CURRICULUM

APPROVED BY

BOARD OF STUDIES (BOS)
2nd MEETING, March 18, 2009
SENATE MEETING
June 5, 2009

1) B. TECH.: i) FINAL TEACHING SCHEME

ii) DETAILED SYLLABUS

2) **Ph.D. : THEORY COURSES**

DEPARTMENT OF BIOTECHNOLOGY

JUNE 2009

Dr B R AMBEDKAR NATIONAL INSTITUTE OF TECHNOLOGY
JALANDHAR – 144011

Phone: 0181-2690301, 02 (Ext. 358, 268) Fax: 0181-2690932 Website: www.nitj.ac.in

B.TECH. BIOTECHNOLOGY

1st and 2nd SEMESTER COMMON FOR ALL BRANCHES

First Semester

S.N.	Course Code	Name	L	T	P	Contact hours	Credit
1.	MA-101	Mathematics-I	3	1	0	4	4
2.	PH - 101	Physics	3	1	0	4	4
3.	IC/EC-101	Electrical Science	3	1	0	4	4
4.	CS - 101	Computer Programming	2	0	0	2	2
5.	BT - 101	Introduction to Bio Science	3	0	0	3	3
6.	HM - 101	Psychology of Human Behaviour	2	0	0	2	2
7.	PH - 102	Physics Lab	0	0	2	2	1
8.	ME - 101	Engineering Graphics	1	0	4	5	3
9.	IC/EC - 102	Electrical Programming Lab	0	0	2	2	1
10.	CS - 102	Computer Programming Lab	0	0	2	2	1
		Total	17	03	10	30	25

Second Semester

S.N.	Course Code	Name	L	T	P	Contact hours	Credit
1.	MA	Mathematics-II	3	1	0	4	4
2.	CY - 101	Chemistry	3	1	0	4	4
3.	ME - 102	Elements of Mechanical Engg.	3	1	0	4	4
4.	HM - 102	English Communication	3	0	0	3	3
5.	CE - 101	Environmental Science &Tech	2	0	0	2	2
6.	HM - 103	Introduction to Management	2	0	0	2	2
7.	IN - 101	Manufacturing Processes	1	0	4	5	3
8.	ME - 103	Mechanical Engg. Lab	0	0	2	2	1
9.	HM - 104	English Communication Lab	0	0	2	2	1
10.	CY - 102	Chemistry Lab	0	0	2	2	1
		Total	17	03	10	30	25

III Semester, B.TECH. BIOTECHNOLOGY

Course No.	Subject	L	T	P	Contact hours	Credits	Prerequisite
BT-201	Microbiology	3	0	0	3	3	Nil
BT-203	Biochemistry	3	0	0	3	3	Nil
BT-205	Bioprocess Calculation	3	1	0	4	4	Nil
BT-207	Bioprocess Engineering	3	1	0	4	4	Nil
MA-202	Numerical Methods	3	1	0	4	4	
CH-001	Fluid and Particle Mechanics	3	1	0	4	4	
BT- 209	Microbiology Laboratory	0	0	4	4	2	Nil
BT- 211	Biochemistry Laboratory	0	0	4	4	2	Nil
	Total	**18**	**4**	**8**	**30**	**26**	

IV Semester, B.TECH. BIOTECHNOLOGY

Course No.	Subject	L	T	P	Contact hours	Credits	Prerequisite
BT-202	Cell and Molecular Biology	3	0	0	3	3	BT-201, BT-203
BT-204	Genetic Engineering	3	1	0	4	4	BT-201, BT-203
BT-206	Immunology	3	0	0	3	3	BT-201, BT-203
BT-208	Industrial Biotechnology	3	0	0	3	3	BT-201, BT-207
CH-002	Heat and Mass Transfer	3	1	0	4	4	
EC-258	Digital Electronics and Microprocessor	3	0	0	3	3	
BT- 210	Bioprocess Engineering Laboratory	0	0	4	4	2	BT-201, BT-207
BT- 212	Molecular Biology and Genetic Engineering Lab	0	0	4	4	2	BT-201, BT-203
BT- 214	Immunology Laboratory	0	0	2	2	1	BT-201, BT-203
	Total	**18**	**2**	**10**	**30**	**25**	

V Semester, B.TECH. BIOTECHNOLOGY

Course No.	Subject	L	T	P	Contact hours	Credits	Prerequisite
BT-301	Separation Methods in Biotechnology	3	1	0	4	4	BT-207, BT-208
BT-303	Animal Cell and Tissue culture	3	0	0	3	3	BT-204, BT-206
BT-3XX	DE - I	3	1	0	4	4	
BT-3XX	D E - II	3	1	0	4	4	
HM-201	Engineering Economics & Industrial Management	3	0	0	3	3	
	Open Elective-I	3	0	0	3	3	
BT-305	Separation process Laboratory	0	0	2	2	1	BT-207, BT-208
BT-307	Cell and Tissue Culture Laboratory	0	0	4	4	2	BT-204, BT-206
	Total	**18**	**3**	**6**	**27**	**24**	

VI Semester, B.TECH. BIOTECHNOLOGY

Course No.	Subject	L	T	P	Contact hours	Credits	Prerequisite
BT- 302	Bioinformatics	3	1	0	4	4	BT-202, BT-204
BT-304	Bioprocess Modeling and Simulation	3	0	2	5	4	BT-207
BT- 3XX	D E - III	3	1	0	4	4	
BT- 3XX	D E - IV	3	1	0	4	4	
HM- 202	Entrepreneurship development & Management	3	0	0	3	3	
	Open Elective-II	3	0	0	3	3	
BT-306	Bioinformatics Laboratory	0	0	2	2	1	BT-202, BT-204
	Total	**18**	**3**	**4**	**25**	**23**	

VII Semester, B.TECH. BIOTECHNOLOGY

Course No.	Subject	L	T	P	Contact hours	Credits	Prerequisite
BT- 401	Biological Waste Treatment	3	1	0	4	4	BT-201, BT-208
BT - 4XX	D E - V	3	1	0	4	4	
BT - 4XX	D E-VI	3	1	0	4	4	
BT - 4XX	D E –VII	3	1	0	4	4	
	Open Elective-III	3	0	0	3	3	
BT-403	Biological waste treatment Laboratory	0	0	2	2	1	BT-201, BT-208
BT-300	Industrial Practical Training	0	0	0	0	4*	
BT-400	Project (Phase –I)	0	0	4	4	2	
	Total	**15**	**4**	**6**	**25**	**26**	

***** Industrial Practical Training will be held during summer vacation after sixth semester

VIII Semester, B.TECH. BIOTECHNOLOGY

Course No.	Subject	L	T	P	Contact hours	Credits	Prerequisite
BT- 4XX	D E –VIII	3	0	0	3	3	
BT- 4XX	D E –IX	3	0	0	3	3	
BT-4XX	D E -X	3	0	0	3	3	
	Open Elective-IV	3	0	0	3	3	
BT-400	Project (Phase –II)	0	0	8	8	4	
	Total	**12**	**0**	**8**	**20**	**16**	

List of Departmental Core Courses Theory

S No	Course No	Course Title	Periods			Contact Hours	Credits
			L	T	P		
1	BT-201	Microbiology	3	0	0	3	3
2	BT-203	Biochemistry	3	0	0	3	3
3	BT-205	Bioprocess Calculation	3	1	0	4	4
4	BT-207	Bioprocess Engineering	3	1	0	4	4
5	BT-202	Cell and Molecular Biology	3	0	0	3	3
6	BT-204	Genetic Engineering	3	1	0	4	4
7	BT-206	Immunology	3	0	0	3	3
8	BT-208	Industrial Biotechnology	3	0	0	3	3
9	BT-301	Separation Methods in Biotechnology	3	1	0	4	4
10	BT- 303	Animal Cell and Tissue culture	3	0	0	3	3
11	BT-302	Bioinformatics	3	1	0	4	4
12	BT-304	Bioprocess modeling and simulation	3	0	2	5	4
13	BT- 401	Biological waste treatment	3	1	0	4	4
		TOTAL	39	6	2	47	**46**

List core courses Practical (including project and training)								
S No	**Course No**	**Course Title**	**L**	**T**	**P**	**Contact Hours**	**Credits**	**Semester**
1	BT-209	Microbiology Laboratory	0	0	4	4	2	**III**
2	BT- 211	Biochemistry Laboratory	0	0	4	4	2	**III**
3.	BT-210	Bioprocess Engineering Laboratory	0	0	4	4	2	**IV**
4.	BT-212	Molecular Biology and Genetic Engineering Laboratory	0	0	4	4	2	**IV**
5.	BT-214	Immunology Laboratory	0	0	2	2	1	**IV**
6.	BT-305	Separation process Laboratory	0	0	2	2	1	**V**
7.	BT-307	Cell and Tissue Culture Laboratory	0	0	4	4	2	**V**
8.	BT-306	Bioinformatics Laboratory	0	0	2	2	1	**VI**
9.	BT-403	Biological Waste Treatment Laboratory	0	0	2	2	1	**VII**
10.	BT- 300	Industrial Practical Training	0	0	0	0	4	**VII**
11.	BT-400	Project (Phase –I)	0	0	4	4	2	**VII**
12.	BT-400	Project (Phase –II)	0	0	8	8	4	**VIII**
					40	40	**24**	

Department Electives							
S No	**Course No**	**Course Title**	**L**	**T**	**P**	**Contact Hours**	**Credits**
1	BT 3XX	Elective-I	3	1	0	4	4
2	BT 3XX	Elective-II	3	1	0	4	4
3	BT 3XX	Elective –III	3	1	0	4	4
4	BT 3XX	Elective –IV	3	1	0	4	4
5	BT 4XX	Elective – V	3	1	0	4	4
6	BT 4XX	Elective – VI	3	1	0	4	4
7	BT 4XX	Elective – VII	3	1	0	4	4
8	BT 4XX	Elective – VIII	3	0	0	3	3
9	BT 4XX	Elective – IX	3	0	0	3	3
10	BT 4XX	Elective – X	3	0	0	3	3
			30	7	0	37	**37**

List of Departmental Electives

(A) Semester V: Departmental Elective I and Departmental Elective II

02 subjects out of following group:

S.No	Course Code	Course Title	L	T	P	C
1	BT-321	Plant Cell and Tissue Culture Engg	3	1	0	4
2	BT-323	Agricultural Biotechnology	3	1	0	4
3	BT-325	Biochemical Reaction Engineering	3	1	0	4
4	BT-327	Biosensors	3	1	0	4

(B) Semester VI: Departmental Elective III and Departmental Elective IV

02 subjects out of following group:

S.No	Course Code	Course Title	L	T	P	C
1	BT-322	Bioprocess Equipment Design and Economics	3	1	0	4
2	BT-324	Protein Engineering	3	1	0	4
3	BT-326	Computational Biology and Drug design	3	1	0	4
4	BT-328	Biostatistics	3	1	0	4

(C) Semester VII: Departmental Elective V, VI and VII

03 subjects out of following group:

S.No	Course Code	Course Title	L	T	P	C
1	BT-421	Analytical Methods in Biotechnology	3	1	0	4
2	BT-423	Enzyme Engineering and Technology	3	1	0	4
3	BT-425	Environmental Biotechnology	3	1	0	4
4	BT-427	Metabolic Engineering	3	1	0	4
5	BT-429	Biopharmaceuticals	3	1	0	4
6	BT-431	Transport Phenomena	3	1	0	4

(D) Semester VIII: Departmental Elective VIII, IX and X

03 subjects out of following group:

S.No	Course Code	Course Title	L	T	P	C
1	BT-422	Food Process Biotechnology	3	0	0	3
2	BT-424	Bioprocess Safety and Bioethics	3	0	0	3
3	BT-426	Nanobiotechnology	3	0	0	3
4	BT-428	Secondary Metabolites in Plants & Microbes	3	0	0	3
5	BT-430	Biomaterials	3	0	0	3
6	BT-432	IPR in Biotechnology	3	0	0	3
7	BT-434	Stem Cell Biology	3	0	0	3

DETAIL SYLLABUS

(Departmental Subjects)

DEPARTMENT OF BIOTECHNOLOGY

Detailed syllabus 3rd Semester:

BT- 201 Microbiology [3 0 0 3]

Unit-I

Scope and History of Microbiology: Scope and History of Microbiology, Classification, Characterization, Identification and Nomenclature of Microorganisms, Microscopy, Morphological, Structural and Biochemical characteristics of prokaryotes and eukaryotes (bacteria , yeast, mold, algae, protozoa, actinomycetes)

Cultivation of Microorganisms: Microbiological media, physical conditions required for growth.

Reproduction and Growth of Microorganism: Modes of cell division, growth curve of microbes, Quantitative measurement of growth.

Unit-II

Methods in Microbiology: Chemical, Physical and Biological methods of selection of microorganisms, Methods of isolating pure cultures, Maintenance and preservation of pure cultures, microbial mutation.

Microbial Metabolism: Metabolic pathways and Bioenergetics, Aerobic and Anaerobic growth, Transport of nutrients across cell membranes

Physical and Chemical Control of Microorganism: Major groups of antimicrobial agents, Mode of action and practical applications

Energy Transduction Mechanisms in Microbial Cell: Aerobic and anaerobic respiration, Microbial photosynthesis, Transduction, Transformation, Conjugation

Unit-III

Microbial Interaction: - Roles of microbes in Nitrogen, Carbon and Sulphur cycle

Application of Microorganism in various Field: - Agriculture, food, environment, medicine, public health and industry.

Viruses: Classification, morphology and composition, DNA and RNA bacteriophages, Lysogeny and lytic cycle

Books Recommended

1. Pelczar M J, Chan E C S and Krieg N R "*Microbiology*, 5th Edition, " Mc Graw Hill, New York (1995)
2. Salle A J, "*Fundamental Principles of Bacteriology*" , 7th Edition, Tata McGraw Hill, New Delhi (1984)
3. Stanier R Y, "*Text in Microbiology*" McMillan Press London (1995)
4. Davis B D, "*Microbiology*", Harper and Row Publications, Hageston (1980)
5. Casida L E, "*Industrial Microbiology*", New Age International Publishers, New Delhi (2003)

BT-203 Biochemistry [3 0 0 3]

Unit-I

Molecular basis of life, study of macro molecules

Carbohydrates: Their structure and biological functions, Monosaccharides disaccharides and polysaccharides Glycoproteins.

Amino Acids and Proteins: Their structure and function, Types of amino acids, Fibrous proteins and globular proteins, Separation of proteins

Fats and Lipids: Their structure and biological functions, Types of lipids, triacylglycerol, Waxes, Phospholipids, Sphingolipids, Lipoproteins

Unit-II

Nucleic acid and Nucleotides: DNA, Structure of chromosomes and genes, Replication and transcription of DNA, RNA Protein synthesis and its regulation, Genetic recombination and cloning

Vitamins and Hormones: Types, Structure and functions

Photosynthesis: Chlorophylls, Kinds and roles of photosystems, Calvin cycle

Enzymes: Properties and types, Kinetics of enzyme action, Enzyme inhibition, Allosteric enzymes, Assay of enzymes, Regulation of enzyme activity

Unit-III

Bioenergetics and Metabolism: Metabolism, basic concepts and design, Glycolysis citric acid cycle oxidative phosphorylation pentose phosphate pathway and gluconeogenesis glycogen and disaccharide metabolism amino acid degradation and urea cycle

Biological Membranes: Characteristics of biological membranes components of membranes types of membranes fluid mosaic model membrane asymmetry

Books Recommended

1. Stryer L, "*Biochemistry"* , 5th Edition, W.H.Freeman and Company (2002)
2. Lehninger, A L **"***Principles of Biochemistry*", 4th Edition Butterworth Publishers, New York (2003)
3. Conn E E and Stump P K "*Outlines of Biochemistry*" ,John Wiley and Sons, New York (1987)
4. Walsh G , " *Proteins Biochemistry and Biotechnology"* John Wiley and sons (2003)
5. Rastogi," *Biochemistry"* , 2nd Edition, Tata Mc Graw Hill (2003).

BT-205 Bioprocess Calculation [3 1 0 4]

Unit-I

Introduction to Biochemical Engineering Calculations: Units and dimensions, mole concept, conventions in methods of analysis and measurement, basis, temperature, pressure, the chemical equations and stoichiometry, limiting and excess reactant, conversion and yield. Mass and energy balances in bioprocesses, flow sheet and process calculations, metabolic stoichiometry of growth and product formation, material balance and energy balance with recycle, by pass and purge streams.

Unit-II

Material Balance: Material balance, program of analysis of material balance problems, solving material balance problems that do not involve chemical reactions, solving material balances problems involving chemical reactions, multiple subsystems, recycle, bypass, and purge calculations.

Gases Vapors, Liquids and Solids: Ideal gas law calculations, real gas relationships, vapor pressure and liquids, saturation, partial saturation and humidity.

Unit-III

Energy Balances: Concepts and units, calculation of enthalpy changes, application of the general energy balance without reactions occurring energy balances that account for chemical reaction, reversible processes and the mechanical energy balances, heats of solution and mixing, psychometric charts and their use.

Books recommended

1. Himmelblau D M, "*Basic Principles and Calculations in Chemical Engineering,"* Prentice Hall (1998).
2. Haugen O A, Watson K M and Ragatz R A, "*Chemical Process Principles (Part-I): Material and Energy Balances*", Asia Publishing House (1995).
3. Bhatt B I and Vora S M, "*Industrial Stoiciometry*": Tata McGraw Hill Publishing, New Delhi (1987).
4. Reklaitis G V, "*Introduction to material and energy balances"* Wiley, New York (1983)

BT-207 Bioprocess Engineering [3 1 0 4]

Unit-I

Microbial Growth Kinetics: Batch, continuous and fed batch, mass balance in series of vessels, recycle system

Media Sterilization: Methods of media sterilization, batch and continuous sterilization, kinetics of sterilization

Air Sterilization: Methods of air sterilization, mechanism of air sterilization, filter design.

Unit-II

Design of Fermenter: Construction materials, Temperature control, Mass transfer and microbial respiration, Baffles, Sterilization of fermenter, different types of fermenter,

Aeration and Agitation: bubble aeration and mechanical agitation, correlation between oxygen transfer coefficient and operating variables, factors affecting volumetric oxygen transfer, the effect of degree of agitation on volumetric oxygen transfer, rheology of fermentation fluids

Scale Up: Scale up concepts, criteria for bioreactors scale up.

Unit-III

Monitoring of Bioprocesses: On line data analysis for measurement and control of important physicochemical and biochemical parameters, parameter estimation techniques for biochemical processes, parameter estimation techniques for biochemical processes, Computer based data acquisition,

Books Recommended

1. Shuler M L, Kargi F, " *Bioprocess Engineering- Basic Concepts*" , 2nd ed, Prentice Hall of India Ltd. (2002)
2. Aiba S, Humphrey A E and Millis N F ,"*Biochemical Engineering*" , Academic Press (1973)
3. Stanbury P F and Whitaker A, "*Principles of Fermentation Technology*," 2nd edition, Elsevier, (1995)
4. Bailey J E and Ollis D F, "*Biochemical Engineering Fundamentals"* , McGraw Hill (1986)

5. Harvey W. Blanch and Douglas S.Clark, "*Biochemical Engineering*", Marcel Dekker (1996).

6. Lee J M, "*Biochemical Engineering*" , Prentice Hall (1992)

CH-001 Fluid Mechanics & Mechanical Operation) [3-1-0-4]

Unit-I

Introduction to Fluid flow: Ideal and real fluids, Extensive and Intensive properties, viscosity, surface tension, capillarity, evaporability, vapour pressure, Newtonian and Non Newtonian fluids.

Fluid Statistics: Hydro statistics law, Pascal's law, Different types of Manometer, centrifugal decanter

Fluids Kinematics and Dynamics: Classification of fluid flow, streamline, streakline, pathlines, flow rate and continuity equation, Bernaulli's theorem and its application, kinetic energy and momentum correction factor in Bernaulli's equation, concept of friction law in fluid flow, various pumps.

Laminar Viscous flow and flow measurement devices: Reynolds numbers, Hagen Poiseuille Law, Venturi meter, Orifice meter.

Unit-II

Size Reduction: Particle size and shape, particle mass, size and shape distributions, measurement and analysis, concept of average diameter, size reduction, crushing, grinding and law of grindings.

Screening: Equipment, capacity and effectiveness of screen, effect of mesh size on capacity of screen.

Settling: Flow around a single particle, drag force and drag coefficient, settling velocity of particles in a fluid, hindered and free settling of particles, thickening gravity separation

Separation of solid from liquid: Classification of filters, various types of cake filters, principle of cake filtration, clarification filters, liquid clarification, centrifugal settling process.

Unit-III

Agitation & Mixing: Agitation of liquids, axial flow impellers, radial flow impellers, velocity and power consumption of agitated vessels, blending & mixing.

Fluidization: Packed beds, bed porosity, flow though a bed of particles, fluidization & fluidized bed, conditions for fluidization minimum velocity, types of fluidization.

Books Recommended

1. Smith J C, Mccabe W L and Harriot P H, *"Unit Operations of Chemical Engineering"*, McGraw Hill, 7th edition, (2005).
2. Richardson and Coulson *"Chemical Engineering Vol II", 5th ed.,* Butterworth – Heinemann (2003).
3. Perry's, "*Handbook of Chemical Engineering*", 7th Ed, McGraw Hill (1997).

BT- 209 Microbiology Laboratory [0 0 4 2]

1. To study the microscope.
2. Preparation and sterilization of the medium for bacteria yeast and mold.
3. Preparation of slants /plates /deeps for culture of bacteria yeast and mold.
4. Aseptic transfer of microbial cultures.
5. To study the morphology of bacteria, yeast and mold.
6. Staining of bacteria (Gram's stain).
7. The quantitative bacteriological examination of water/milk.
8. Determination of phenol coefficient.
9. a) Determination of cell mass in a fermentation broth.
   b) Calibration of cell mass vs. cell number and cell mass vs optical density
10. Serial dilution to quantify the viable cells.

BT- 211 Biochemistry Laboratory [0 0 4 2]

1. Determination of reducing sugar by dinitro-salicylic (DNS) method.
2. Protein estimation by Lowry's method.
3. Estimation of DNA by diphenylamine reagent method.
4. Determination of Michaelis constant of enzymes.
5. Determination of isoelectric point of casein.
6. Extraction of lipids from egg yolk.
7. Separation by amino acids by paper electrophoresis
8. Preparation of different buffer solutions for biochemical experiments
9. Determination of pKa values
10. Titration curves of amino acids
11. Ultraviolet absorption of nucleic acids, amino acids and protein
12. Determination of acid value, iodine value and specification value of fat
13. Experimental analysis of biochemical compounds by TLC
14. Estimation of cholesterol.

DEPARTMENT OF BIOTECHNOLOGY

Detailed syllabus 4th Semester:

BT 202 Cell and Molecular Biology [3 0 0 3]

Unit-I

Introduction to the Cell: Evolution of cell: prokaryotic and eukaryotic cell, unicellular and multicellular organisms.

Cell Organells: Cell wall, cell membranes, cytosol, mitochondria, chloroplast, nucleus, nucleolus, ribosome, lysosomes, Golgi body, endoplasmic reticulum, motility organelles, flagella, pilli, cilia

Structure and function of nucleus: organization of the chromosome; eu-and heterochromatins; nucleosome; cell cycle regulation - CDC mutants, protein kinase; cyclin; synthetic pattern and control of cell divisions; biochemistry of meiosis

Chromosome biology: ultra structure of chromosomes, types of chromosome, chromosomal aberration (Numerical & structural), chromatin, Chromosomal DNA, chromosomal proteins and its packaging

Unit-II

Molecular Genetics: Cell cycle, Cell division, mechanism of cell division, Cell theory, mechanism of cell development, formation of tissues, types of tissue (both plant and animals)

Cell Signaling: General principles of cell signaling, signaling via G-Protein linked cell-surface Receptors, Signaling via Enzyme- linked cell-surface Receptors, target cell adaptation

The biochemical basis of inheritance: DNA as the genetic material; DNA structure and replication in Prokaryotes and eukaryotes; nucleotide sequence composition: unique, middle and highly repetitive DNA; Redundant DNA; Genetic Code; transcription and translation machinery in Prokaryotic and eukaryotic system. Regulation of gene expression in E. coli-operon concept; hormonal control of gene expression in eukaryotes.

Unit-III

Microscopy: Compound, Phase contrast, Fluorescent, Confocal, EM,

Fractionation: Cell rupture techniques, Fractionation of subcellular organelles by centrifugation, flow cytometry

Books Recommended

1. De- Robertis, F D P and De Robertis E M F, "*Cell and Molecular Biology"*, Saunders, Philadelphia (1991)
2. Lewin B *"Gene IX"*, Oxford University Press, Oxford (2008)
3. Sambrook J, Fritsch E F and Maniatis T, "*Molecular Cloning"* ., Cold Spring Harbor Laboratory Press (1989)

BT-204 Genetic Engineering [3 1 0 4]

Unit-I

Introduction to Genetic Engineering: Gene its concepts and inheritance, development of Molecular Biology and Genetic Engineering, DNA–structure, forms and replication, RNA–types and functions, ribosome and translation, regulation of transcription and translation

Genome Organization: Genome size and complexity, the super coiling of DNA the structure of prokaryotic and eukaryotic chromosome, satellite DNA, centromere and telomere structure.

Bacteria: Transformation, transduction and conjugation.

Eukaryotes: Transcription, RNA splicing, Retroviruses.

Virus: Bacteriophages, genome its organization and its expression, virus of eukaryotes.

Mutation: Spontaneous versus induced mutations, types of mutations, mechanism of DNA repair, mutations frequency gene transfer and expression in bacteria, eukaryotes and viruses.

Unit-II

Basics of Recombinant DNA: Role of genes within cells, genetic code, genetic elements that control gene expression, method of creating recombinant DNA research, restriction enzymes and mapping in eukaryotes, plasmids, bacteriophage lambda and M-13 molecular biology, RNA tumour viruses- replication and function

Construction of c DNA libraries: Construction of genomic and c DNA libraries, methods of nucleic acid sequencing, expression of cloned genes

Polymerase Chain Reaction: Thermostable DNA Polymerases, PCR technique, Inverse PCR, Nested PCR, RACE PCR, Real-Time PCR, Site directed mutagenesis,

Unit-III

Methods In Genetic Engineering: Restriction and modifying enzymes, Restriction mapping, Southern blot, Northern blot, Western blot.

Application of Recombinant DNA Technology: In agriculture, transgenic plants and animals, gene therapy, synthesis of important molecules like insulin, growth hormone interferon etc

Books Recommended

1. De- Robertis, F D P and De Robertis E M F, "*Cell and Molecular Biology"*, Saunders, Philadelphia (1991)
2. Lewin B *"Gene IX"*, Oxford University Press, Oxford (2008)
3. Sambrook J, Fritsch E F and Maniatis T, *"Molecular Cloning"* ., Cold Spring Harbor Laboratory Press (1989)
4. Lehninger A L, **"***Principles of Biochemistry*", Butterworth Publishers, New York (1993)

BT 206 Immunology [3 0 0 3]

Unit-I

The immune system: innate and acquired immune system, components of immune system, role of humoral and cell-mediated immunity. Antibodies, the genetic basis of antibody diversity, structure-function, immunoglobulin classes. Polyclonal and Monoclonal antibodies, Catalytic antibodies. Structure and properties of antigens, biological aspects of antibody-antigen interaction. Identification and measurement of antibodies and antigens, Radial Immuno diffusion,

Cells and Organs of Immune System: Lymphoid cell, heterogeneity of lymphoid cells, T-Cells, primary and secondary lymphoid organs- thymus, bursa of fabricus, spleen,
Lymph nodes, lymphatic system,, mucosal associated lymphoid tissue (MALT)

Unit-II

Humoral Immunity: B-lymphocytes and their activation, structure and function of immunoglobulins, immnunologobulin classes and subclasses, genetic control and production, monoclonal antibodies and diagnosis, major histocompatibility complex, complement fixing antibodies and complement cascade

Cellular Immunity: Thymus derived lymphocytes (T-cells their classification antigen presenting cells (APC), Macrophage their origin and function, mechanism of phagocytosis, Identification of cell types of immune systems, immuno suppression and immune tolerance, interferrons and their mechanism of action, interleukins and their functions.

Immunity and Infection: Hypersensitivity reactions, types and mechanisms of T Cell activation, Cytokines and their role in immune response, transplantation and rejection, graft rejection, Immunosuppressive drugs, mechanism of immunity, tumor antigens.

Immune Disorders and Diseases: Primary immuno deficiency, secondary immuno-deficiency, Acquired immuno deficiency syndrome (AIDS)

Unit-III

Auto Immunity: Auto antibodies in humans, Pathogenic mechanisms, experimental models of auto immune disease, treatment of autoimmune disorders.

Immunological Techniques and Vaccines: Precipitation, agglutination, RIA, ELISA, Immunoelectrophoresis, Immunodiffusion

Books Recommended

1. Kuby J "*Immunology"* , W.H. Freeman and Company, New York (2003)
2. Roitt I M "*Essentials of Immunology"* , Blackwell Scientific Publications Oxford (1991)
3. Benjamin E and Leskowity S "*Immunology*, A *Short Course"*, Wiley Liss (1991)
4. Pinchuk G, "*Schaum's Outline of Immunology*",Tata McGraw Hill (2004)

BT- 208 Industrial Biotechnology [3 0 0 3]

Unit-I

Introduction to Industrial Biotechnology: Definition and scope of Industrial Biotechnology, historical overview of industrial fermentation processes and products.

Bioprocess development on an industrial scale: Microorganisms and various unit operations involved, process parameter optimization, products and market economics relating to modern industrial biotechnology.

Raw materials and microorganism for fermentation process: Isolation, preservation and maintenance and improvement of industrial microorganisms for overproduction of primary and secondary metabolites, media requirements for fermentation processes, carbon, nitrogen, minerals, vitamins and other nutrients, simple and complex media, media economics,

Unit-II

Commercially Important Products: Enzymes and recombinant proteins having therapeutic and diagnostic applications, specialty by products for agricultural, food and pharmaceutical industries, biopesticides, biofertilizer and plant growth stimulants, biopolymers, single cell proteins, baker's yeast, high fructose corn syrup.

Production of Primary Metabolites: Organic acids, alcohols, acetone and butanol etc.,

Unit-III

Production of Secondary Metabolites: Antibiotics – Beta lactam antibiotics, amino glycosides, tetracyclines, erythromycin, vitamins and steroids.

Biological Waste Treatment: Overview of various aerobic and anaerobic processes.

Books Recommended

1. Crueger W and Crueger A, "*Biotechnology: A Text book of Industrial Microbiology*" Sinouer Associate, Inc. Sunderland MA, USA(1990)
2. Casida L E, "*Industrial Microbiology"* , New Age International Publishers Ltd.(2003)
3. Reed G, "*Prescott and Dunn's Industrial Microbiology*" CBS publishers and distributors, New Delhi (1987). ,
4. Mansi E M T EL, Bryce C F A, "*Fermentation Microbiology and Biotechnology*". Ane Books Publishers and Distributors (2003)
5. Kumar H D, "*A Text book of Biotechnology*", EWP (1994).

CH 002 Heat and Mass Transfer [3-1-0-4]

Unit-I

Conduction: Fourier's law, steady state heat conduction through a composite solid, cylinders, spheres, different insulating materials for process equipment

Convection: Convection, individual and overall heat transfer coefficient, heat transfer between fluids separated by plane wall and by cylindrical wall (pipes), critical/ optimum insulation thickness, concepts of heat exchanger.

Heat Transfer with phase change: Boiling phenomena, correlation for nucleate boiling, critical heat flux, condensation phenomena, film condensation on a vertical surface.

Radiation: Blackbody radiation, Planck's law, Wein's displacement law, the Stefan Boltzmann law, Kirchoff's law.

Evaporation: Single and multiple effect evaporators, capacity and economy, boiling point elevation.

Unit-II

Mass Transfer Coefficient: Local and overall mass transfer coefficient, local two phase mass transfer coefficients, Local overall Mass Transfer coefficients.

Gas Absorption: Choice of solvent, number of ideal stages, height of column, equipment for gas absorption

Drying: Equilibrium in drying, rate of batch drying, time of drying, drying equipments.

Distillation : Raoult's Law and Dalton's law, partial vaporisation condensation, relative volatility, differential & flash distillation, steam distillation, total reflux , minimum and optimum reflux ratios, Lewis Sorel and MaCabe –Thiele methods, Ponchon Savarit method

Liquid – Liquid Extraction: Ternary phase diagrams & choice of solvent, single stage and multistage cross current, co-current and counter current extraction operation

Unit-III

Adsorption: Introduction and the nature of adsorbent, adsorption equilibria, the Langmuir isotherm, BET isotherm and Gibbs isotherm, adsorption equipments.

Crystallization: Formation and properties of crystals, crystallisers

Books Recommended

1) Smith J C, Mccabe W L and Harriot P H, *"Unit Operations of Chemical Engineering"*, McGraw Hill, 7th edition, (2005).
2) Richardson and Coulson *"Chemical Engineering Vol II", 5th ed.,* Butterworth – Heinemann (2003).
3) Perry's, "*Handbook of Chemical Engineering*", 7th Ed, McGraw Hill (1997).
4) Geankopolis C J, "*Transport Processes and Separation Process Principles*", Prentice Hall of India, 4th Edition, Eastern Economy Edition (2004)
5) Treybal R E , "Mass Transfer Operations" 3rd ed. , McGraw Hill (1980)

BT- 210 Bioprocess Engineering Laboratory [0 0 4 2]

1. Sterilization of bio reactor.
2. To estimate growth kinetic parameters of *Escherichia coli*.
3. To determine Volumetric Oxygen Transfer Coefficient (Kla) in fermentation system by dynamic method.
4. To determine Volumetric Oxygen Transfer Coefficient (Kla) in fermentation system by sulphite oxidation method.
5. To determine mixing time in a stirred tank reactor (STR).
6. Estimation of cell maintenance coefficient and true growth yield by studying the mass and energy balance during cell growth.
7. Comparison between aerobic and anaerobic fermentation.
8. To determine Residence Time Distribution (RTD) for a CSTR.
9. Immobilization of the enzymes over the carriers.
10. Immobilization of the cells over the carriers.
11. Studies on the kinetics of immobilized enzyme and immobilized cells.

BT- 212 Molecular Biology and Genetic Engineering Laboratory [0 0 4 2]

1. Isolation and purification of genomic DNA from bacteria, plant and animal tissues.
2. Isolation and purification of plasmid DNA.
3. Analysis of DNA by agarose and polyacrylamide gel electrophoresis.
4. Recovery of DNA from gels.
5. Restriction analysis of DNA and restriction mapping.
6. Spectrophotometric estimation of DNA, RNA and proteins.
7. *In situ* gel assays for peroxidase, SOD, acid phosphatase and LDH.
8. Southern, Northern and dot blotting technique
9. Determination of phosphorous content of nucleic acids
10. Analysis of proteins by gel electrophoresis
11. Analysis of proteins by 2D gel electrophoresis
12. Estimation of RNA by means of orcinol reaction

BT- 214 Immunology Laboratory [0 0 2 1]

1. Immunodiffusion
2. Immunoelectrophoresis
3. Western blotting
4. Production of monoclonal antibodies and testing,
5. Antigen – Antibody reactions (Widal test, Blood grouping, Rh factor)
6. RBC & WBC count by haemocytometer
7. ELISA
8. Immunochemical assay techniques

DEPARTMENT OF BIOTECHNOLOGY

Detailed syllabus 5th Semester:

BT 301 Separation Methods in Biotechnology [3 1 0 4]

Unit-I

Separation of insoluble products: sedimentation, sedimentation coefficient, filtration, membrane filtration, centrifugation, microcentrifuge, ultracentrifuge, differential and density gradient centrifugation, coagulation and flocculation.

Cell Disruption: Mechanical methods, Non-mechanical methods.

Dialysis and Filtration: electro-dialysis, ultra-filtration and micro-filtration, cross-flow ultra-filtration and micro-filtration.

Separation of soluble products: Liquid-liquid extraction, aqueous two-phase extraction, precipitation, adsorption, salt and solvent precipitation of protein, recombinant protein purification.

Unit-II

Electrophoresis: Gel electrophoresis (Agarose, PAGE, SDS PAGE), Disc gel electrophoresis, Gradient electrophoresis, pulse field gel electrophoresis, 2 D gel electrophoresis, capillary electrophoresis, Isoelectric focusing, Gel capillary electrophoresis, Capillary zone electrophoresis, Autoradiography, Radioimmunoassay.

Chiral separation of biomolecules: Chiral Thin layer chromatography, chiral gas-liquid chromatography, non chromatographic chiral separation

Chromatography: Method selection; selection of matrix; Adsorption chromatography, Ion-exchange chromatography, gel-filtration chromatography, size exclusion chromatography, ion exclusion chromatography, affinity chromatography, hydrophobic interaction chromatography, high pressure liquid chromatography, Co-valent chromatography; IMAC chromatography, Dye ligand chromatography. Chromatography scale-up.

Unit-III

Crystallization: Theory and methods; API-electrospray and MADI-TOF; Mass spectrometry; Enzyme and cell immobilization techniques; DNA & Peptide Synthesis.

Reverse Micelles: Reverse micelles formation, correlation of miceller size and protein size, Reverse micelles extraction method

Molecular Imprinting: Imprint property, selectivity of molecular imprinting.

Drying: Lyophilization, Spray drying, vacuum drying, air drying.

Books Recommended

1. Willard, H., Meritt,L.L., Dean J.A. and Settle F.A., *"Instrumental Methods of analysis"*, 6th edition, CBS Publishers, (1986)
2. Vogel's, *"Textbook of Quantitative Chemical Analysis"*, 6th Edition, Pearson, (2005).
3. Skoog,D.A. , F.J. Holler and T.A. Nieman., *"Principles of Instrumental analysis"*, 5th Edition , Harcourt Area PTE (1998)
4. Okotore, R.O., *"Basic Separation Techniques in Biochemistry"*, New Age (1998)
5. Sivasankar, B., *"Bioseparation: Principles and Techniques"*, Prentice Hall India (2005).
6. R. Scopes, Protein Purification - Principles & Practices, 3rd Edition, Springer Verlag, 1994.

BT-303 Animal Cell and Tissue Culture [3 0 0 3]

Unit-I

Basics of Cell and Tissue Culture: Laboratory requirements for tissue culture, substrates for cultures, culture media for animal cell cultures, culture procedures and principles, freeze storing of cells and transport of cultures, Primary culture, secondary culture; Continuous cell lines; Suspension cultures.

Characteristics of Cells in Culture: Contact inhibition, anchorage independence/dependence, cell-cell communication, cell senescence.

Cell Culture Lines: Definition, development and maintenance, characteristics of animal cells and their implication on process design, nutritional requirements and serum free culture of mammalian cells, kinetics of growth and product formation, cloning of cell lines, cell synchronization, viral sensitivity of cell lines, cell line characterization, stem cell lines.

Unit-II

General Tissue Culture Techniques: Types of tissue cultures, methods of disaggregating primary cultures, primary tissue explanation technique, reactor systems for large-scale production using animal cells.

Organ Culture: Methods, behavior of organ explants and utility of organ culture, whole embryo culture.

Methods in Cell Culture: Micro carrier cultures, cell immobilization, animal cell bioreactor, large scale cell cultures for biotechnology, somatic cell fusion, flow cytometry, transfection.

Applications of Animal Cell Culture: Use in gene therapy, cloning from short-term cultured cells, cloning from long-term cultured cells, cloning for production of transgenic animals, cloning for conservation. Application of animal cell culture for *in vitro* testing of drugs; Testing of toxicity of environmental pollutants in cell culture.

Unit-III

Hybridoma technology: Production of monoclonal and polyclonal antibodies with different types of antigens, antigen preparation and modification, adjuvants dose and route of antigen administration, collection of sera, purification of antibodies, production and applications of monoclonal antibodies for diagnosis and therapy, production of virus vaccines, specific vaccines, production of cellular chemicals like Interferons, Interleukin etc. Immunoassay procedures.

Books Recommended

1. Freshney R. Ian, *"Culture of animal cells: A manual of Basic Technique"*, Willey-Liss Publisher, 5th edition (2005).
2. Jenkins N, ed., *"Animal Cell Biotechnology: Methods and Protocol"*, Humana Press (1999).
3. Minuth W.W., Strehl R., Schumacher K., *"Tissue Engineering: Essential for Daily Laboratory Works"*, Willey Publisher (2005).
4. Butler, M "*Mammalian Cell Biotechnology- A Practical Approach*," IRL Oxford University Press (1991)

BT-305 Separation Process Laboratory [0 0 2 1]

1. Harvesting of fermentation broth and its processing for product purification.
2. Solid-liquid separation
3. Liquid-liquid separation
4. Disruption of microbial cells
5. Separation by precipation through adding salts and solvents.
6. Dialysis
7. Ultrafilteration
8. Vaccum evaporation
9. Drying and crystallization
10. Separation of proteins and other biomolecules by various Chromatography techniques

BT-307 Cell and Tissue Culture Laboratory [0 0 4 2]

1. Introduction to Tissue Culture Laboratory facilities
2. Preparation of medium and sterility tests
3. Principles and Technique for monolayer and suspension culture
4. Subculture of animal cell line and cell preservation
5. Genetically engineered cell
6. Mass cell cultivation
7. Preparation of Culture Media for plant cell, Sterilization of Culture Media
8. Explant selection, sterilization and inoculation;
9. Various media preparations; MS, B5, SH PC L-2;
10. Callus and cell suspension culture
11. Plant regeneration from embryo, meristem and callus culture.

BT-321 Plant Cell and Tissue Culture [3 1 0 4]

Unit-I

Introduction: Special features of plant cells, totipotency, regeneration of plants, organogenesis, Somatic Embryogenesis, somaclonal variation, its genetic basis and application in crop improvement

Basic techniques in cell and tissue culture: Culture media composition and preparation, cell growth regulations

Cell Cultures: Initiation and maintenance of callus and suspension culture, protoplast isolation, fusion and culture, somatic hybridization, Role of tissue culture in rapid clonal propagation, production of pathogen - free plants and "synthetic seeds". Overcoming Barriers using Tissue Culture: Pre- and Post-Fertilization barriers, Production and Use of Haploids.

Micropropagation : Techniques, factors affecting morphogenesis and proliferation rate , technical problems in micro propagation, meristem culture for the production of pathogen free plants , applications of micro propagation.

Unit-II

Protoplast technology: Isolation, culture and plant regeneration, protoplast fusion, identification and characterization of somatic hybrids, applications of protoplast technology.

Biochemistry of major metabolic pathways and products: Autotrophic and heterotrophic growth – carbon dioxide assimilation, carbohydrate metabolism, nitrogen assimilation.

Specific gene transfer: Indirect and direct methods, current status and limitations.

Plant products of industrial importance: Cell suspension culture development and production of secondary metabolites by suspension cultures (case studies of azardiractin, podophyllotoxin)

Biological and technology barriers: Mutation, somaclonal variation, hydrodynamic shear and its quantification, mixing and impeller design aspects.

Unit-III

Transgenic Plants: Genetically Modified Crops, Resistance against Biotic and Abiotic Stresses, Molecular Farming.

Plant Cell Reactors: Comparison of reactor performance, immobilized plant cell and cell retention reactors.

Automation in plant tissue culture: Field techniques for propagation of regenerated plants.

Books Recommended

1. Bhojwani S.S. and Razdan M.K., "*Plant Tissue culture Theory and Practice*", Elesevier Science , Netherlands (2004)
2. Razdan M.K., "Introduction *to Plant Tissue culture"*, 2nd Edition, Science Publishers (2003).
3. Narayanswamy S.,"*Plant Cell and Tissue culture"*, Tata Mc-Graw Hill publishing Co. Ltd. (2002).
4. Trigiano R.N., Grey D.J., *"Plant Tissue Culture: Concepts and Laboratory Exercises"*, 2nd Edition, CRC Press (2000).
5. Trigiano R.N., Grey D.J., *"Plant development and Biotechnology"*, CRC Press (2005).
6. Dixon R.A., Gonzales R.A., *"Plant Cell Culture: A practical approach"*, Oxford University Press (1994).

BT-323 Agricultural Biotechnology [3 1 0 4]

Unit-I

Production of disease free plants : shoot - tip - cultures, shoot - tip - grafting, viricidal compounds.

Tissue culture as a source of genetic variability: somaclonal and gametoclonal variant selection, sources and causes of variation, application in crop improvement.

Protoplast isolation: culture and fusion, selection of hybrid cells and regeneration of hybrid plants, somatic hybridization

Unit-II

Plant cell cultures for useful chemicals: pigments perfumes, flavors, insecticides, anticancer agents and pharmacologically important compounds.

Genetic Engineering in Agriculture: techniques for the insertion of foreign genes into plant cells, Ti plasmid and vectors, production of transgenic plants, (i) Transgenic plants (ii) gene

cloning, restriction fragment length polymorphisms, transposons, and insertional mutagenesis. Molecular Farming: Plants As factories for biopharmaceuticals, Transgenic value added specialty crops, Use of antisense RNA and other technologies.
Nitrogen fixation: nif-gene transfer, herbicide resistance and stress tolerance in plants. Isolation and characterization of organelle genome (Plastome and Chonodriosome).

Unit-III
Bioinsecticides and biofertilizers: Preservation of rare plant species germplasm collection and conservation. Soil Reclamation: Phytoremediation

Books Recommended

1. Bhojwani S.S. and Razdan M.K., "*Plant Tissue culture Theory and Practice*", Elesevier Science , Netherlands (2004)
2. Trigiano R.N., Grey D.J., *"Plant Tissue Culture: Concepts and Laboratory Exercises"*, 2nd Edition, CRC Press (2000).
3. Lindsey K, *"Plant Tissue culture Manual"*, Kluwer Academic Publ. (1991).
4. Kung S D, Wu R, *"Transgenic Plants Vol. 1 & 2"*, Academic Press, San Diego (1993).
5. Lindsey K, Jones M G K, *"Plant biotechnology In Agriculture"*, Prentice hall (1990).

BT-325 Biochemical Reaction Engineering [3 1 0 4]

Unit-I
Biochemical Reaction Engineering: Kinetics of homogeneous reactions; reaction mechanism; Temperature dependency from Arrhenius law; Theoretical prediction of rate constant: Interpretation of batch kinetic data.
Kinetics of enzyme catalyzed reactions in free and immobilized states: Michaelis-Menten equation and its various modifications. Effects of External mass transfer in immobilized enzyme systems; analysis of intraparticle diffusion and reaction.
Kinetics of substrate utilization, product formation and biomass production : Monod growth model and its various modifications; structured and unstructured kinetic rate models; Thermal death kinetics of cells & spores; Transport phenomena in Bioprocess systems; gas-liquid mass transfer in cellular systems. Mass transfer for bubbles swarms;

Unit-II
Types of reactors: batch, plug flow reactor (PFR), continuous stirred rank reactors (CSTR), fluidized bed reactor, bubble column, air life Fermentor, etc; Concept of ideal and non-ideal reactor: residence time distribution; Operating considerations in bioreactors for suspension and immobilized cultures, modifying batch and continuous reactors, immobilized cell systems, solid state fermentation.
Models of non-ideal reactors: plug flow with axial dispersion, tanks-n-series model.
Unconventional bioreactors: Hollow fiber reactor, membrane reactor, perfusion reactor for animal and plant cell culture.
Unit-III
Kinetics of mixed cultures: Major classes of interaction in mixed cultures, models describing mixed-culture interactions, reaction dynamics, industrial application of mixed cultures.

Books Recommended

1. Levenspiel O, *"Chemical Reaction Engineering"*, 3rd Ed , John Wiley & Sons, Singapore (1999).
2. Lee J M, "*Biochemical Engineering*" , Prentice Hall (1992)
3. Shuler M L, Kargi F, " *Bioprocess Engineering- Basic Concepts*" , 2nd ed, Prentice Hall of India Ltd. (2002)
4. Aiba S, Humphrey A E and Millis N F ,"*Biochemical Engineering*" , Academic Press (1973)

BT-327 Biosensor [3 1 0 4]

Unit-I

Overview of Biosensors: Fundamental elements of biosensor devices, Fundamental engineering aspects of biosensors, Signal processing for biosensors.

Fundamentals of measurement science: applied to optical, electrochemical, mass, and pressure signal transduction.

Theoretical analysis of biosensor: design and performance.

Unit-II

Electro chemical biosensors: Electrochemical principles, Amperometric biosensors and charge transfer pathways in enzymes, Glucose biosensors, engineering electrochemical biosensors, Other than electrochemical or optical sensing schemes.

Optical Biosensors: Optics for biosensors, Attenuated total reflection systems, Non-invasive optical sensors

Unit-III

Mass and Acoustic Biosensors: Saubrey formulation, Acoustic sensor formats, Quartz crystal microbalance, Whole cell biosensors

Books Recommended

1. Anthony E G C, Cooper J M, *"Biosensors"*, Oxford University Press (2004)
2. Roger K R , Mulchandani A, *"Enzyme and Microbial biosensors"*, Humana Press (1998)
3. Bilitewsk U, Turner A P F, *" Biosensor in Environmental Monitoring"*, Taylor & Francis (2000)
4. Donald G B, *"Biosensors: Theory and Applications"*, CRC Press (1993)
5. Donald L W, *"Bioinstrumentation and Biosensors"*, CRC Press (1991)
6. Donald L W, Wingard L B, *"Biosensors with fiber optics"*, Humana Press (1991)

DEPARTMENT OF BIOTECHNOLOGY

Detailed syllabus 6th Semester:

BT-302 Bioinformatics [3 1 0 4]

Unit-I

Information search and data retrieval: Biological information resources and retrieval system; data characteristics and presentation, major databases, data management & analysis, data mining.

Biological Data bases and their management: Introduction to SQL (Sequence Query Language), Searching of databases similar sequence; The NCBI; Publicly available tools; Resources at EBI; Resources on the web; Database mining tools.

Pairwise alignment: Pair wise and multiple sequence alignment, Scoring matrices, Secondary Structure predictions, Fold recognition.

Multiple sequence alignment and Phylogenic analysis: Gene identification methods; data mining (Genome databases) and phylogenetic analysis; tree evaluation, Predictive methods using nucleic acids and protein sequences.

Unit-II

Genome analysis and gene mapping: Analysis Tools for Sequence Data Bank, sequence homology searching using BLAST and FASTA, FASTA and BLAST Algorithms comparison.

Profiles and Hidden Markov Models: Explanation and application of the tools

Gene identification methods: Genomics and Human genome project; Pattern recognition, Gene prediction methods, Strategy of genome sequencing.

Gene Expression and Microarrays: DNA Microarrays, clustering gene expression profiles, tools for microarray analysis, application of microarray technology.

Unit-III

Bioinformatics Software: Molecular structure drawing tool (Chemdraw); VMD/Rasmol/Insight-II; Clustal X1.8; OLIGO; PERL, Molecular modeling/ Docking (CAChe); Clustal W, oligoprimer. ALSCRIPT, MOLSCRIPT, Rasmol, Phylip, Submitting sequence to databases, Computational tools for DNA sequence analysis: GCG: The Wisconsin package of sequence analysis programs; Web-based interfaces for the GCG sequence analysis programs.

Books Recommended

1) Brgeron Bryan, *"Bioinformatics Computing"*, Prentice Hall of India (2003).
2) Rastogi S.C., Mendiratta N., Rastogi P., Bioinformatics, 2nd edition, Prentics Hall (2006).
3) Attwood T K, and Parry- Smith *"Introduction to Bioinformatics"*, Pearson Education, Singapore (2000).
4) David W. Mount, Bioinformatics: Sequence and Genome Analysis 2nd Edition, CSHL Press, 2004.
5) P. E. Bourne and H. Weissig, Structural Bioinformatics, 2nd Edition, Wiley, 2008.
6) Westhed D R , Parish J H and Twyman R M, *"Bioinformatics"* ,Viva Books Pvt. Ltd. , New Delhi (2003).
7) Jonathan Pevsner, Bioinformatics and Functional Genomics,1st Edition, Wiley-Liss, 2003.

BT-304 Bio Process Modeling and Simulation [3 0 2 4]

Unit-I

Simulation: basics, discreet event simulation, conducting a simulation project, building a system model, model verification and validation, Simulation of batch pharmaceutical manufacturing systems

Batch process simulation: concept, goals and capabilities.

Software: SuperPro Designer, K-Tops, Aspen

Modeling: basic process operations with SuperPro Designer, chemical reactions, separation operations

Unit-II

Study of Structured Models: Analysis of various bioprocesses; Model simulation using MATLAB-SIMULINK and ISIM software packages.

Fundamental laws: continuity equation, energy equation, equation of motion, transport equation, equation of state, Phase and chemical equilibrium, chemical kinetics.

Examples of Mathematical Models: Modeling of gene regulation (Genetic switches), Modeling of signal transduction in prokaryotes and eukaryotes, Insilico microorganisms, metabolic flux analysis.

Unit-III

Elementary mode analysis: Heat and Mass Transfer Equipment such as Heat exchangers, evaporators, flash distillation, differential distillation, continuous binary distillation in tray and packed column, vaporizers, single phase separation adsorption, absorbers and strippers, agitated vessels, mixing process. Reaction Equipment: Batch reactor, Semi batch reactor, Continuous stirred tank reactor, Plug flow reactor, Packed column reactor, Bioreactors, Reactors used in effluent treatments, Fluidized bed reactor.

Books Recommended

1. Harrell, C., Ghosh, B., Bowden, R., *"Simulation Using Promodel"*, McGraw Hill (2004).
   Software: ProModel v.6.1 (incl. with the textbook) SuperPro Designer v. 6.0 or higher.
2. Luyben W L, "*Process Modeling Simulation and Control for Chemical Engineers", international* ed. McGraw Hill (1990).
3. Rose L M, "The *Application of Mathematical Modeling to Process Development and Design",* First Ed. Applied Science Publisher Limited. London (1974).
4. Bequette, "Process *Dynamics- Modeling, Analysis and Simulation*", PHI International (2003).
5. Rase H F, "*Chemical Reactor Design for Process Plants, Vol II: Case Studies and Design Data*", 1st Ed., John Wiley and Sons, New York (1997)
6. Denn M Morton, "*Process Modeling"*, First Ed. Longman Publisher (1986).
7. J.R. Leigh, Modeling and Control of fermentation Processes, Peter Peregrinus, London, 1987.

BT-306 Bioinformatics Laboratory [0 0 2 1]

1. Various tools related to Bioinformatics, MATLAB Bioinformatics Toolbox
2. Handling of different primary databases and retrieval of primary data of both protein and nucleotide (Expasy, Entrez) of a particular group or type of an enzyme.
3. Nucleotide sequence of specific organs of specific organism, Analysis and comparison of nucleotide sequence for specific gene between 2 animals or plants or microbes.
4. Sequence based and structure-based approaches to assignment of gene functions e.g. sequence comparison, structure analysis (especially active sites, binding sites) and comparison, pattern identification, etc.
5. Handling of different specialized databases: Pathway, protein folding classification, Comparison of amino acid sequence of specific protein between different animals or plants or microbes.
6. Different approaches of Prediction of Genes: Promoters, splice sites, regulatory regions, application of methods to prokaryotic and eukaryotic genomes and interpretation, gene expression profiling.
7. Different approaches for analysis of ligand-protein and protein- protein interactions.
8. Study to find out potential drug targets for cardio vascular, neurological diseases etc. using proprietary and public domain software's *(eg. VEGAZZ) (ligand design, optimization and improvement)*

BT-322 Bioprocess Equipment Design and Economics [3 1 0 4]

Unit-I

Design and Analysis of **Bioreactors:** Chemostat model with cell growth kinetics, Plug flow reactor for microbial processes; optimization of reactor systems; Multiphase bioreactors, packed bed with immobilized enzymes or microbial cells; three phase fluidized bed trickling bed reactor; Component of Fermentor and their design, asceptic operations, RTD studies in bioreactors, Design and analysis of the above reactor systems; Gas liquid reactors; Reactor with non-ideal mixing; dispersion model; Tanks in series Model; Bubble column reactors, airlift fermenters etc. Air and medium sterilization

Mechanical fittings in a bioreactor: vessel, agitation system materials, welds, finish, valves, piping and valves for biotechnology, cleaning of production plants.

Unit-II

Instrumentation and control of bioprocesses: Physical and chemical sensors for the medium and gases. Online sensors for cell properties, off-line analytical methods; Biosensors.

Cost Estimation: Capital investments (Fixed and working capital), Types of capital cost estimates, Cost Indexes, Estimating equipment costs by scaling 6/10 Factor Rule, Purchase Equipment Installation, Insulation costs, Instrumentation & Control, Piping , Electrical Installation , Service facilities, Land, Engineering . & Supervision, Start –up expenses. Methods of Estimating Capital Investment, Estimation of total product cost, Different costs involved in the total product for a typical Chemical Process plant.

Interest & Investment Costs: Types of interest (simple & compound interest), Nominal & Effective Rates of interest, Continuous interest, Present worth & discounts, perpetuities, ccapitalized costs, Interest & Investment costs.

Unit-III

Depreciation: Types of Depreciation, Depletion, Service life, Salvage value, Present value, Methods of Determining Depreciation.

Optimum Design: General procedure for Determining optimum conditions, Procedure with one variable, Procedure with Two or More variables, Break even chart for production schedule and its significance for optimum analysis. Examples of optimum design in a Chemical Process Plant.

Books Recommended

1. Shuler M L, Kargi F, " *Bioprocess Engineering- Basic Concepts*" , 2nd ed, Prentice Hall of India Ltd. (2002)
2. Aiba S, Humphrey A E and Millis N F ,"*Biochemical Engineering*" , Academic Press (1973)
3. Stanbury P F and Whitaker A, "*Principles of Fermentation Technology*," Pergamon Press (1995)
4. Bailey J E and Ollis D F, "*Biochemical Engineering Fundamentals"* , McGraw Hill (1986)
5. Peters, M S & Timmerhaus K D,"*Plant Design and Economics for Chemical Engineers"*, McGraw Hill, New York , 4th Edition (2003)
6. Ulrich , G D,"*A Guide to Chemical Engineering Process Design and Economics"*, John Wiley (1984)

BT-324 Protein Engineering [3 1 0 4]

Unit-I

Structure of protein: Primary, secondary, tertiary, quaternary structure, Protein folding, molten globule structure, characterization of folding pathways. Post translation modification.

Methods to alter primary structure of protein: Random mutation Site directed mutation, Catalytic activity.

Protein modification: thermal, enzymatic, physical, pressure, solvents, interactions.

Protein raw materials: cereals, legume, oil seeds and pseudo cereals. Muscle protein, Milk protein, Egg protein, Hemoglobin, Collagen, Keratin. Nutritive role of food proteins.

Sequence and 3Dstructure analysis: Data mining, Ramachandran map, Mechanism of stabilization of proteins from psychrophiles and thermophiles vis-à-vis those from mesophiles; Protein design.

Unit-II

Methods to determine structure of proteins: Protein structure determination, X-Ray analysis of protein, NMR and mass Spectroscopy, Absorption and Fluorescence, Circular Dichroism, FT-Raman, FT-IR, MALDITOF. Protein characterization, 2 D Gel Electrophoresis.

Structure and function prediction: Protein Bimolecular interaction, Drug protein interaction

Thermal properties of proteins and application of DSC. Protein denaturation, aggregation and gelation. Flow properties of proteins and sensory properties of pertinacious foods.

Protein engineering: definition, application; Features or characterstics of proteins that can be engineered (definition and Electives methods of study)–affinity and specificity Spectroscopic properties; Stability to changes in parameters as pH, temperature and amino acid sequence, aggregation propensities, etc.

Unit-III

Methods of measuring the stability of a protein: Spectroscopic methods to study physicochemical properties of proteins: far-UV and near-UVCD; Fluorescence; UV absorbance; Hydrodynamic properties–viscosity, hydrogen-deuterium exchange; Brief introduction to NMR spectroscopy – emphasis on parameters that can be measured/obtained from NMR and their interpretation

Books Recommended

1. Permington S R , Dunn M J,*"Proteomics from Protein sequence to function"* , Viva Books Pvt. Ltd., New Delhi
2. Edited by T E Creighton, Protein function. A practical approach. Oxford university press. 2004.
3. Cleland and Craik, Protein Engineering, Principles and Practice, Vol 7, Springer Netherlands 1998.
4. Mueller and Arndt., Protein engineering protocols, 1st Edition, Humana Press, 2006.
5. Ed. Robertson DE, Noel JP, Protein Engineering Methods in Enzymology, 388, Elsevier Academic Press, 2004.
6. J Kyte, Structure in protein chemistry, 2nd Edition, Garland publishers, 2006.
7. Walsh G, "Proteins *Biochemistry and Biotechnology"* John Wiley and sons (2003).

BT-326 Computational Biology and Drug Design [3 1 0 4]

Unit-I

Databases: Primary and Secondary Databases; GenBank, EMBL, DDBJ, Swissplot, MIPS, PIR, TIGR, Hovergen, TAIR, PlasmoDB, ECDC, Protein and Nucleic Acid Sequences.

Search Algorithm: Scoring Matrices and their use; Computational complexities; Analysis of Merits and demerits; Sequence pattern; Pattern database; PROSITE, PRINTS, Markov chains and Markov models; Viterbi algorithm; Baum-Welch algorithm; FASTA and Blast Algorithm; Needleman-Wusch & Smith-Waterman algorithms.

Unit-II

Structure and Analysis: Representation of molecular structures; External and internal co-ordinates; Concept of free energy of molecules; Introduction to various force fields; Molecular energy minimization techniques; Monte Carlo Molecular Dynamics simulation.

Experimental Methods: Molecular structure Determination, Principle of X-ray crystallography and NMR spectroscopy; 2D Protein Data bank and Nucleic Acid Data bank; Storage and Dissemination of molecular structure.

Unit-III

Modeling: Homology modeling; Threading; Structure prediction; Structure-structure comparison of macromolecules; Simulated ducking; Drug design; 2D and 3D QASR; Ligand databases.

Books Recommended

1. David W.Mount.Bioinformatics: Sequence and Genome Analysis 2 nd Edition,CSH Press, 2004.
2. A. Baxevanis and F.B.F Ouellette,Bioinformatics: a practical guide to the analysis of genes and proteins, 2nd Edition,John Wiley, 2001.
3. Jonathan Prevsner.Bioinformatics and Functional Genomics, 1st Edition, Wiley-Liss,2003.
4. C.Branden and J.Tooze,Introduction to Protein Structure, 2nd Edition,Garland Publishing,1999.

BT-328 Biostatistics [3 1 0 4]

Unit-I

Applications of statistics in biological sciences and genetics: Descriptive statistics; Mean; Variance; Standard deviation and coefficient of variation (CV); Comparison of two CVs; Skewness; Kurtosis

Probability: axiomatic definition; Addition theorem; Conditional probability; Bayes theorem; Random variable; Mathematical expectation; Theoretical distributions — Binomial, Poisson, Normal, Standard normal and Exponential distributions; Sampling- \ parameter, statistic and standard error; Census - sampling methods; Probability and non-probability sampling; Purposive sampling; Simple random• sampling;, Stratified sampling.

Unit-II

Testing of hypothesis: Null and alternative hypothesis; Type I and type II errors; Level of ,significance; Large sample tests; Test of significance of single and two sample means; Testing of single and two proportions - Small sample tests: F-test — testing of single mean; Testing of two sample means using independent t test, paired t test; Chi square test: Test for goodness of fit - association of attributes — testing linkage — segregation ratio.

Correlation: Pearson's correlation coefficient and Spearman's rank correlation; Partial and multiple correlation — regression analysis; Sample linear and non linear regression; Multiple regression.

Unit-III

Analysis of variance: definition — assumptions — model; One way analysis of variance with equal and unequal replications; Two way analysis of variance; Non parametric tests — sign test — Mann Whitney 'U' test — Kruskal Wallis test.

Books Recommended

1. Jerrold H. Zar, Biostatistical Analysis, 4th Edition, Pearson Education, 1999.
2. Wayne W. Daniel, Biostatistics, 7th Edition, Wiley India, 2005
3. P.S.S. Sundar Rao, P.H.Richard, J.Richard, An introduction to Biostatistics, Prentice Hall of India (P) Ltd., New Delhi, 2003.
4. Rangaswamy, R, A text book of Agricultural Statistics, New Age International (P) Ltd., 2000.
5. Panse V.G.Panse, Sukhatme P.V, Statistical methods for Agricultural Workers, ICAR Publications, New Delhi, 2000

DEPARTMENT OF BIOTECHNOLOGY

Detailed syllabus 7th Semester:

BT-401 Biological Waste Water Treatment [3 1 0 4]

Unit-I
Characteristics of waste water: Physical, chemical and biological; BOD, COD
Primary Treatment: Screening, Grit Chamber, removal of oil and grease.
Aerobic processes of secondary treatment: activated sludge, lagoons, stabilization ponds, suspended growth, nitrification, trickling filters, rotating biological contactors, anoxic suspended growth and fixed film denitrification.

Unit-II
Anaerobic processes of treatment: biological concepts, suspended growth and fixed film processes and reactor configuration, Sequential batch reactor for combined processes (aerobic and anaerobic)
Tertiary Treatment: Effluent disposal and reuse.
Bioenergy from biological waste: Production of biogas and bio hydrogen from various biological wastes by fermentative processes.

Unit-III
Solid waste management: Using biomass, production of Bioenergy from the solid waste
Designing: Wastewater treatment plant, anaerobic biogas generation plant

Books Recommended

1. Metcalf & Eddy, *"Wastewater Engineering"*, 4th edition, TATA-McGraw Hill (2003).
2. Hammer M J, *" Water and Wastewater Technology"*, 2nd edition, John Wiley & Sons (1989)
3. Davis M L, Corwell D A, *"Introduction to Environmental Engineering"*, 2nd edition, Mc Graw Hill (1991)
4. Peavy H S, Rowe D R, *"Environmental Engineering"*, Mc Graw Hill (1985)
5. Eckenfelder W W, *" Industrial Water Pollution Control"*, 2nd edition, Mc Graw Hill (1991)

BT-403 Biological Waste Treatment Laboratory [0 0 2 1]

1. Determination of Solids in waste water
2. Determination of Alkalinity of water
3. Determination of specific gravity of sewage sludge
4. Determination of organic nitrogen in sewage sample
5. Determination of sludge volume and Index
6. Bacteriological analysis of water
7. Determination of sulphates and chloride in given sample of waste water
8. Determination of total iron by spectrophotometer method
9. Determination of Dissolved Solid content of waste water
10. Determination of BOD and COD
11. Determination of total hardness of a given waste water sample

BT-421 Analytical Methods in Biotechnology [3 1 0 4]

Unit-I

Absorption and emission spectroscopy: Properties of electromagnetic radiation, interaction with matter

UV and visible spectrophotomerty: Principle, Beers-Lamberts law, application of UV spectroscopy

Nephelometery, turbidance and reflectance: Principles, parameters involved, correlation of nephelometry with spectroscopy

Fluorescence and phosphorescence spectrophotomerty: Principle, methodologies and application

Flame emission and atomic absorption spectrometry: Flames and flame temperature, disadvantage of flame Ionization, burners, interferences. Flame spectrometric technique, flame absorption spectrophotomerty and atomic absorption spectrophotomerty, comparison of flame emission and atomic absorption techniques.

Unit-II

Inductively coupled plasma atomic emission spectrophotomerty: Plasma emission sources, inductively coupled argon plasma, direct current argon plasma

IR Spectrophotomerty: Vibrational spectroscopy, principle, methodologies and application

X-rays techniques: X-ray diffraction, images analysis by Fourier transformation, symmetry elements, determination of 3 dimensional structures of organic and inorganic molecules

NMR spectroscopy: Principles and methodologies followed, utilities, effectivity of the method for determining 3 dimensional structure of organic and inorganic molecules

Electro analytical techniques, voltamtery, conductimetry, polargraphy: Current voltage relationship, diffusion current and factors affecting diffusion current, half-wave potential, voltametric and polarographic technique, electrolyte conductivity measurement of electrolytic conductance, conductance cells, conductometric titration, measurement of dielectric constants.

Gas Chromatography: Gas solid and gas liquid chromatography, detectors- TCD and FID, column efficiency, Van Deemter equation, application of gas chromatography.

Unit-III

Karl Fischer moisture analysis: Principles of methodologies, utilities of the method

HPLC: Mobile phase , elution , normal phase and reverse-phase HPLC, column packing material, efficiency of column ,types of HPLC – principles of methodologies ; HPLC pumps - efficiency and suitability, Different injectors and Detectors.

Books Recommended:

1. Willard, H., Meritt,L.L., Dean J.A. and Settle F.A., Instrumental Methods of analysis, 6th edition, CBS Publishers, (1986)
2. Vogel's, "*Textbook of Quantitative Chemical Analysis"*, 6th Edition, Pearson, (2000).
3. Skoog,D.A. , F.J. Holler and T.A. Nieman., 'Principles of Instrumental analysis', 5th Edition, Harcourt Area PTE (1998)
4. Okotore, R.O., Basic Separation Techniques in Biochemistry, New Age (1998)
5. Braun, R.D., Introduction to Instrumental Analysis, McGraw Hill (1987).

BT-423 Enzyme Engineering and Technology [3 1 0 4]

Unit-I

Basic concepts of enzyme: Mechanism of Enzyme Action and kinetic of reaction: Concept of active sites, and energetic of enzyme substrate complex formation, Specificity of enzyme action, Estimation of Michaelis-Menten Parameter

Stability of enzymes: PH, Temperature, Mechanical forces, Heterogeneous system.

Production and purification of enzymes: Extract from plant, animal and microbial sources, Methods of characterization of enzymes, Development of enzymatic assays.

Unit-II

Enzyme immobilization: Physical and chemical techniques for enzyme immobilization adsorption, Matrix entrapment, Encapsulation, cross linking, covalent binding, Advantages and disadvantages of different immobilization techniques.

Applications of enzymes: Classification of enzymes, Commercial application of enzymes in food, Pharmaceutical and other industries, Enzymes for analytical and diagnostic application.

Unit-III

Mass transfer effects in immobilized enzymes: Analysis of film and pore diffusion effects on kinetics of immobilized enzyme reaction, Formulation of dimensionless groups, Calculation of effectiveness factors

Books Recommended

1. Price N C and Stevens L, *"Fundamentals of Enzymology: The Cell and Molecular Biology of Catalytic Proteins"*, 3rd Edition, Oxford University Press (2003).
2. Bailey and Ollis, *"Biochemical Engineering Fundamentals"* , McGraw Hill (1996)
3. Lehninger, A L ***"****Principles of Biochemistry*", Butterworth Publishers, New York(1993)
4. Conn E E and Stump P K,"*Outlines of Biochemistry*" John Wiley and Sons, New York (1987)
5. Stanbury P F and Whitaker A, "*Principles of Fermentation Technolgy,*"Pergamon Press (1995)

BT-425 Environmental Biotechnology [3 1 0 4]

Unit-I

Introduction: Environment; Basic concepts; Resources; Eco system: plants, animals, microbes; Ecosystem management; Renewable resources; Sustainability; Microbiology of degradation and decay; Role of Biotech in environmental protection; Control and management of biological processes

Pollution: Environmental pollution; Source of pollution; Air, water as a source of natural resource; Oil pollution; Surfactants; Pesticides; Measurement of pollution; Water pollution; Biofilm; Soil pollution; Radioactive pollution; Radiation; Ozone depletion; Green house effect; Impact of pollutants; Pollution of milk and aquatic animals

Unit-II

Control, remediation and management: Waste water collection; control and management; Waste water treatment; Sewage treatment through chemical, microbial and biotech techniques; Anaerobic processes; Anaerobic filters; Anaerobic sludge blanket reactors; Bioremediation of organic pollutants and odorous compounds; Use of bacteria, fungi, plants, enzymes, and GE organisms; Plasmid borne metabolic treatment; Bioáugmentation; Bioremediation of contaminated soils and waste land; Bioremediation of contaminated ground water; Macrophytes in water treatment; Phytoremediation of soil metals; Treatment for waste water from dairy, distillery, tannery, sugar and antibiotic industries

Alternate source of energy: Biomass as source of energy; Bioreactors; Rural biotechnology; Biocomposting; Biofertilizers; Vermiculture; Organic farming; Bio-minearlization; Biofuels; isoethanol and biohydrogen; Solid waste management.

Unit-III

Environment and health in respect to genetics: Gene and environment; Effect of carbon and other nanoparticles upon health; Gene mutation; Genetic testing; Genetic sensors; Environmental pollution and children; Human biomonitoring.

Books Recommended

1. Met Calfe and Eddy Inc., Wastewater Engineering: Treatment, Disposal and Reuse", 4th Edition, McGraw Hill Book Co., 2003
2. Mackenzie L. Davis and David A. Cornwell, Introduction to Environmental Engineering, 4th Edition, McGraw Hill Book Co., 2006.
3. R.M.Maier, I.L.Pepper and C.P.Gerba, Elsevier, Environmental Microbiology: A Laboratory Manual, 2nd Edition, Academic Press, 2004.
4. B.C. Bhattacharyya and R. Banerjee, Environmental Biotechnology, Oxford University Press.

BT-427 Metabolic Regulation & Engineering [3 1 0 4]

Unit-I

Elements of Metabolic Engineering: Historical perspective and introduction; Importance of metabolic engineering; Paradigm shift; Information resources; Scope and future of metabolic engineering; Building blocks of cellular components

Review of cellular metabolism: Transport mechanisms and their models; Regulation of enzyme activity versus regulation of enzyme concentration; Regulation of metabolic networks;. Regulation of at the whole cell level; Examples of important pathways; Case studies and analytical-type problems

Unit-II

Material and Energy Balances: Stoichiometric models and representation; The chemical reaction vector and energetic; Material and energy balances revisited; Basis for simplification of reaction; Elemental balances; Component balances and the link with macroscopic measurements; Examples of construction of elemental and component balances

Metabolic Flux Analysis and control theory: The theory of flux balances; Derivation of the fundamental principle; Degree of freedom and solution methods; Moore-Penrose inverse and Tsai-lee matrix construction; Examples of applications of flux analysis introduction Metabolic

Control Theory; Control coefficients; Elasticity coefficients; Summation and connectivity theorems; Case Studies and examples.

Unit-III

Metabolic Engineering Practice: The concept of metabolic pathway synthesis; Need for pathway synthesis, Examples for illustration; Overall perspective of MFA, MCA and MPA and their applications; Three success case studies

Books Recommended

1. Gregory N. Stephanopoulos, Aristos A. Aristidou, Jens Nielsen, Metabolic Engineering — Principles and Methodologies, 1st Edition, Academic Press, 1998
2. Gerhard Gottschalk, Bacterial Metabolism, 2nd Edition, Springer Verlag, 1986
3. S. A. Teukolsky, W. T. Vellerling, B. P. Flannery, W. H. Press, Numerical Recipes in C, Cambridge University Press, 1993.

BT-429 Bio Pharmaceuticals [3 1 0 4]

Unit-I

Introduction to Biopharmaceutical: Biopharmaceutical, Current status and future prospects

Drug development process: Drug discovery, Patenting, Delivery of pharmaceutical, Preclinical trials, Drug regulatory authorities, Genomics and its impact on medicine.

Unit-II

Drug manufacturing process: Manufacturing practice, Facilities, Analysis of products.

Pharmaceutical products: Interleukins, interferon, Growth factor, Hormones, Therapeutic enzymes, Antibodies, Vaccines, Nucleic acid therapeutics, Antibiotics.

Molecular medicine: rational drug design, gene testing, gene therapy, pharmacogenomics. Genetic diseases and DNA based diagnosis of genetic diseases.

Unit-III

Development of genetically engineered pharmaceuticals: Drug Design, novel drug delivery systems, improved formulation

Books Recommended

1. Leon Lachmant et al "*Theory and Practice of Industrial Pharmacy"*, 3 editions, Lean and Febiger (1986).
2. Remington's Pharmaceutical Sciences, Mark Publishing and Co. (2000).
3. Klefenz H "*Industrial Pharmaceutical Biotechnology*" Wiley – VCH Verlag GmbH Germany (1999).
4. Vyas S P and Dixit U K "*Pharmaceutical Biotechnology*" CBS Publisher New Delhi (2004).

BT-431 Transport Phenomena [3 1 0 4]

Unit-I

Momentum Transport: Viscosity and the mechanism of momentum transport, newton's law of viscosity, non- newton fluids, pressure and temperature dependence of viscosity, theory of viscosity of gases at low density, theory of viscosity of liquids.

Velocity Distributions in Laminar Flow: Shell momentum balances: boundary conditions, flow of a falling film, flow through a circular tube, flow through an annulus, adjacent flow of two immiscible fluids.

The Equations of Change for Isothermal System : To equation of continuity, the equation of motion, the equation of mechanical energy.

Interphase Transport in Isothermal System: Definition of friction factors, friction factors for flow in tubes, friction factors for flow around spheres, friction factors for packed columns.

Unit-II

Thermal Conductivity and the Mechanism of Energy Transport: Fourier's Law of heat conduction, temperature and pressure dependence of thermal conductivity in gases and liquids, theory of thermal conductivity of gases at low density, theory of thermal conductivity of liquids, thermal conductivity of solids.

Temperature Distributions in solids and in Laminar Flow: Shell energy balances; boundary conditions, heat conduction with an electrical heat source, heat conduction with a chemical heat source, heat conduction through composite walls: Addition of Resistance, Forced Convection, Free Convection.

The Equations of change for Nonisothermal systems: The equations of energy, the energy equation in curvilinear coordinates, the equations of motion for forced and free convection in nonisothermal flow, summary of the equations of change, use of equation of change to set up steady – state heat transfer problems.

Diffusivity and the Mechanism of Mass Transport: Definition of concentrations, velocities and mass fluxes, fick's law of diffusion, theory of ordinary diffusion in gases at low density, theory of ordinary diffusion in liquids.

Unit-III

Concentration Distributions in Solid and in Laminar Flow: Shell mass balances: boundary conditions, diffusion through a stagnant gas film, diffusion with heterogeneous chemical reaction, diffusion with homogeneous chemical reaction, diffusion into a falling liquid film l forced – convection mass transfer, diffusion and chemical reaction inside a porous catalyst: the "effectiveness factor".Analogies between Heat, mass and momentum and transfers.

Books Recommended

1. Bird R B, Stewart W E and Light fort R N, "*Transport Phenomena"*, John Wiley (2002).
2. Welty J R , Wilson R E and Wicks C E , "*Fundamentals of Momentum , Heat and Mass Transfer",* 4th ed,John Wiley and Sons (2001).
3. John C Slattery, "*Momentum, Energy and Mass transfer in continua"*, McGraw Hill, Co. (1972).
4. Bennet C U and Myers J E, " *Momentum, Heat and Mass Transfer*" Tata McGraw Hill Publishing Co. (1975)
5. Robert S Brodkey and Harry C Hersing, " *Transport Phenomena a Unified approach*" McGraw Hill Book Co. (1988).

BT-400 Project Phase –I [0 0 4 2]

Every student will be required to submit a project report in a typed form, on a topic selected by the student, but specifically approved by the faculty member, who will guide the student or on a topic to be assigned by one or more faculty members.

The project work on the topic will consist of either some investigational work, computer simulation or design problem or experimental set up of some development work of or prototype equipment. Every student has to give a presentation in the topic incorporated in the project and in the project and in the related area of specialization.

The student will be required to submit three copies of his/her project report to the department office for record. One copies each for the department library, participating faculty and students own copy.

DEPARTMENT OF BIOTECHNOLOGY

Detailed syllabus 8th Semester:

BT-400 Project (Phase –II) [0 0 8 4]

Every student will be required to submit a project report in a typed form, on a topic selected by the student, but specifically approved by the faculty member, who will guide the student or on a topic to be assigned by one or more faculty members.

The project work on the topic will consist of either some investigational work, computer simulation or design problem or experimental set up of some development work of or prototype equipment. Every student has to give a presentation in the topic incorporated in the project and in the project and in the related area of specialization.

The student will be required to submit three copies of his/her project report to the department office for record. One copies each for the department library, participating faculty and students own copy.

BT-422 Food process Biotechnology [3 0 0 3]

Unit-I

Introduction to Food Biotechnology: Biotechnological processes in conventional and non-conventional food, safety aspects, food industry wastes

Food Biotechnology Products : Dairy products, cereal products, fruit and vegetable products, meat and fish, food ingredients , High Fructose Corn Syrup , Mycoprotein etc. Flavors and Pigments, New protein food,- SCP, mushroom; food yeasts, algal proteins

Unit-II

Biotechnology and Food Preservation : Different techniques in food preservation, canning, drying, freezing encapsulation and controlled release of food components, microwave food processing , super critical fluid extraction , accepting processing of food. Organisms and their use of pickling; alcoholic beverages and other products. Mechanism of enzyme functions and

reactions in process techniques starch and sugar conversion processes or baking by amylases; de-oxygenation and desugaring by glucose oxidase; beer mashing and chill-proofing or cheese making by proteases and various other enzyme catalytic actions in food processing.
Genetically Modified and Transgenic Food: Development, processing, nutrition and safety aspects.

Unit-III
Bioreactors in Food Biotechnology: Use of different bioreactors (e.g membrane bioreactors) for various food productions, Modeling , simulation and optimization of industrial processes, use of sensor and biosensors ,process control.

Books Recommended

1. Angold ,Beech and Taggart "*Food Biotechnology*" , Cambridge University Press , New York (1989)
2. Schwartzberg H G and Rao M A "*Biotechnology and Food Process Engineering"*, Marcel Dekker, IC (1990)
3. Moo- Young Murray, "*Comprehensive Biotechnology Vol. II & IV*", Pergamon Press New York (1985)
4. Reed G, "*Prescott and Dunn's Industrial Microbiology*" CBS publishers and distributors, New Delhi (1987).

BT-424 Bioprocess Safety and Bioethics [3 0 0 3]

Unit-I
Public acceptance issues for biotechnology: Case studies/experiences from developing and developed countries.

Unit-II
Biotechnology and hunger: Challenges for the Biotechnological research and industries. The Cartagena protocol on biosafety. Bioterrorism (planning and response), Pertinent Federal, State, and Local regulations, standards, and guidelines.

Unit-III
Biosafety management: Ethical implications of biotechnological products and techniques. Social and ethical implications of biological weapons.

Books Recommended:

1. Fleming D O, Hunt D L, *"Biological Safety: Principles and Practices"*, 3rd edition, ASM press (2000).
2. Cartagena Protocol on Biosafety, January 2000.
3. Dano M R, *"Biological Warfare in the 21st century"*, Brassies London, 1994.
4. Traynor P L, "*Biosafety Management"*, Virginia polytechnic Institute Publication, 2000.

BT-426 Nanobiotechnology [3 0 0 3]

Unit-I

Nanotechnology: Materials Analysis using traditional and nontraditional techniques, Interaction of x-rays, ions, and electrons. Imaging, diffraction, scattering and spectroscopic methods of characterization, Applications of metrology in nanotechnology, biotechnology, semiconductor processing, and other Silicon Valley growing technical areas.
Nanobiotechnology: biological problems; Nanocrystals in Biological Detection;

Unit-II

Microfluidic Meets Nano: Potential for Nanobiotechnology; Protein based Nanocrystals; Microbial nanoparticle production; DNA based nanostructures and Gold nanoparticle conjugates; Luminescent quantum dots for biological imaging;
Emerging Nanotechnologies: Nano labels, biosensors, Nano medicine, molecular imaging

Unit-III

Application: proteinomics; genomics, cancer therapy, drug delivery.

Books Recommended

1. Greco R. S., Prinz F. B., and Smith, R. L. (eds.), *"Nanoscale Technology in Biological Systems"*, CRC Pres, ISBN: 0849319404, (2005).
2. Ratner, M. and Ratener, D, "*Nanotechnology A Gentle Introduction to the Next Big Idea"*, Prentice Hall, ISBN: 0131014005, (2003).

BT 428 Secondary Metabolites in Plants and Microbes [3 0 0 3]

Unit-I

Introduction to primary & secondary metabolism: structure, biosynthesis and metabolism of important secondary products; Glycosides, isoprenoids, cardenolides, alkaloids, phenylpropanoids and antibiotics.

Unit-II

Important groups of secondary metabolic enzymes: Significance of secondary metabolism and products for the producer organism.
Regulation and expression of secondary metabolism: regulation of enzyme activity; regulation of enzyme amount; integration with differentiation and development; action of inducers; coordinated enzyme expression and sequential gene expression.

Unit-III

Metabolic pathway engineering: Enzymes involved in various metabolic pathways, Analysis of metabolic control and the structure metabolic network.

Books Recommended

1. Ramawat KG and Merillon J M (eds.), *"Biotechnology secondary metabolite: plants and microbes"*, 2nd edition, Science Publishers, USA (2007).
2. Lehninger A L, **"***Principles of Biochemistry*", 3rd edition, Butterworth, New York (2000).

3. Harvey L, Berk A, Zipursky S L, Matsuidaira P, Baltimore D, Darnell J E, *"Molecular Cell biology",* 4th edition, W.H.Freeman, New York (2000).

BT-430 Biomaterials [3 0 0 3]

Unit-I

Introduction: Definition and general classification of biomaterials (natural and synthetic) and the Relationship between biomaterials and medical (and dental) devices.

Market for biomaterials: World-wide market for biomaterials, projections for developments in the uptake of biomaterials (demographics, medical advances, etc.) and the clinical implications of Biomaterials development.

Common type: Biopolymers/bioplastics, bioceramics metals and metal alloys, shape memory alloys, composites woven and non-woven fabrics, hydrogels, bio-adhesives controlled drug delivery systems.

Key Materials issues in Biomaterials: Polymer technology for the fabrication of medical devices. Chemical, physical and mechanical properties of ceramic materials for hard tissue implants. Development of medical grade metals and metal alloys: shape memory alloys. Composite Materials (polymer/polymer, polymer/metal, polymer/ceramic), fibre/particulate reinforced.

Unit-II

Regulation and standard for safety: FDA, EU - Medical Device Directives, GMP, ISO, CE marking.

Application in biomedical: biomaterial evaluation procedures. Replacement of skeletal hard tissues. Cardiovascular implants. Artificial vascular grafts. Biomaterials for ophthalmology. Biomaterials in audiology. Facial implants. Dental implants. Skin repair/replacement materials. Cosmetic implants, controlled drug delivery systems. Hydrogels and artificial organs.

Clinical aspects for using biomaterial: Biocompatibility and biomimicery, surface interactions: - tissue and blood interactions. microbial biofilm formation bacterial adhesion toxicology

Surface modification for better functionality: Enhancement of biocompatibility by the use of:- Corona discharge and plasma processes. Surface coatings Silver/silver oxide silicone hydrogels UV curable systems PC coatings, Heparin loaded systems

Unit-III

Characterization and Testing of Biomaterials: Bulk analysis methods applied to the study of Biomaterials (XRD, FTIR, SEM/EDX, DSC, TGA, DEA, etc.) Surface analysis methods applied to the study of biomaterials (XPS, SIMS, AES, SERS, AFM/STM, etc.) Mechanical test: wear, friction, flexibility, fatigue, etc.

Books Recommended:

1. Buddy D R, Allan S H, Frederick J S, Jack E L, editors, *"Biomaterials Science – An Introduction to Materials in Medicine",* Academic Press (1996)
2. Joon B P, Roderic S L, *"Biomaterials: An Introduction",* 2nd edition, Plenum Press, 1992.

BT-432 IPR in Biotechnology [3 0 0 3]

Unit-I

Introduction: General Introduction., Patent Claims, the Legal Decision-Making Process, Ownership of Tangible and Intellectual Property.

Basic Requirements of Patentability: Patentable Subject Matter. Novelty and the Public Domain. Nonobviousness.

Unit-II

Special Issue in Biotechnology Patents: Disclosure Requirements, Collaborative Research, Competitive Research, Plant Biotechnology, Foreign Patents.

Patent Litigation: Substantive Aspects of Patent Litigation, Procedural Aspects of Patent Litigation., Recent Developments in Patent System and Patentability of Biotechnological invention, IPR issues in the Indian Context.

Unit-III

Biotechnology and intellectual properties: Intellectual property rights (IPR) and protection (IPP), patents, trade secrets, copyrights, trade marks, GATT and TRIPS.

Books Recommended

1. The Law & Strategy of Biotechnology Patents, Sibley Kenneth.

BT 434 Stem Cell Biology [3 0 0 3]

Unit-I

Introduction to Stem Cells: Definition, Classification and Sources

Embryonic Stem Cells: Blastocyst and inner cell mass cells; Organogenesis; Mammalian Nuclear Transfer Technology; Stem cell differentiation; Stem cells Cryopreservation.

Unit-II

Application of Stem Cells: Overview of embryonic and, adult stem cells for therapy Neurodegenerative diseases; Parkinson's, Alzheimer, Spinal Code Injuries and other Brain Syndromes; Tissue systems 'Failures Diabetes Cardiomyopathy; Kidney failure; Liver failure; Cancer; Hemophilia etc.

Unit-III

Human Embryonic Stem Cells and Society: Human stem cells research: Ethical considerations; Stem cell religion consideration; Stem cell based therapies: Pre clinical regulatory consideration and Patient advocacy

Books Recommended

1. Ann A. Kiessling, Human Embryonic Stem Cells: An introduction to the Science and Therapeutic Potential, Jones and Bartett, 2003.
2. Peter J. Quesenberry, Stem Cell Biology and Gene Therapy, 1st Edition, Willy-Less, 1998.
3. Robert Lanja, Essential of Stem Cell Biology, 2nd Edition, Academic Press, 2006.
4. A.Ho., R.Hoffiman, Stem Cell Transplantation Biology Processes Therapy, Willy-VCH, 2006.
5. C.S.Potten, Stem Cells, Elsevier, 2006.

Ph D courses:

Semester-I

Course Code	Course	Hours/week			Credits
		L	T	P	
BT-503	Bioenergetics and Metabolism	3	0	0	3
BT-505	Bioreactor and Bioprocess Design	3	0	0	3
BT-507	Bioseparation Engineering	3	0	0	3

Semester-II

Course Code	Course	Hours/week			Credits
		L	T	P	
BT-504	Enzyme Biotechnology	3	0	0	3
BT-506	Modern Methods of Analysis	3	0	0	3

BT 503 : BIOENERGETICS AND METABOLISM [3 0 0 3]

Unit – I

Introduction: First and second law of thermodynamics, standard free energy, reasons for high standard free energy of hydrolysis of ATP, Electron transport, oxidative phosphorylation,chemiosmotic model, prenention of oxidative phosphorylation by uncoupling agents and ionophores. Metabolism – anabolism/ catabolism, differences between catabolic & anabolic pathways.

Anaerbolic Carbohydrate Metabolism: Individual reactions of glycolysis, entry of galactose & fructose in glycolysis, utilization of sucrose and lactose, alcoholic fermentation , reduction of pyruvate to lactate, glycogenlysis, biosynthesis of starch & sucrose, gluconeogenesis, regulation of glycolysis.

Cittric acid cycle: Oxidation of Pyruvate to Acetyl CoA,individual reaction of TCA cycle, energetics of the cycle, anaplerotic reactions, regulation of TCA.

Unit – II

Lipid Metabolism: Individual reaction of beta oxidation pathway, omega oxidation, oxidation of unsaturated fatty acid and odd chain fatty acids, formation of ketone bodies, biosynthesis of fatty acids, role of serum lipoproteins (LDL & HDL) in the developlemt of coronary heart diseases.

Nitrogen Metabolism: Transamination , deamination reactions, transport of ammonia from peripheral tissues to liver by glutamine, excretion of nitrogen (Ammonotelic, Uricotelic), Urea cycle (preliminary account), Metabolism of purines & pyrimidines (preliminary account), biosynthesis of non essential amino acids, as precursors of biological amines like dopamine, non epinephrine, epinephrine, GABA, & Histamine.

Unit – III

Transport across cell membrane: Passive transport (transport of chloride and bicarbonate across erythrocyte membrane, glucose transport), Active transport (Primary & secondary), Na* and K* pump, glucose transport in intestinal epithelial cells, symport, antiport, and uniport (examples), ion channels (voltage gated and ligand gated) brief idea.

Books Recommended:

1. Albert Lehninger, Principles of Biochemistry
2. Lehninger, Nelson, Cox, Principles of Biochemistry
3. Cohn and Stumpf, Outlines of Biochemistry
4. Lubert Stryer, Jeremy M. Berg, John L. Tymoczko, Biochemistry
5. M. Treven, Immobilized Enzymes
6. R.K. Murray, D.K. Granner at al., Harper's Biochemistry
7. Voet & Voet, Biochemistry

BT 505 : BIOREACTOR AND BIOPROCESS DESIGN [3 0 0 3]

Unit – I

Design consideration for designing bioreactors: oxygen transfer, heat transfer, rheology, mixing.
Analysis of ideal bioreactors: fed-Batch reactors, Enzyme catalyzed reactions in CSTRs, CSTR reactors with recycle and Wall growth, Ideal Plug- Flow Tubular Reactor.
Reactors with non-ideal mixing: Mixing time in agitated tanks, Residence time distributions, Models for non-ideal reactors.
Scale up and scale down concepts,

Unit – II

Mechanical Fittings in a bioreactor: vessel, agitation system materials, welds, finish, valves, piping and valves for biotechnology, special requirements of utilities and clearing of production plants.
Calculation for designing a bioreactor.

Unit – III

Instrumentation and control of bioprocesses: Physical and chemical sensors for the medium and gases, online sensors for cell properties, off-line analytical methods; Biosensors.

Books Recommended:

Coulson, Richardson, Sinnott, An introduction to chemical engineering design, Pergamon Press.
Lydersen, D' Elia, Nelson, Bioprocess engneering: Systems and equipment.
Bailey and Ollis, Biochemical Engineering Fundamentals.

BT 507: BIOSEPARATION ENGINEERING [3 0 0 3]

Unit – I

Separation of insoluble products: sedimentation, filtration, centrifugation, coagulation and flocculation. Cell Disruption: Mechanical methods, Non-mechanical methods.

Unit – II

Separation of soluble products: Liquid-liquid extraction, aqueous two-phase extraction, precipitation, adsorption. Dialysis, electro-dialysis, ultra-filtration and micro-filtration, cross-flow ultra-filtration and micro-filtration.

Unit – III

Chromatography: Adsorption chromatography, Ion- exchange chromatography, gel-filtration chromatography, affinity chromatography, high pressure liquid chromatography, hydrophobic chromatography. Chromatography scale-up. Crystallization and drying.

Books Recommended:

1. M.R. Ladisch, Bioseparation Engineering
2. Kennedy and Cabral, Recovery processes for biological materials.
3. Heinemann, Product Recovery in Bioprocess Technology, Butterworth Publication.

BT 504: ENZYME BIOTECHNOLOGY [3 0 0 3]

Unit –I

Discovery, classifications and nomenclature of enzymes. Enzyme isolation. Enzyme assay, Intracellular localization of enzymes. Isozymes, Multienzyme complex, and multifunctional enzymes.

Enzyme kinetics and kinetics of enzyme inhibition. Competitive, non-competitive and un-competitive inhibition of enzymes. Double reciprocal plots. Effect of PH, temperature, substrate and enzyme and inhibitors concentration on enzyme kinetics. Phenomena of allosterism and allosteric kinetics.

Unit – II

Molecular structure and function of enzymes. Physico-chemical characterization of enzymes. Folding and active site formation in enzymes. Stability of enzymes: Enzyme stabilization by genetic engineering, protein engineering, reaction environment rebuilding.

Techniques used in the purification of the enzymes. Criteria of enzyme homogeneity, Techniques used for determinations of native and sub-unit molecular weight of enzymes.

Unit – III

Bio-separations in enzymology: solid-liquid separation (filtration, centrifugation, membrane, flocculation), extraction, concentration (reverse osmosis, ultrafiltration), drying, instrumentation (GC/HPLC).

Enzyme immobilization, production and application of free and immobihzed enzymes in food and feed, detergent, textiles, pulp and paper, pharmaceuticals, diagnostics.

Books Recommended:

1. Godfrey and West, Industrial enzymology

2. Dordick, Biocatalyst for industry.
3. Bommatius, A.S. et al., Biocatalysis: Fundamentals and Application- Wiley Publication
4. Hans Bisswanger, Enzyme Kinetics- Wiley Publication
5. Methods in Enzymology- A series.

BT 506: MODERN METHODS OF ANALYSIS [3 0 0 3]

Unit -I

Chromatographic Techniques – I: (a) Introduction to chromatography; General principles, column chromatography - columns, stationary phases. Packing of columns, application of simple, column development, fraction collection and analysis). Partition and adsorption chromatography. (b) Affinity Chromatography; Principle, materials – matrix, selection of attachment of attachment of ligands, practical procedures, specific and non-specific elution, applications. (c) Ion Exchange Chromatography: Principal, types of Exchangers , materials, choice of exchangers and buffers and applications. (d) Gel Filtration: Principle, idea of distribution coefficient, exclusion limit, fractionation range, bed volume, void volume, elution volume, chemical properties of gel and applications.

Chromatographic Techniques – II: (a) Gas Chromatographic: Principle of GC system, solid support, capillary column, stationary phase, preparation and application of sample, separation conditions, detection system and applications. (b) HPLC: Principle, components of HPLC system, column, column packing, chromatographic solvents, pumping systems, detectors system, and its applications.

Unit – II

Electrophoresis: (a) General Principle, factors affecting electrophrosis – voltage, current, resistance, buffer – composition, concentration, pH. (b) Gel electrophoresis;

Types of gel (strarch,agarose, polyacrylamide), Idea of electrophoresis unit, preparation of gel , sample application, running the samples, SDS-PAGE – Principle, apparatus and methods, gradient gels , Two dimensional gels, Isoelectric focusing.

Spectroscopy – I: (a) Spectroscopic Techniques; Introduction, Energy levels and transition of electrons, Types of spectra, Beers Lamberts law, molar and and extinction coefficient, limitations of Beers Lamberts law. (b) Visible and UV Spectrophotomerty; Principles, Instrumentation and application. (c) Spectroflourimetry; Principle, stoke's shift, quantum efficiency, Instrumentation and application.

Unit - III

Spectroscopy – II (a) Atomic and Flame Spectrophotomerty; Principles, Instrumentation and application for flame emission/atomic absorption spectrophotomerty and their comparative study. (b) Mass spectrometry; Principles, Instrumentation and application

Thermal Analysis Differential scanning calorimetry and differential analysis – Instrumentation, Thermogravimetry, Methodology of Thermogravimetry, differential scanning calorimetry and differential thermal analysis.

Books Recommended:

1. K. Wilson & K.H. Goulding, A biologist's guide to Princles and Tehniques of Practical Biochemistry.
2. Wilard and Merit, Instrumentation Methods Analysis.
3. Ewing GW Instrumental Methods of Chemical analysis.