

COURSE CONTENT FOR B.Sc. (Hons) BIOTECHNOLOGY

FIRST PROFESSIONAL

Paper-1 INTRODUCTORY BIOTECHNOLOGY

A. Introductory Biotechnology-I

1. Biotechnology, an interdisciplinary pursuit, historical perspective and applications
2. Nature of organic matter and review of organic reaction mechanisms
3. Chemical structure and biological function
4. Properties of water and aqueous solutions
5. Chemical equilibrium
6. Review of thermodynamic principles
7. Prebiotic molecular evolution and origin of life
8. A review of variety and ecology of the living world
9. Biochemical basis of structural and functional variations in living beings
10. Evolution of life

B. Introductory Biotechnology-II

1. The organism and relationship between primary and secondary metabolism
2. Cell cycle (Bacterial growth)
3. History and applications of genetic engineering; genome, management and analysis
4. Basic tools of genetic engineering (isolation, cutting, ligation etc); mechanism of gene transfer
5. DNA sequencing and genome libraries
6. Introduction to nature, classification and action; application of enzymes in genetic and protein engineering
7. Introduction to role of enzymes in industrial product synthesis
8. Cell tissue culture details of culture techniques (explants, sterilization, growth, differentiation, etc), applications
9. Principles of microbial growth; important products formation
10. Bioreactor/ fermenter technology
11. Pharmaceuticals and bio-pharmaceuticals, antibiotics, vaccines etc.
12. Introduction to gene therapy and AIDS

Paper-II CHEMISTRY-I

A. Physical Chemistry

Theory:

1. Introduction to physical chemistry

2. Gases: ideal gas laws, kinetic theory of ideal gases, numerical value of R, kinetic equation of gases, deduction of gas laws from kinetic gas equation, molecular velocities, specific and molar capacity of gases, behavior of ideal and real gases.
3. Liquids: structural difference between gases, liquid and solids, vapor pressure and its measurements, surface tension and its measurements, parachor, viscosity and its measurements, rheochord, refractive index and its measurements
4. Basic concept of thermodynamics, thermodynamics terms, first law of thermodynamics, enthalpy, second law of thermodynamics, entropy and its physical significance, measurement of heat of reaction, gibbs free energy and its application
5. Solution: basic concept, types of solution, concentration units, the ideal and non ideal solution, henry's law, the rout law, activity and activity coefficient, diffusion, osmosis and osmotic pressure, laws of osmotic pressure, the concept of ph and its determination, buffer solutions, indicators, theory of dilute solution
6. Chemical kinetics: Introduction to chemical kinetics, the concept of rate of reaction and specific rate constant, rate law, order and molecularity of reaction, zero, first and pseudo first order kinetics, second order kinetics, determination of reaction order, activation energy

Practical:

1. Introduction to solution, preparation of solutions
2. Determine the surface tension of the given liquid using stalagmometer
3. Determine the parachor value of the given liquid at room temperature using stalagmometer
4. Determine the percentage composition of the given liquid mixture using stalagmometer
5. Determine the coefficient of viscosity of the given liquid at room temperature using Ostwald's viscometer
6. Determine the Rheochor value of the given liquid at room temperature using Ostwald's viscometer
7. Determine the percent composition of the given liquid using Ostwald's viscometer
8. Determine the refractive index and molar refractivity of the given liquid by refractometer
9. Determine the percent composition of the given liquid solution by refractive index measurement
10. Determine the heat of the solution of given substance say oxalic acid by solubility method
11. Determine the heat of solution for the given salt at a specified water salt mole ratio
12. Kinetics study of acid catalyzed hydrolysis of ethyl acetate
13. Determine the transition temperature of sodium sulphate decahydrate
14. Determine the strength of given solution of NaOH by titrating it against standard HCl solution using a conductivity meter
15. Determine the strength of HCl solution by titrating against NaOH solution potentiometrically.

B. Organic Chemistry

1. Introduction to organic chemistry, organic chemistry a separate discipline, importance of organic chemistry, source of organic compounds

2. The nature of covalent bond, atomic structure, valence of carbon, bond length, bond energy, bond angle, atomic, molecular and hybrid orbital, multiple bonds, hybridization of atomic orbital, ionic character of covalent bonds, polar and non-polar bonds, polar and non-polar molecules, inductive effective, dipole moment
3. Basic concepts in organic chemistry, delocalized chemical bonding, the concept of resonance, canonical forms, contribution of canonical forms, rules governing resonance, stability of resonance hybrid, resonance energy, resonance effect, steric inhibition of resonance, hyper conjugation, hydrogen bonding, tautomerism
4. Stereo isomerism, structural isomerism, stereo isomerism, optical isomerism, enantiomers, chirality and optical activity, racemization, resolution of racemate, geometrical isomerism, determination of the configuration of the geometrical isomers, conformational isomerism, conformational analysis of ethane and n-butane.
5. Alkyl halides, preparation of alkyl halides, nucleophilic substitution reactions, factors affecting reactivity in nucleophilic substitution reactions, elimination reactions, orientation in elimination reactions, organometallic compounds, Grignard reagents
6. Carbohydrates: carbohydrates and its classification, monosaccharides, nomenclature, configuration and reactions of monosaccharides, structure of glucose and fructose, disaccharides, sucrose, polysaccharides, starch, cellulose
7. Amino acids and proteins: amino acids, dipolar nature of amino acids, isoelectric point and nomenclature of amino acids, methods of preparation, properties and reactions of amino acids, glycine, peptides, proteins, its classification and isolation, structure and general properties of proteins, denaturation of proteins, importance of proteins, color tests of proteins
8. Synthetic polymers: polymers and macromolecules. Shorthand for writing polymer reaction, classification of polymers, addition and condensation polymerization, thermoplastic and thermosetting polymers, natural and synthetic rubbers.

Practical:

1. Introduction to organic chemistry practical. General procedure for the identification of unknown organic compound
2. Determination of physical constants
3. Detection of elements
4. Solubility behavior
5. Litmus test
6. NaHCO₃ test
7. Neutral FeCl₃ test
8. Conc. H₂SO₄ test
9. KMNO₄ test
10. Br₂ water test
11. Ignition test
12. Hinsberg test

13. Nitrous acid test
14. Soda lime/NaOH test
15. 2,4-Dinitrophenylhydrazine test
16. Silver mirror test, fehling solution test
17. Iodoform test with NaOH+I₂
18. Molisch test
19. Lucas test
20. Specific tests for individual class, tests for aromatic hydrocarbons and aryl halides
21. Tests for carboxylic acids and amides
22. Tests for alcohols and esters
23. Tests for carbohydrates, aromatic nitro compounds and alkyl halides

Paper-III ISLAMIC STUDIES/ETHICS & PAKISTAN STUDIES

A. Islamic Studies (For Muslims)

موضوعات
(۱) عقائد

(الف) توحید

(۱) لو كان فيهما الهة ————— عما يصفون (الانبياء : 22)
(۲) والهكم اله ————— الرحمن الرحيم (البقرة : 163)
(۳) ان في خلق ————— لقوم يعقلون (البقرة : 164)

(ب) رسالت

(۱) ما كان لبشر ————— كنتم تدرسون (آل عمران : 79)
(۲) وما اتاكم الرسول ————— العقاب (الحشر : 7)
(۳) اليوم اكملت لكم دينكم ————— ديننا (المائدة : 3)

(ج) آخرت

(۱) يا ايها الناس ————— زوج بهيج (الحج : 5)
(۲) واتقوا يوما ————— ربكم عظيم (البقرة : 48-49)

احاديث

(۱) عن عمر بن الخطاب قال قال رسول الله ﷺ حين سئل عن الايمان تومن بالله وملائكته وكتبه ورسوله واليوم الآخر وتومن بالقدر خيره وشره (متفق عليه)
(۲) عن العباس ابن عبد المطلب قال قال رسول الله ﷺ ذاق طعم الايمان من رضى بالله وبلاسلام ديننا وبمحمد رسولا
(۳) عن ابي سعيد الخدرى قال من راي منكم منكر فليغيره بيده فان لم يستطع فبلسانه فان لم يستطع فبقليه وذلك اضعف الايمان (رواه مسلم)
(۴) عن عبد الله بن عمر قال قال رسول الله ﷺ الا كلكم راع وكلكم مسئول عن رعيته فالامام الذى الناس راع ومسئول عن رعيته والرجل راع على اهل بيته وهو مسئول عن رعيته (متفق عليه)

۴ (۲۰۲) اتحاد امت

- (۱) واعتصموا بحبل الله جميعا --- تهتدون (ال عمران : 103)
 (۲) انما المؤمنون اخوة --- ترحمون (الحجرات : 10)
 (۳) قل يا اهل الكتاب --- مسلمون (آل عمران : 61)
 (۴) ولا تسبوا الذين يعملون --- يعملون (الانعام : 108)

احادیث

- (۱) عن انس قال قال رسول الله والذى نفسى بيده لا يؤمن عبد حتى يحب لآخيه ما يحب لنفسه (متفق عليه)
 (۲) عن النعمان بن بشير قال قال رسول الله ﷺ ترى المؤمنين فى تراحمهم وتؤانسهم وتعاطفهم كمثل الجسد اذا اشتكى عضو تدعى له سائر الجسد ورضى بالله ربا وبالإسلام ديناً وبمحمد رسولا (مسلم)

(III) عبادات

- (۱) سورة المؤمنون کی پہلی گیارہ آیات
 قد افلح المؤمنون --- هم فيها خلدون (المؤمنون : 1-11)

احادیث

- (۱) عن ابن عمر رضى الله عنه قال قال رسول الله ﷺ بنى الاسلام على خمس شهادة ان لا اله الا الله وان محمدا عبده ورسوله واقام الصلوة وابتاء الزكوة والحج وصوم رمضان (متفق عليه)
 (۲) وفى حديث جبرائيل قال رسول الله ﷺ الاسلام ان تشهد لا اله الا الله وان محمدا رسول الله وتقيم الصلوة وتؤتى الزكوة وتصوم رمضان وتحج البيت ان استطاع اليه سبيلا (متفق عليه)

(IV) امر بالمعروف ونهى عن المنكر

- (الف) دعوت دین کی ضرورت و اہمیت
 (۱) كذقم خیر امة اخرجت للناس --- الفسقون (آل عمران : 110)
 (۲) طریق دعوت

(۷) کسب حلال

- (۱) کلو ا من طيبات ---- فقد هوى
(۲) قل من حرم ---- يعلمون
(۳) ولا تاكلوا ---- تعلمون
- (طه : ۸۱)
(الاعراف : ۳۲)
(البقرة : ۱۸۸)

احاديث

(۱) عن النعمان بن بشير قال قال رسول الله ﷺ الحلال بين والحرام بين وبينهما مشتبهات لا يعلمهن كثير من الناس فمن اتقى الشبهات استبرأ لدينه وعرضه ومن وقع في الشبهات وقع في الحرام كالراعى يرعى حول الحمى يوشك ان يرتع فيه وان لكل ملك حمى الا وان حرم الله محارمه والا ان في الجسد مضغة اذا صلحت صلح الجسد كله واذا فسدت فسد الجسد كله الا وهى القلب (متفق عليه)

(۲) ان ابي هريره قال قال رسول الله ان الله طيب لا يقبل الا طيبا وان الله امر المؤمنين بما امر به المرسلون فقال ياايها الرسل كلوا من طيبات واعلموا صالحا وقال الله تعالى ياايها الذين امنوا كلوا من طيبات ما رزقناكم ثم ذكر الرجل يطيل السفر ويمد يديه الى السماء يارب مطعمه حرام ومشربه حرام وملبسه حرام وغذى بالحرام فانى يستحاب لذلك (رواه مسلم)

(۷) حقوق العباد

(الف) بنيادى انسانى حقوق

(الف) جان كا تحفظ

من اجل ذلك ---- لمسرفون (النساء: ۳۳)

ياايها الذين ---- بكم رحيم (النساء: ۳۹)

(ج) عزت كا تحفظ

ياايها الذين امنوا ---- تواب الرحيم (الحجرات: ۳۲)

(د) دين ميں سختى نهيں

لا اكراه فى الدين (البقرة: ۲۵۶)

(ر) حق مساوات

(س) اہلیت کی بنیاد پر مواقع کے حصول کا حق

- (ان النساء: 58) ان الله يامرکم ----- بصیرا
(ش) حصول انصاف کا حق یا ایہا الذین ----- تعملون خیرا
(سورۃ النساء: 135)

(VII) حقوق نسواں

- (1) من عمل ----- يعلمون (النحل: 97)
(2) ان المسلمون ----- اجرا عظیما (الاحزاب: 35)
(3) للرجال نصیب ----- نصیبا مقروضا (النساء: 7)

(VIII) غیر مسلموں سے تعلقات

- (1) لا ینہاکم الله ----- الظلمون (سورۃ 28 سے 7)
(2) وان جنحو للسلم ----- السميع العليم
مذکورہ بالا تمام عنوانات کی قرآنی تشریح عنوانات احادیث کے تحت دی گئی ہے

(2) اسوہ حسنہ (سیرت طیبہ)

- (1) ولادت باسعادت
(2) قبل از نبوت کی زندگی
(3) بعثت نبوی
(4) دعوت و تبلیغ اور اس کی مشکلات
(5) ہجرت مدینہ
(6) مواخات اور بیثاق مدینہ
(7) غزوات نبوی (بدر، خندق، احد)
(8) حجۃ الوداع (9) وصال

(4) اجمالی نظر

- (الف) برصغیر پر اسلامی اثرات
(ب) اسلام سے پہلے برصغیر کی مذہبی حالت
(ج) اسلامی تہذیب اور عوامل
(د) برصغیر پر اسلامی تہذیب کے اخلاقی، سیاسی اور سماجی اثرات

(II) اسلامی تہذیب کے عالمی اثرات

- (1) اسلام کی علمی تحریک
(2) فکری اثرات

B. Ethics (For Non-Muslims)

1. Ethical teachings of world religious with special reference to Budhish, Judaism, Christianity and Islam
2. 100 ethical precepts from Quran and Sayings of the Prophet
3. Virtues
Duty towards parents: respect for human life, unity of mankind, peace, justice, tolerance, beneficence, pity, contentment, chastity, meekness, repentance, social solidarity, individual accountability, moral excellence, patience and perseverance, forgiveness
4. Vices
Arrogance, ostentation, extravagance, misery, greed, jealousy, suspicion, back biting, coercion, hypocrisy, bribery, obscenity, and immodesty.
Promotion of moral values in society
Attitude of Islam towards Minorities.

C. Pakistan Studies

1. Definition of the ideology of Pakistan (with reference to the views of Allama Iqbal and Quaid-e-Azam)
2. Renaissance Movements:
The reform movements of Sheikh Ahmad Sarhindi
Shah Wali ullah's reform movements
Jehad movement of Syed Ahmad Brelvi and Shah Ismail Shaheed
The Fariadi Movement of East Bengal
The Ali Garh Movement
The Khilafat Movement
Result of the Khilafat Movement and causes of failure of the movement
Politics in 1920's
Political parties formed in 1920
3. Partition of Bengal
4. Shimla Deputation
5. Nehru Report: Historical background and causes of the report
6. Congress and Nehru report: British political sphere and Nehru report
7. Quaid-e-Azam's fourteen points: historical background, fourteen points, significance, comparison between Nehru report and fourteen points
8. Functions of congress government under the govt. of India act 1933: historical background, formation, atrocities, end of congress rule, day of deliverance
9. Pakistan Resolution
10. Critical Analysis
11. Crips Mission
12. Shimla conference
13. Cabinet mission

14. Partition of India and the creation of Pakistan: interim govt 1946, Mountbaton's decision, third June plan, law of independence 1947, referendum, transfer of powers

Paper-1V BIOLOGICAL SCIENCES-I

A. Plant Sciences

1. Plant kingdom: brief introduction and classification
2. Virology: general morphology, biochemical natures and replication. Biological and economic importance
3. Bacteriology: introduction, biological and economic importance
4. Mycology: introduction, life history, pathogen city and economic importance of Phytophthors, Ustilago, Ruccinia, Penicillium, Claviceps and yeast
5. Phycology: general introduction, habit, habitat, morphology, asexual and sexual reproduction/ life history of example plants viz Nostoc, Chara, Pinnularia, Ectocarpus and Batrachospermum. Economic importance of Cyanophyta, Chlorophyta, Bacillariophyta, Phaeophyta and Rhodophyta.
6. Lichenology: introduction, biological and economic importance
7. Bryophyta: introduction, habit, habitat, morphology, and reproduction/ life history of example plants viz Marchantia, Anthoceros and Polytrichum
8. Pteridophyta: introduction, importance, habit, habitat, morphology and reproduction/ life history of example plants viz Adiantum and Marsilea.
9. Gymnosperms: introduction and economic importance, habit, habitat, morphology and reproduction/life history of Conifers.
10. Angiosperms: general introduction, importance of families viz Ranunculaceae, Fabaceae, Solanaceae and Poaceae

Practical:

1. Flower description
2. Study of diffusion and osmosis
3. Study the ascent of sap in plants
4. Study of different given seeds to determine whether they are monocot or dicot
5. Identification of specimens (models, slides, preserved or fresh samples)
6. Labeling the given diagram
7. Collection, identification and preservation of local flora on Herbarium sheets
8. Study of gross cell structure by using compound microscopes, by staining the nuclear material.

B. Animal Sciences

1. Animal kingdom: brief introduction and classification up to phylum level.
2. Protozoa: introduction, life history and economic importance of five important protozoa viz Trypanosoma, Entamoeba, Giardia, Plasmodium, and Leishmania
3. Porifera: introduction, biological and economic importance of porifera

4. Coelentrata: introduction, economic importance with emphasis on coral reefs.
5. Platyhelminthes: introduction, life history and economic importance of two important animals viz *Fasciola hepatica* and *Taenia solium*
6. Nematoda: introduction, economic importance, life history and economic importance of *Ascaris Lumbricoides*
7. Annelida: introduction, economic importance, life cycle and economic importance of Leech.
8. Mollusca: introduction, economic importance, detailed study of feeding and gas exchange system of fresh water mussel.
9. Arthropods: introduction, life cycle and economic importance of two important insects viz honeybee and silkworm.
10. Echinodermata: introduction, details of water vascular system, feeding and reproduction of starfish.
11. Vertebrata: diagnostic features of five classes pices, amphibia, reptilia, aves and mammals. Detail study of digestive, circulatory, respiratory, excretory, nervous, endocrine, and reproductive system of rabbit.

Practical:

1. Give the phylum name of the given animals
2. Biochemical tests for the identification of lipid proteins and carbohydrates
3. Study of ecology of the given animals
4. Identification of specimens (models, slides, preserved or fresh samples)
5. Dissection of one invertebrate animal (cockroach) and one vertebrate animal (rabbit)
6. Labeling the given diagram
7. Animals collection.

Paper-V COMMUNICATION SKILLS

A. Basics in Computers

1. Introduction to computer: what is computer, uses of computer, characteristics, history, generations of computers, type of computers?
2. Computer Hardware: components of computer, input devices, output devices, system unit, storage devices, communication devices, memory
3. Computer software: types of software, operating system, types of operating system, utility programs, program, programming languages, language processors
4. Windows operating system: understanding windows 2000/xp desktop, start menu, system tray, exploring the start menu, date and time, mouse properties, keyboard properties, using printer with windows, drivers, folders and files, operation on files and folders, exploring my computer, exploring windows explorer, files management functions, folder management functions
5. Word processing: introduction to word processing, working with the page and paragraph formatting, password protection for document, using the file find features, deleting document files, inserting and typing text, displaying non printing characters, inserting and typing text,

inserting new paragraph, text and graphic selection, using the mouse for selection, copying, moving, deleting, text and graphics, symbol and special features, undo and redo command, finding and replacing text, finding and replacing format and fonts, finding and replacing special characters, character formatting, paragraph formatting, section and page formatting, spell check tool, grammar check tool, the auto correct tool, creating, modifying, and formatting a table, inserting pictures in document, working with the drawing tool, print preview, print options, print to file.

6. Spreadsheet work: introduction to Microsoft excel, excel's interface, concepts of workbook and worksheets, moving in different worksheets, entering data, navigating in a region, what is cell, many ways to select cell, shift+click techniques, selecting whole worksheets, naming a selection, inserting and removing column, inserting and removing rows, moving or copying more than one worksheet, formatting, removing format cells, working with styles, copying your data, moving your data, what is formula, operators, copying formula, moving a formula, what is function, editing a function, printing worksheet, creating a chart
7. Preparing presentations: introduction to power point, designing templates, how to exit power point, editing and arranging your presentations, how to select the presentation printing option, how to modify your entire presentation style, minor edition when required, how to insert art and text, when to go clip gallery, how to setup slide show, how to prepare slide show, how to prepare slideshow presentations.
8. Websites retrieving for biotechnological information: introduction to internet, what is world wide web? searching the internet, searching engines, starting internet explorer, using address bar, downloads, reloading pages, what is e-mail, sending and receiving emails, interpretation of sequence data, working with web mails, software for biotechnology teaching and research
9. Computer applications for biotechnologists: various biotech and statistical software applications.

B. English

1. Essay writing: main points, descriptive, narrative and reflective essay
2. Application writing: application for different topics
3. Letter writing: rules, formal and informal letters
4. Report writing: introduction, explanation of rules
5. Comprehension: introduction, explanation of rules
6. Precis writings: introduction, explanation of rules
7. Communication skills: rules for effective Commutation

SECOND PROFESSIONAL

Paper-I BIOLOGICAL CHEMISTRY-I

A. Biological Chemistry-A

Theory:

1. Amino acids, proteins and their properties
2. Covalent structure of proteins
3. Secondary structure and fibrous proteins
4. Tertiary structure and globular proteins
5. Protein stability, quaternary structure
6. Protein folding, structure prediction
7. Protein structure evolution
8. Chemical nature and role of purines, pyrimidines, nucleosides and nucleotides

Practical:

1. Hydrolysis of a protein and qualitative tests for amino acids
2. Paper chromatography of amino acids
3. Estimation of proteins by Lowry's, dye binding and Kjeldahl's methods
4. Titration curves of amino acids

B. Biological Chemistry-B

Theory:

1. Monosaccharides: classification, structures, sugar derivatives
2. Oligo, polysaccharides and carbohydrate analysis
3. Structural polysaccharides; storage polysaccharides; other carbohydrates of biological interest
4. Proteoglycans and glycoproteins structure and function; bacterial cell walls
5. Lipid classification; structure and functions of different types of lipids; micells; bilayers and liposomes
6. Structure of biological membranes; kinetics and mechanisms of membrane transport; structure and functions of lipoproteins

Practical:

1. Distinction between pentoses and hexoses, reducing and non-reducing sugars, mono, di- and polysaccharides
2. Estimation of glucose in a mixture of monosaccharides
3. Estimation of sucrose by polar meter
4. Paper chromatography of sugars
5. Extraction of glycogen from liver
6. Acid and enzymic hydrolysis of glycogen
7. Lipid separation from brain tissue and fractionation by TLC
8. Tests for fats, sterols and phospholipids
9. Estimation of cholesterol
10. Acid, saponification and iodine values of fat

Paper-II CHEMISTRY-II

A. Organic Chemistry-II

Theory:

1. Saturated Hydrocarbons

Alkanes: Introduction, Natural sources of alkanes, Preparation of alkanes from alkyl halides, Hydrolysis of Grignard reagents, reduction of carbonyl compounds, Kolbe's electro synthesis, Wurtz reaction, hydrogenation of alkenes and alkynes. Physical properties of alkanes, Reactions of alkanes with halogens, their mechanism and comparison of reactivity of halogens; combustion, isomerization, nitration and sulfonation, pyrolysis.

Cycloalkanes: Preparations of cycloalkanes by Freund synthesis, Dehalogenation of dihalides, Hydrogenation of cyclic alkenes, reduction of cyclic ketones, Physical properties (structure and stability) of cycloalkanes; Reactions of cycloalkanes, Addition reactions, substitutions reaction, Sulfonation, Combustion.

2. Unsaturated Hydrocarbons:

Alkenes and Alkynes: Preparation of alkenes from elimination reaction of alkyl halides and alcohols; Mechanism and orientation of eliminations; Dehalogenation of vicinal dihalides with mechanism, hydrogenation of alkynes. Physical properties of alkene, Reactions of alkene; relative stability and reactivity; Addition of halogens, additions of halogen acids and the rules governing these reactions, hydration reactions, Hydrogenation, oxidation reactions including epoxidation and hydroxylation, polymerization. Alkynes: Preparation of alkynes by carbide process, dehydrohalogenation of dihalides and alkylation of terminal alkynes. Reactions of alkynes: addition reactions with mechanisms of hydrogenation, halogenation, addition of Hydrogen halides, hydration reactions, polymerization (linear and closed chain).

3. Aromatic Hydrocarbons

Structure of benzene, Resonance energy of benzene, Aromaticity, criteria for aromaticity, Evidences of aromaticity; Natural sources of aromatic hydrocarbons; Preparation of aromatic hydrocarbons by different methods; dehydrogenation of cyclohexane, Cyclization of alkenes, Friedal crafts reactions, Diels- Alder reactions, Grignard synthesis, Reaction of aromatic hydrocarbons: Addition reactions, oxidation, electrophilic aromatic substitution reactions i.e. nitration, halogenation, Friedel-Crafts reaction and its limitations, sulfonation; Orientation and reactivity of substituted benzenes.

Polycyclic aromatic hydrocarbons; Naphthalene; reactions, oxidation, Reduction, Nitration, Halogenation, Anthracene and Phenantharene; Preparation and chemical reactions, oxidation, reduction, substitution.

4. Alcohol, Phenols and Ethers

Alcohols: Preparation of alcohols by the hydration of alkene, hydrolysis of alkyl halides; Physical properties; Reactions of alcohol with metals, carboxylic acids; Oxidation of alcohols; Conversion to alkyl halides.

Phenols: Synthesis of phenols by fusion of sodium benzenesulfonate with alkali, oxidation of cumene; Physical properties and acidity of phenols; Reactions of phenols such as salt, ether and ester formation, nitration, halogenations. Chemical test for phenol.

Ethers: Preparation of ethers from alcohols, alkyl halides and alkenes; Reactions of ethers; polyether as antibiotics.

5. Aldehyde and ketones:

Preparation of Aldehydes; oxidation of alkenes, oxidation of alcohols, oxidation of methyl benzene, hydration of alkynes, from carboxylic acid, from acid chloride, by Grignard synthesis, Physical properties and chemical tests for aldehyde and ketones, reactions of aldehydes and ketones, nucleophilic addition, acid catalyzed reactions, addition of alcohols, addition of water.

6. Organic nitrogen compounds:

Preparation of amines; Alkylation of ammonia, reactions of amines, salt formation, alkylation, sulfonation, oxidation, amino acids, synthesis and chemical reaction.

Practical:

Organic Synthesis

- 1) Preparation of 2-4-6 tribromophenol
- 2) Preparation of Benzoic acid
- 3) Preparation of Nitrobenzene
- 4) Preparation of Aspirin
- 5) Preparation of Ethyl acetate

Basic Experimental techniques used in organic chemistry

- 1) Filtration
- 2) Simple distillation
- 3) Solvent extraction

4) Sublimation

5) Re-crystallization

B. Enzymology

Theory:

1. General characteristics of enzyme reactions
2. Enzyme nomenclature and classification
3. Substrate specificity, Coenzymes, regulation of enzyme activity, chemical kinetics and enzyme kinetics
4. Michaelis-Menten equation, activation energy, effect of pH and other factors on rate of reactions
5. Inhibition of enzymatic reactions and kinetics, bisubstrate reactions, catalytic mechanisms
6. Structure and mechanics of lysozymes
7. Serine proteases and glutathione reductases
8. Immobilized enzymes

Practical:

11. Preparation and assay of amylase/peroxidase
12. Effect of pH, temperature, enzyme and substrate concentration on activity
13. Effect of cofactors, activators and inhibitors
14. Determination of enzyme kinetics, k_m and V_{max} , enzyme stability

Paper-III CELL BIOLOGY AND GENETICS

A. Cell Biology

Theory:

1. Introduction to cell theory and structure
2. Chemical composition of cell
3. Types of cell organelles, structure and functions, and their separation
4. Transport properties of cell membrane
5. Cell cycle; mitosis, molecular organization and functional role
6. Meiosis, division and genetic consequences; comparison with mitosis
7. Chromosomal aberrations, variation in chromosome number and structure
8. Material basis of heredity
9. Chromosomes of bacteria, viruses and their functions
10. Genes, chromosomes and the mechanism of Mendelian inheritance
11. Multiple alleles and gene interaction, epistasis, pleiotropy
12. Sex determination and differentiation
13. Sex linked inheritance, sex linked genes, sex anomalies
14. Linkage and crossing over; linkage analysis and gene mapping in eukaryotes

Practical:

1. Microscopic examination of prokaryotic and eukaryotic cells
2. Preparation of slides to show stages of cell division
3. Study of some properties of biological molecules
4. Study of cell structure and division
5. Separation and characterization of cell organelles

B. Principles of Genetics

Theory:

1. Heredity and variations
2. Morphology and structure of eukaryotic chromosomes
3. Mitosis and meiosis; monohybrid, dihybrid, trihybrid crosses
4. Mandelian parameters and their locations
5. Gene interaction and lethality
6. Modifications of Mandelian ratios, modifying gene and lethal genes
7. Penetrance, expressivity's, pleiotropism and phenocopies, twin studies, nature and nurture
8. Chromosome mapping, crossing over, methodology of mapping, interference, coefficient of coincidence
9. Blood groups
10. Sex chromosomes, sex linked inheritance and sex determination

Practical:

1. Problems related to Mandelian inheritance
2. Gene interaction
3. Gene mapping
4. ABO blood groups and Rh factors, drosophila culture techniques
5. Study of mitosis and meiosis, using onion root tips and flower buds.

Paper-IV MICROBIOLOGY & PLANT PHYSIOLOGY

A. Microbiology ایمان۔ احسان۔ اخلاص۔ اتفاق

Theory:

1. Light microscope and microbial identification
2. Biophysical and biochemical factors for growth
3. Culture enrichment and isolation
4. Anaerobic cultures, solid cultures, batch and continuous cultures
5. Methods of growth measurement; culture preservation
6. Mutation and protoplast fusion for culture improvement
7. Gene transfer for transformation, transduction and conjugation; microbial metabolism

8. Classification and characteristics of main groups of microorganisms
9. Growth under extreme environments; archaeobacteria
10. Structure and biology of bacteriophages and animal and plant viruses

Practical:

1. Different methods for growing microorganisms
2. Culture preservation
3. Experiments to determine some metabolic functions using microorganisms and animal tissues.

B. Plant Physiology

Theory:

1. Plant structure; introduction to tissues and tissue systems in primary plant body
2. Water relations
3. The plant-soil atmosphere continuum
4. Physicochemical properties of water
5. Water in the soil and its potentials
6. Water absorption, ascent and role in plant development
7. Translocation of food; materials translocated, pathways, source sink interaction, mechanism of phloem transport
8. Leaves and atmosphere; gaseous exchange, stomatal structure, mechanism and factors affecting stomatal movement
9. Plant mineral nutrition. Importance of minerals, their absorption and role in plant development
10. Fertilizers and their significance in agriculture
11. Photosynthesis. Concept, an overview of mechanism, pigments and photosynthetic activity, photosystem I & II
12. Phosphorylation and its mechanism
13. Dark reactions, C₄ & CAM pathways
14. Respiration; concept, respiratory substrates and quotient. Mobilization of substrates. Mechanism of aerobic and anaerobic respiration
15. Electron transport, ATP formation and oxidative phosphorylation. Pentose phosphate pathway
16. Fermentation, control and factors affecting respiration
17. Assimilation of nitrogen, Sulphur and phosphorus
18. Nitrogen cycle and fixation, Sulphur and phosphorus assimilation
19. Plant growth and development
20. Phytochromes and role in biological processes
21. Phytohormones-kinds, structure and mechanism of action
22. Physiological effects of auxins, gibberellins, cytokinins, abscisic acid and ethylene.
23. Photoperiodism and mechanism
24. Control of flowering, metabolic aspects of senescence, aging and death
25. Role of hormones in seed germination

26. Gene regulation and signal transduction

Practical:

1. Identification of C3 and C4 leaves
2. Identification of stomata types
3. Study of TS of stem and root
4. Determination of water potential by chardakov method
5. Effects of light and stomatal movement
6. Extraction of chlorophyll from leaves
7. Oxygen estimation by winkler method
8. Estimation of Amylase from germinating wheat grains
9. Measurement of relative growth rate
10. Measurement of specific leaf area and plant activity

Paper-V BIOMATHEMATICS & BIO-STATISTICS

A. Biomathematics

1. Biomathematics, algebraic expressions
2. Polynomials, factoring of polynomials, fractional expressions
3. The binomial theorem and its use
4. Use of differentiation and integration highs and lows, a special kind of point, optimization, functions in reality
5. The exponential growth curve,
6. The definite integral, properties and applications of definite integration
7. Principles of calculus, trigometry and algebra of importance for biotechnology.

B. Biostatistics

1. Basics statistics for biotechnology
2. Organizing and summarizing data
3. Population samples, bio-statistical analysis, ordered array, frequency distributions, polygons and curves, histograms; measures of central tendency
4. Arithmetic mean; measures of dispersion, range, mean derivation, standard derivation and error, coefficient of variation
5. Probability distributions, normal, binomial and poisson distributions
6. Hypothesis testing, statistical decision, one and two sample hypothesis, Z and other tests
7. Simple linear regression and correlation
8. Analysis of variance; non parametric and distribution free test.

THIRD PROFESSIONAL

Paper-I BIOTECHNOLOGY-BASICS

A. Elements of Biotechnology

Theory:

1. Introduction to biotechnology
2. Microbial growth kinetics, shake flask, solid state, anaerobic, batch and continuous fermentations
3. Pilot scale and scaling up of fermentation
4. Bioinstrumentation and computer control of fermentation processes
5. Immobilized enzymes and cell
6. Mammalian and plant cell culture
7. Industrially important microorganisms and biotechnological products
8. Economic aspects of fermentation process
9. Biotechnology in health, agriculture and industry, future trends in biotechnology

Practical:

1. Preparation and characterization of chromosomal, plasmid and bacteriophage DNA and RNA.
2. Mini project to clone a specific gene in E. coli
3. Techniques used in molecular biology and genetic engineering

B. Techniques of Biotechnology

Theory:

1. General methods of fractionation and characterization of proteins and nucleic acids
2. Dialysis; ultrafiltration; lyophilization
3. Principles and application of visible, UV, IR, MALDI-TOF, NMR spectroscopy in biotechnology
4. Flame photometry; atomic absorption, fluorescence spectroscopy, x-ray diffraction, principle and application in the study of proteins
5. Principle and applications of electron microscopy
6. Principles and applications of centrifugation
7. Principles and applications of adsorption, partition, ion exchange, hydrophobic and affinity chromatography; chromatofocussing
8. Principles and application of gas chromatography and HPLC
9. Native and SDS-PAGE; isoelectric focusing; immunoelectrophoresis; 2D gel electrophoresis; western blotting, ELISA

Practical:

1. Use and demonstration of variety of chromatographic, electrophoretic and other techniques used for the study of biological compounds and reactions
2. Western blotting for protein identification.

Paper-II MOLECULAR BIOLOGY

A. Molecular Biology

Theory:

1. Chromosomes, Mendelian inheritance and DNA as a carrier of genetic information
2. Double helical structure of DNA
3. Forces stabilizing nucleic acid structures
4. Supercoiled DNA; nucleic acids fractionation and sequencing
5. Chemical synthesis of oligonucleotides
6. DNA polymerase; DNA replication, general aspects and enzymes involved; prokaryotic and eukaryotic replication mechanisms
7. Mutagenesis and mechanism of DNA repair; telomeres and aging; recombination and mobile genetic elements; DNA methylation
8. RNAs and their role in protein synthesis; RNA polymerase and transcription, regulation of transcription in prokaryotes and eukaryotes; post transcriptional processing
9. The genetic code; structure of transfer RNA
10. Prokaryotic and eukaryotic ribosomal structure
11. Translational processes and their control, protein synthesis inhibitors; post translational modifications; protein targeting; protein degradation
12. Non ribosomal polypeptide synthesis
13. Structure and genomic organization, regulation of eukaryotic gene expression
14. Cell differentiation; oncogenes and cancer

Practical:

1. Preparation and estimation of DNA and RNA
2. Plasmid preparation
3. DNA restriction and gel electrophoresis

B. Recombinant DNA Technology

Theory:

1. An outline of DNA cloning experiment, cloning vectors including plasmids, bacteriophages, cosmids, YAC vectors, shuttle and expression vectors
2. Tumor including Ti plasmids
3. Restriction enzymes
4. Gene splicing, genomic and cDNA libraries, screening methods for gene libraries
5. Southern and Northern blotting; chromosome walking, site specific mutagenesis

6. Potentials of recombinant DNA technology
7. PCR; Production of proteins
8. Tissue culture techniques
9. Transgenic organisms and gene therapies; restriction fragment length polymorphisms and disease detection (e.g. cystic fibrosis)
10. Human genome project
11. Stem cells and therapeutic cloning; social considerations

Practical:

1. PCR
2. Southern and Northern blotting
3. RFLP

Paper-III GENETIC ENGINEERING

A. Microbial Genetics

Theory:

1. Morphology and life cycles of bacteria and viruses
2. Recombination in bacteria, transformation, transduction and conjugation, their types, mechanisms and significance
3. Gene mapping in bacteria
4. Mode of action of antibiotics and development of resistance
5. Extra chromosomal elements
6. Plasmids classification with emphasis on R-factors, bacteriocins, biodegradative and yeast plasmids
7. Transposable elements; IS elements, types and function, muphage-structure
8. Life cycle integration and significance, transposition, integrons
9. Recombination in bacteriophages; virulent and avirulent phages

Practical:

1. Growth curve of bacteria; induction of lytic cycle by UV
2. Oligodynamic action of metals on bacteria and yeast
3. Detection of R-plasmids in bacterial strains
4. Detection of transposons in bacterial strains; curing of bacterial plasmids
5. Detection of mutants using replica plating techniques
6. Transfer of genetic markers through conjugation
7. Gene mapping by interrupted mating in bacteria and detection of mutagenic activity by Ames test/ yeast system.

B. Principles of Biochemical Engineering

Theory:

1. Principles of chemical engineering
2. Materials and energy balances and thermodynamics
3. Industrial processes flow diagrams; survey of unit processes and flow diagrams
4. Chemical and biochemical reactors; instrumentation and control
5. Selected processes in downstream processing; novel bioreactor systems

Practical:

1. Study of units operations of chemical and biochemical engineering and related aspects.

Paper-IV BIOTECHNOLOGY OF PLANTS AND ANIMALS

A. Plant Biotechnology

Theory:

1. History of plant tissue culture
2. Different basic media and their components
3. Totipotency; callus culture; haploid production; organogenesis; embryogenesis; somaclonal variation, in vitro multiplication, cell and protoplast culture, cryopreservation, germ plasma preservation
4. Plant genetic engineering
5. Delivery system (electroporation, agrobacterium, particle gun)
6. Transgenic plant production and molecular analysis
7. GM crops and their assessment
8. Biosafety guidelines
9. Marker assisted selection; DNA fingerprinting
10. Biofertilizers and bio-insecticides

Practical:

1. Seed culture; embryo culture; anther culture, microspore culture for double, haploid, micropropagation by auxiliary buds
2. Adventitious shoot proliferation
3. Plant regeneration by organogenesis; somatic embryogenesis from callus culture
4. Meristems culture for virus elimination; in vitro fertilization
5. Protoplast isolation and culture
6. Agrobacterium mediated transformation
7. ELISA to certify pathogen free plants

B. Animal Biotechnology

Theory:

1. History and application of cell and tissue culture techniques
2. Cell and its environment; factors affecting growth of cultured cells; contact inhibition, cell types and morphology, cell strains
3. Establishment of cell lines; cell cycle, chromosomes, polyploidy, karyotypes; genetics of cells in culture
4. Cell transformation with physical, chemical and biological agents
5. Origin of mutant cell line, negative selection, cell fusion, heterokaryons and hybridomas

Practical:

1. Handling and preservation of animal cells
2. Primary culture of chick embryo fibroblasts cloning of animal cells
3. Culture of lymphoid cells, cytotoxicity evaluation, cell transformation

Paper-V BIOLOGICAL CHEMISTRY-II

A. Metabolism-I

Theory:

1. Introduction to metabolism; experimental study of metabolic pathways
2. Role of ATP and other high energy compounds
3. Glycolytic pathway and its significance; fermentation; metabolism of hexoses other than glucose
4. Glycogen breakdown and synthesis pathways; regulation of glycogen metabolism and blood glucose levels
5. Citric acid cycle and its regulation
6. Mechanism of electron transport chain
7. Oxidative phosphorylation and regulation of ATP production
8. Gluconeogenesis; glyoxylate pathway; biosynthesis of oligosaccharides and glycoproteins
9. Mechanism and regulation of pentose phosphate pathway
10. Mechanisms of light and dark reactions in photosynthesis
11. Lipid digestion, absorption and transport; fatty acid oxidation; ketone bodies; fatty acids and triglycerides synthesis; biosynthesis, transport and utilization of cholesterol
12. Prostaglandins, prostacyclines, thromboxanes and leukotrienes; phospholipid and glycolipid metabolism

Practical:

1. Determination of glucose, lactic acid, citric acid, succinic acid etc;
2. Determination of fatty acid, triacylglycerol, glycerol, phospholipids and cholesterol

B. Metabolism-II

Theory:

1. Amino acid deamination mechanisms
2. Urea cycle and its regulation
3. Biosynthesis of essential and non-essential amino acids
4. Metabolic breakdown of individual amino acids, amino acids as biosynthetic precursors
5. Nitrogen fixation
6. Chemical nature and synthesis of purine and pyrimidine ribonucleotides
7. Formation of deoxyribonucleotides
8. Nucleotide degradation; synthesis of nucleotide coenzymes
9. Integration and organ specialization of energy metabolism
10. Regulation, integration, controls and disorders of metabolic pathways

Practical:

1. Determination of proteins, amino acid, urea, uric acid, NH_3
2. Separation of nucleotides and nucleosides by TLC

FOURTH PROFESSIONAL

Paper-I BIOINFORMATICS AND ECONOMICS

A. Bioinformatics

1. Introduction to computer hardware and soft ware
2. Computer applications for biotechnologists, basic principles, spreadsheet work, word processing, graphical and statistical analysis packages, document preparations.
3. Software for biotechnology teaching and research.
4. Website retrieving for biotechnological information; genomic and proteomics data.
5. Interpretation of sequence data.

B. Economics and Business Applications

1. The University and the corporation; Multinational Corporation and biotechnology. R and D contracts
2. Introduction to financial; risk and return; trade off, time value, money; funding agencies and financial institutions; financial market
3. Biotech-economics; consumer behavior and demand; production coasts, Supply and price determination; marketing biotechnology; commodities
4. Biotechnology market regulations
5. Patents, intellectual property rights; plant variety production Act.

Paper-II INDUSTRIAL & ENVIRONMENTAL BIOTECHNOLOGY

A. Industrial Biotechnology

Theory:

1. Water pollution and effluent treatment
2. Biodegradation of Xenobiotic chemicals
3. Ethanol and related fermentations
4. Production of industrial enzymes
5. Fermentation for the production of pharmaceutical products including antibiotics, hormones, vaccines etc
6. Production of other chemicals of industrial importance
7. Microbial metal leaching

Practical:

1. Experiments including physical nutritional aspects of microbial fermentations
2. Aerobic and anaerobic, batch and continuous cultures
3. Ethanol production; product recovery etc.

B. Environmental Biotechnology

Theory:

1. Environmental biotechnology and society
2. Environmental assessment of biotechnological processes, marine environment, agricultural environment; extreme environments.
3. Disposal of domestic and industrial wastes and pollutants
4. Microbial transformations; bioremediation of soil and water
5. Role of bio fertilizers and bio insecticide/microbial deodorization; coal and oil desulphurization;
6. Biosafety guidelines

Practical:

1. Determination of heavy metals ions from various sources
2. Biodegradation of vast and pollutants
3. Cellulose decomposition.

Paper-III FOOD BIOTECHNOLOGY & IMMUNOLOGY

A. Food Biotechnology

Theory:

1. The large-scale biotechnology
2. Isolation, preservation and important of industrial microorganism
3. The scope of biotechnology in food and drink industry; dairy products; production of cheese, yogurt, butter cultures buttermilk, cultured sour cream cereal products; bread and backed good;
4. Starch hydrolysate brewing alcoholic beverage production, beer, wine, spirits, cider and vinegar products
5. Traditional tormented protein food, single protein, mycoprotein
6. Food additives amino acid vitamins and pigments, flavoring oil and fats, gum and thickness;
7. Preservation of fruits vegetables;
8. Soya, products and fruit juices and other products

Practical:

1. Visits to industry, milk and milk products; plain and flavored yogurt; cheese preparation; beverage; malt extract preparation.
2. Preservation of food, vegetables and fruits
3. Pectin production, enzyme activity in juices; cereal production; plain and sour bread.

B. Immunology

Theory:

1. Introduction to the immune system:
2. Elements of innate and acquired immunity; immunogens and antigens
3. Antibody structure and function; antigen antibodies interaction' genetic basis of antibody structure, monoclonal antibodies
4. Biology of the B lymphocytes and role of MHC in the immune System;

5. Biology of the T lymphocytes; Activation and function of T and B cells
6. Control mechanism in immune response; cytokines; complement;
7. Hypersensitivity reaction; type I, II, III, IV
8. Autoimmunity; resistance and Immunization to infectious diseases:
9. Application of immunological functions

Practical:

1. Ouchterlony immune-double diffusion test;
2. Widal tests; ELISA;
3. Production of polyclonal activities

THESIS OR 02 WRITTEN PAPERS

Paper-IV RESEARCH METHODS IN BIOTECHNOLOGY

A. Skills and Research Methodology for Biotechnology

1. Overview of scientific research; improvement through research
2. Nature of scientific inquiry
3. Applications of research in industry
4. Choosing a project; development of a research project; writing a research grant application; role of students; supervisor's role; designing and investigation; identifying the level within investigation; deciding on techniques to be employed; analysis of results; control, samples and replications; reviewing the literature; primary and secondary sources; scientific record keeping
5. Use of microorganisms, animals, plants and humans in experimentation
6. Use of pathogens in experimentation
7. Conflict of interests; ownership of data; writing, presentation and publishing the scientific papers
8. Filing patent application

B. Medical Biotechnology

1. Conventional medical biotechnology
2. Contemporary issues in medical biotechnology
3. Introduction to principles of gene therapy and gene delivery systems
4. Human genome, detection of gene mutation
5. Tissue engineering and transplantation; drug delivery
6. Biodegradable polymers
7. Practical and theoretical problems of modern methods of disease therapy
8. Production of therapeutical monoclonal antibodies and their uses
9. Role of organ transplantation in curing and new organ production
10. Use of transgenic animals in therapy
11. The principles and practices of transfusion techniques; preparation of blood components and their uses

12. Essentials of osteopathic principles; humans and veterinary osteopathy and bone grafting
13. Ethical issues in gene therapy and tissue engineering.

Paper-V ADVANCED MOLECULAR BIOLOGY

A. Advanced Cell culture and Cell Biology

Theory:

1. Introduction to cell theory including historical perspective;
2. Prokaryotic and eukaryotic cell differences including cell wall, membrane structure and chemical constituents of the cell;
3. Function, isolation and molecular organization of cellular organelles specifically the endoplasmic reticulum, Golgi bodies, ribosomes, lysosome, micro-bodies,
4. Mitochondrial ultrastructure and function, Chloroplast ultra-structure and the mechanism of photosynthesis; membrane receptors and transport mechanisms;
5. Cell movement - structure and function of cytoskeleton, centriole, cilia and flagella; nucleus
6. Extracellular matrix
7. Structure and function of chromosomes, Cell cycle, mitosis and meiosis,
8. Cell death, apoptosis, necrosis,
9. Cancer cells and proliferation

Practical:

1. Microscopy and staining techniques; study of prokaryotic, eukaryotic, plant and animal cells;
2. Mitosis: smear/squash, Preparation of onion roots.
3. Animal cell culture techniques
4. Cell transfection techniques
5. Methods for the generation of stable cell lines
6. Luciferase assay
7. Electrophoretic mobility shift assay

B. Advanced Molecular Biology

Theory:

1. Purification of DNA, Polymerase chain reaction (PCR), RT-PCR, qPCR,
2. Online bioinformatics tools for the retrieval of sequence (gene, mRNA, and protein),
3. Vectors for gene cloning, Manipulation of purified DNA, Introduction of gene in living cells,
4. Cloning vector for *E.coli* and eukaryotes, Clone of specific gene,
5. Applications of gene cloning, Gene expression and function,
6. Applications of gene cloning, Gene modification in ES cells, Stem cell manipulation,
7. Stable expression in mammalian cells, Synthesis of commercial products by recombinant DNA technology,
8. cDNA synthesis, DNA sequencing and synthesis,
9. Genetically engineered mice, Phenotype analysis,
10. Designing of CRISPR for knockout mice, Designing of CRISPR for knockin mice

Practical:

1. Extraction of DNA from animal tissues and cultured cells
2. Isolation and qualitative detection of plasmid DNA (miniprep)
3. DNA amplification by polymerase chain reaction (genotyping strategies)
4. Transformation and restriction cloning experiments using *E. coli* as host
5. PCR-facilitated deletion and insertion of domains. Site directed mutagenesis
6. Digestion of DNA with restriction enzymes and elution from gel
7. Culture of eukaryotic and embryonic stem cells
8. Mouse breeding and mouse necropsy

