique (a brief account), Permitted food preservative.

UNIT IV

Biotechnology and Food Ingredients: Biogums, Bio-colours, Citric acid, Fumaric acid and malic acids, Sweeteners, Enzymes, Fat substitutes, Natural and modified starches, Fats and oils.

Protein Engineering in Food Technology: Methods, Targets and applications in foods,

Biosensors & Biological monitoring of foods; Waste management and food processing; HACCP and Hurdle Technology.

Recommended Books:

1. Shetty, K. & Sarkar, D. Functional Foods and Biotechnology: Biotransformation and Analysis of Functional Foods and Ingredients. CRC press. 2020.
2. Lee, B.H., Fundamental of Food Biotechnology, VCH Publishers. 1996.
3. Goldberg I. & Williams R., Biotechnology and Food Ingredients, Van Nostrant., Reinhold, New York. 1991.
4. Doyle, M.P., Food Microbiology: Fundamentals and Frontiers, ASM Press Washington. 1997.
5. Ricke, S., Donaldson, J.R. & Phillips, C.A., Food Safety: Emerging Issues, Technologies and Systems. Academic Press. 2015.
6. Joshi V.K. & Pandey A., Biotechnology: Food Fermentation Vol. 1 & 2, Education Publisher and Distributer, New Delhi. 1999.
7. Marwaha S.S. & Arora, J.K., Food Processing: Biotechnological applications, Asia tech Publishers Inc., New Delhi. 2000.

BTL 546: MEDICAL BIOTECHNOLOGY

(Credits: 4+0)
Max Marks: 80
Internal Marks: 20
Time: 3 Hours

Note: The examiner is requested to set nine questions in all, selecting two questions from each UNIT and one compulsory question (Question No.1 based on entire syllabus will consist of seven short answer type questions each of two marks). The candidate is required to attempt five questions in all selecting one from each UNIT and the compulsory Question No.1.

UNIT I

Medical Biotechnology: An introduction and scope.

Biopharmaceuticals: Pharmaceutical applications of plant, animal and microbial origin, Relevance of medicinal plant, Therapeutic use of recombinant proteins, Proteins drug manufacturing, Design and engineering of proteins as therapeutic agents, Protein drug delivery.

UNIT II

Gene Therapy: Human diseases targeted, delivery systems and targets, Gene therapy of genetic and acquired diseases, Biosensors and Nano-technology for drug targetting, Future and ethical issues, Genetic counseling.

UNIT III

Diagnostics: Use of nucleic acid probes and antibodies in clinical diagnosis, Mapping of human genome, Molecular diagnosis of genetic diseases.

Diseases: Parkinson's disease, AIDS, Alzheimer's disease, Prion diseases, Molecular basis of cancer, Proto-oncogenes, Oncogenes and tumor suppressor genes.

UNIT IV

Drugs Produced through Biotechnology: Humulin, Activase, Humatrope.

Biotechnological Innovations in Vaccines Development: DNA vaccines, Edible Vaccines, Development of malarial vaccine and Tuberculosis vaccine.

Pharmacogenetics: Pharmacogenomics and Personalized medicine - a brief Account.

Recommended books:

1. Wu S. Pong & Rojanasakul. Y., Biopharmaceutical Drug Design and Development. Humana Press, New Jersey. 1999.
2. Walsh, G., Biopharmaceuticals: Biochemistry and Biotechnology, John Wiley & Sons, New York. 1998.
3. Vyas, S.P. & Dixit, V.K., Pharmaceutical Biotechnology, CBS Publisher and Distributor, New Delhi. 2001.
4. Carroll, K.C., Morse, S.A., Butel, J.S., & Mietzner, T.A. Jawetz, Melnick and Adelberg's Medical Microbiology (27th Ed.). McGraw Hill Publication. 2017.
5. Goering, R., Dockrell, H., Zuckerman, M. & Chiodini, P., Mims' Medical Microbiology (6th Ed.). Elsevier. 2018.
6. Willey, J.M., Sherwood, L., Woolverton, C.J., Prescott, L.M. & Willey, J.M. Prescott's Microbiology. New York: McGraw-Hill. 2011.

BTL 547: ENVIRONMENTAL BIOTECHNOLOGY (Credits: 4+0)

Max Marks: 80
Internal Marks: 20
Time: 3 Hours

Note: The examiner is requested to set nine questions in all, selecting two questions from each UNIT and one compulsory question (Question No.1 based on entire syllabus will consist of seven short answer type questions each of two marks). The candidate is required to attempt five questions in all selecting one from each UNIT and the compulsory Question No.1.

UNIT I

Environmental Biotechnology: An overview, Concepts and dynamics of Ecosystem, Food chain and energy flow.

Pollution: Basic concept and issues, Types of pollution, Sources, Chemistry and monitoring of air and water pollution, Methods of pollution measurement.

UNIT II

Concepts of Global Warning and Ozone Depletion, Eco-farming, Organic forming, Greenhouse effect and acid rains, Biotechnological approaches for management (a brief account).

Waste Water Treatment: Microbiology of waste water treatments, Aerobic process, Anaerobic process, Treatment scheme of dairy, distillery, paper, pulp, sugar and antibiotic industries, Solid waste management, Conventional and modern fuels and their environmental impact, Biofuels.

UNIT III

Bioremediation: Concept, Use of bacteria in bioremediation, Bio-pesticide for reducing environmental impact of synthetic pesticides, Biotechnology in forestry and wasteland development, Phyto-remediation, Role of Biosensors for detection of pollutants.

Biodegradation of Xenobiotic Compounds: Organism involved in degradation of chlorinated hydrocarbons, Aromatic compounds, Microbial treatment of oil spills, Treatment of hazardous wastes.

UNIT IV

Biomineralization: Organic matter decomposition- C-cycle, N-cycle, S-cycle, Bioconversion of cellulose, Hemicellulose, Lignin (lignocellulose), Bioleaching of ores, Recovery of metals.

Biotechnological Approaches for Preserving Biodiversity: Gene banks, Germ plasma banks and their management.

Recommended Books:

1. Agarwal, S.K., Environmental Biotechnology, APH Publishing Corporation, New Delhi. 1998.
2. David, S., Bioremediation Protocols, Humana Press, New Jersey. 1997.
3. Stankey, E.M., Environmental Science and Technology, Lewis Publishers, New York. 1997.
4. Glazer & Nikaido, Microbial Biotechnology, WH Freeman & Company, New York. 1998.
5. Singh, A. & Ward, O.P., Biodegradation and Bioremediation: Soil Biology, Springer. 2004.

6. Evans, G.N. & Furlong, J.C., Environmental Biotechnology: Theory and Applications. Wiley Publishers. 2003.
7. Ritmann, B. & McCarty, P.L., Environmental Biotechnology: Principle & Applications (2^{nd} Ed.). McGraw Hill Science. 2000.
8. Scragg, A., Environmental Biotechnology. Pearson Education Limited. 2005.
9. Devinny, J.S., Deshusses, M.A. & Webster, T.S., Biofiltration for Air Pollution Control, CRC Press. 1998.

BTP 548: Lab VII (Fermentation Technology) (Credits: 0+3)

Max Marks: 80
Internal Marks: 20
Time: 3 Hours

List of Experiments:

1. Isolation purification and screening of industrially important microorganisms from natural sources such as soils/ food processing waste/ and animal droppings.

a) Isolation of antibiotic producing microorganisms
b) Isolation of enzyme producing microorganisms
c) Isolation of organic acid producing microorganisms
d) Isolation of xenobiotic degrading microorganisms

2. To evaluate the production of alcohol/Lactic acid/Citric acid/bioactive compound.
3. Microbial biomass production (fungi/bacteria/yeast), batch /continuous culture.
4. Production of extra cellular enzymes (amylases/ proteases/ xylanases/phytase) by thermophilic/mesophilic fungal/Bacterial culture.
5. Scale up from frozen vial to agar plate to shake flask culture.
6. To study the BOD, COD, TDS, TSS, TS levels of different water systems.
7. Bacteriological analysis of water by presumptive, confirmatory and completed tests.
8. Industrially important product production and quality evaluation: Yogurt production/ wine preparation/Milk quality testing/ fermentation of vegetables etc.
9. Instrumentation: Microplate reader, spectrophotometer, microscopy.
10. Anatomy of fermenter: Anatomy of fermenter whereby the students are required to dismantle and identify the various components of the fermenter and study the various systems making up the fermenter. Cleaning and operation of fermenter: Students are required to learn the importance of cleaning the fermenter properly and to carry out COP cleaning and operation of laboratory fermenter.
11. Visit to any fermentation industry/ Waste water treatment plant. (Optional)
12. Unit operations
    a. Microfiltration: Separation of cells from broth.
    b. Bioseparations: Various chromatographic techniques and extractions.
    c. Bioanalytics: Analytical techniques like HPLC, GC, LC/GC-MS *etc.* for measurement of amounts of products/substrates.

Recommended Books:

1. Shuler, M.L. & Kargi, F., Bioprocess Engineering: Basic Concepts. Upper Saddle River, NJ: Prentice Hall. 2002.
2. Stanbury, P.F. & Whitaker, A., Principles of Fermentation Technology. Oxford: Pergamon Press. 2010.
3. Blanch, H.W., & Clark, D.S., Biochemical Engineering. New York: M. Dekker. 1997.
4. Bailey, J.E. & Ollis, D.F., Biochemical Engineering Fundamentals. New York: McGraw-Hill. 1986.
5. El-Mansi, M. & Bryce, C.F., Fermentation Microbiology and Biotechnology. Boca Raton: CRC/Taylor & Francis. 2007.