YENEPOYA

(DEEMED TO BE UNIVERSITY)
Recognized under Sec 3(A) of the UGC Act 1956
Accredited by NAAC with 'A' Grade

YENEPOYA (DEEMED TO BE UNIVERSITY)

Deralakatte, Mangaluru -575018

REGULATIONS AND CURRICULUM GOVERNING

POSTGRADUATE PROGRAM IN

MASTER OF SCIENCE BIOSCIENCE

(REVISED CURRICULUM – AMENDED UP TO 2020)

Structure of the program clearly indicating courses, credits/Electives **Click Here**

ATTESTED

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Ref: No. Y/REG/ACA/38-ACM/2020

14.05.2020

NOTIFICATION – 38-ACM/09/2020 dtd. 14.05.2020

Sub: Revision in the curriculum of M.Sc. (Bioscience)

Ref: Resolution of the Academic council at its 38th meeting held on 27.04.2020, vide agenda - 20

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The Academic Council at its 38th meeting held on 27.04.2020 and subsequently the Board of Management at its 49th meeting on 30.04.2020 have resolved to approve the following revision in the curriculum of M.Sc. (Bioscience).

In the Practical examination pattern, major and minor experiments are divided as category A and category B practical exercises. All those "Major experiments" and "Minor experiments" are listed as category A and category B practical exercises respectively in the curriculum.

The notification has been issued for implementation with effect from the academic year 2020-21.

SEMESTER 1

1	Discontinuation of the elective course "Genomics and Epigenetics" All the four theory courses are considered as Core courses.
Syllabus Revision	
2	**Course name: Biochemistry (AP02BS-1C1)** ***New Topics included*** **Unit 4:** "Classification, nomenclature and properties, Factors affecting enzyme activity. Enzyme inhibition" nature and physiological significance. Porphyrins chemistry and disorders". ***Shifting of topics to other units*** **Unit 1:** "Enzymes: Classification, nomenclature and properties, Enzyme kinetics-one

	substrate reaction (Michaelis-Menten Equation). Factors affecting enzyme activity. Enzyme inhibition. Allosteric enzymes. Isozymes (LDH)" **to Unit 4** ***Deletion of topics*** **Unit 1:** "nucleic acids" **Unit 2:** "Electrophoresis: Moving boundary and zonal electrophoresis, paper and gel electrophoresis, PAGE and SDS-PAGE, isoelectric focusing technique" Topics "design of colorimeter and spectrophotometer, applications of UV-Vis spectrophotometry" **Unit 3:** "Basic law of thermodynamics, internal energy, enthalpy, entropy, concept of free energy, redox potentials, high energy compounds, structure and function of ATP". **Unit 5:** "Evaluation of organ function tests of gastric, pancreas, kidney and liver. Bilirubin, direct and indirect Vanderwal tests and their clinical significance, jaundice. Fatty liver, Bile pigments - chemical
2	**Course name: Cell and Molecular Biology (AP02BS-1C3)** ***New Topics included*** **Unit 3:** Specific transcription factors "polymerases, p53, IFs, EFs, TRF I, II &III" **Unit 4:** "Types of vectors" ***Deletion of topics*** **Unit 3:** "Genetic variations and Mutations" Unit 4 "gene dosage, gene amplification"
3	**Course Name: Microbiology (AP02BS-1C3)** ***New Topics included*** **Unit 1** "Ananda Chakrabarty" **Unit 4:** "fungal and viral" **Unit 5:** "Anthrax, Bovine tuberculosis, Foot and Mouth Disease, Avian Influenza , Anthrax, Bovine tuberculosis, Foot and Mouth Disease, Avian Influenza". ***Deletion of topics*** **Unit 1:** "Theory of spontaneous generation" **Unit 3:** "Gene Regulation, Microbial DNA Replication, Mutation". **Unit 5**: "Biotechnological applications of Microbes in from Extreme environments: Physiological adaptations, enzyme activities and their biotechnological applications"
4	**Course Name: Genetics (AP02BS-1C4)** ***New Topics included*** **Unit 1:** "Autosomal, non- Mendelian inheritance" **Unit 3.** "Congenital and common genetic diseases, prevalence and databases Common syndromes due to numerical chromosome changes (Downs, Patau, Edwards, Turner, Klinefelter, Jacobs syndromes)" **Unit 4:** "Genetic mapping: Linkage analysis (RFLP/MS/SNP); Applications of mapping in normal and disease genome analysis: Gene identification using positional and functional cloning approach, Linkage mapping" "Human genetic diversity- Methods of study Biochemical/molecular genetic markers; some

	examples. Tracing human migrations with autosomal, Y-chromosomal and mitochondrial markers". **Unit 5:** "Gene dosage, gene amplification, molecular combing /fibre analysis". ***Shifting of topics to other units*** **Unit 1:** Quantitative inheritance, Linkage Meiotic consequences in structural heterozygotes, role in speciation and evolution" **to Unit 4.** **Unit 3**: "Human genome mapping methods: Physical mapping: Introduction to physical map markers- Chromosomal, G/Q- banding, radiation hybrid mapping" to **Unit 2** "Genetic mapping: Linkage analysis (RFLP/MS/SNP); Applications of mapping in normal and disease genome analysis: Gene identification using positional and functional cloning approach" to **Unit 4** "Fluorescence in situ hybridization, comparative genome hybridization, long range restriction mapping, high resolution mapping STS/EST/MS/SNP/sequencing" to **Unit 5** "Human genetic diversity- Methods of study Biochemical/molecular genetic markers; some examples. Tracing human migrations with autosomal, Y-chromosomal and mitochondrial markers" to **Unit 4** "Chromosomal disorders" **to Unit 5** ***Deletion of topics*** **Unit 5:** "Pedigree analysis, Linkage mapping, Positional/structural and functional cloning". "Statistical methods used; Pharmacogenetics: History, Early evidence; Clinical determinants; Molecular insights (genes involved in pharmacokinetics and pharmaco dynamics of drugs); Applications in pre-prescription testing".

SEMESTER 2

Syllabus Revision	
1.	**Course name: Environment and Health (AP02BS-2O1)** ***New Topics Introduced:*** **Unit 1:** "Flouride and thoron toxicity, health impact". **Unit 4:** "Biomagnification" ***Deletion of topics*** **Unit 2**: "chemical speciation, Particles, ions and radicals in the atmosphere" "Oxygen and ozone chemistry. Chemistry of air pollutants ". **Unit 3:** "Natural and anthropogenic sources of pollution, Primary and Secondary pollutants, Transport and diffusion of pollutants" **Unit 4:** "Soil Pollution Control, Thermal Pollution".
2	**Course name: Nanobiotechnology (AP02BS-2C1)** ***Change in Credits:*** existing 4 revised to 3 ***New syllabus*** **Unit 1: Introduction to nanomaterials:**

	Nanotechnology history and scope, nanosize and properties, classification of nanostructured materials Bio nanotechnology-biological and biomimetic nanostructures-functional biological nanomaterials-impact of nanotechnology on medicine-medical nanotechnology-nanomedicine. **Unit 2: Synthesis of nanomaterials** Synthesis of nanomaterials: physical methods-high energy ball milling-mechanical, evaporation-sputterdeposition-chemicalvapourdeposition-electricarc deposition. Chemical methods; synthesis of nanoparticles by colloidal route-microemulsion-sol-gel method-hydrothermal process-sonochemical synthesis-chemical precipitation-microwave synthesis and pyrolysis. Biological methods; synthesis using microorganism-plant extracts-use of protein and template like DNA. **Unit 3: Characterization Techniques for nanomaterials** UV-Visible spectroscopy-fourier transform infrared spectroscopy-fluorescence spectroscopy-differential thermal analysis-thermo gravimetric analysis-dynamic light scattering-X-ray diffraction-X-ray photoelectron spectroscopy-atomic force microscopy-field emission scanning electron microscopy-transmission electron microscopy-energy dispersive X-ray diffraction. **Unit 4: Biomacromolecules** History of macromolecular science and concept of macromolecules; Basic concepts in polymer science-classification-monomer structure and polymerizability-concept of functionality-measurement of molecular weight and size-degree of polymerization-molecular weight distribution and polydispersity-biodegradable and water soluble polymers-polymer nanogels-bioresponsive polymers and natural biopolymers. **Unit 5: Use of nanomaterials:** Fundamentals of nanotechnology in bio sensing-cosmetics-imaging-drug delivery system for small molecules and proteins-tissue repair-antibacterial-antifungal-antiviral agents-biopolymers in medicine-role of nanotechnology in environmental applications and toxicity.
3	**Course name: Stem Cells and Developmental Biology (AP02BS-2C2)** ***New Topics Introduced:*** **Unit 3:** "Research using induced pluripotent stem cells and its advantages" ***Deletion of topics*** **Unit 1:** " Diversification of gene and protein expression"
4	**Course name: Immunology (AP02BS-2C3)** ***New Topics Introduced:*** **Unit 2:** "Cytotoxic T cells, Natural Killer Cells, ADCC, NK cell receptors, inverse correlation with target MHC expression, and missing self hypothesis, cytotoxicity reaction, hypersensitivity" **Unit 4**: "CarT cell therapy and dendritic cell vaccines" ***Deletion of topics*** **Unit 4:** T "Stem cell technology. Manufacturing and Clinical Trials"

5	**Course name: Toxicology (AP02BS-2C4)** ***New Topics Introduced:*** **Unit 3:** "Classification of drug interaction, Drug interactions with vitamins (interactions of retinoids with Vitamin A , levodopa with Vitamin B6 , warfarin with vitamin E and vitamin K, methotrexate with folic acid), Drug interactions with minerals (interactions of tetracyclins and fluoroquinolones with calcium, aluminium and magnesium, methyldopa and proton pump inhibitors with iron, angiotensin receptor blockers and diuretics with potassium) Drug-nutrient interactions - Mechanism based classification system (ex-vivo bioinactivations, absorption phase associated interactions, physiological action associated interactions, elimination phase associated interactions) Drug- dietary supplement interactions (interactions of coenzyme Q10, fish oil and herbal supplements with drugs) Drug toxicity – Mutagenecity, teratogenecity and carcinogenicity" **Unit 5:** "in vitro, in vivo, molecular, epidemiological): Assessment of genetic toxicity (COMET assay, micronucleus assay), in vitro toxicity assays (MTT assay, Neutral red uptake assay), carcinogenicity (transgenic mice models, initiation/promotion models) and mutagenecity testing (Ames test, mouse lymphoma thymidine kinase assay)". ***Shifting of topics to other units*** **Unit 1:** "OECD Guidelines for the Testing of Chemicals. Various techniques for toxicity evaluation (in vitro, in vivo, molecular, epidemiological." **to Unit 5** and rearranged as "Various techniques for toxicity evaluation OECD Guidelines for the Testing of Chemicals". ***Deletion of topics*** **Unit 3:** "Basic principles and specific examples of Hepato and renal toxicology, Reproductive and developmental toxicology, Immunotoxicology, cutaneous and pulmonary hypersensitivity". "Persistent Organic Pollutants (POPs) and dioxins. Neurotoxicology, Metal toxicology: mercury, cadmium. Ozone, a criteria for air pollutant. Nanoparticle toxicology. Environmental diseases: Asbestosis, silicosis, synopsis, asthma, fluorosis and allergies, epidemiological issues – Malaria, Kala azar and water borne diseases. Properties and toxicities of animal venoms with special reference to scorpions, spiders, ticks, centipedes, millipedes, ants, bees, wasps, snails, lizards and snakes. Anti-venoms. Toxic effects of plant, fungi and algae".

SEMESTER 3

Course Structure:	
i.	Discontinuation of " Biostatistics and Bioinformatics (code): Theory 4 credit course"
ii.	Introduction of "Biostatics" practical course (3 credits)
iii.	Introduction of "Research Methodology" course (4 credits)

iv.	Discontinuation of "Cell Culture Techniques" theory course
v.	Increase in credit for "Cell Culture Techniques" Practical course from 2 credits to 3 credits
vi.	Renaming of "Systems Biology and Omics Technology" as "Bioinformatics and Omics Technology"
vii.	Renaming of "Systems Biology and Omics Technology" as Omics Technology and Systems Biology"
Syllabus Revision	
1.	**Course Name: Omics Technology and Systems Biology (AP02BS-3C2)** ***Deletion of topics*** **Unit-2:** "Epigenetics, CpG island methylation, Histone acetylation, Bisulfite sequencing" **Unit 3:** "Protein sequence and spectral databases/ libraries, de-novo sequencing" **Unit 5:** "Proteogenomics-concepts"
2.	**Course Name: Genetic Engineering (AP02BS-3C3)** ***Rearrangement of topics*** **Unit 1:** "Plasmid vectors, Vectors_based on the lambda Bacteriophage, Cosmids, M13 vectors, Expression vectors, Vectors for cloningand expression in Eukaryotic cells, Super vectors, YACs and BACs." as "Structural and functional organization of plasmids, plasmid replication, stringent and relaxed plasmids, incompatibility of plasmid maintenance. Lambda phage vectors" ***Deletion of topics*** **Unit 2:** "Use of Phage display techniques to facilitate the selection of mutant peptides, Gene shuffling, production of chimeric proteins" **Unit 5:** "site-directed mutagenesis and Protein engineering: Primer extension, PCR based site directed mutagenesis, Random mutagenesis,_Ethicalconsiderations, epigenetic modification".

REGISTRAR

To,

The Dy. Director, YRC

Copy to:

1. Controller of Examinations
2. File copy

Regulations, Scheme and Syllabus

Master of Science (M.Sc., in Bioscience) Choice Based Credit System

Preamble

The broad goal of teaching and training of postgraduate students in M.Sc. Bioscience is to enable a student acquire sound knowledge in the subject and develop practical skills to contribute effectively in the fields of academics and research.

Yenepoya Research Centre has established several research facilities and has accumulated expertise in the frontier areas of life sciences, such as Stem cells and tissue engineering, Proteomics, genomics and metabolomics, bioinformatics, molecular biology and nanobiotechnology. The M.Sc. course is envisaged under the centre's vision of knowledge dissemination in the broad area of Bioscience. And for offering this program, the centre has adequate human resources and expertise needed for offering the postgraduate course.

Master of Science (M.Sc.) in Bioscience is a post graduation course of Yenepoya (Deemed to be University), Mangalore. The Choice based credit system to be implemented through this curriculum, shall allow students to develop a strong footing in the fundamentals and specialize in the disciplines of his/her liking and abilities.

The students pursuing this course would develop in depth understanding various aspects of the modern biology.

The new developments in medical/healthcare/pharmaceutical/research areas require skilled manpower with good theoretical knowledge.

The working principles, design guidelines and experimental skills associated with different fields of Biosciences help the students to pursue researches in field of recent and advanced areas like Stem Cell and Omics Technologies.

The learning healthcare environment in the campus will be very conducive for the learners to have practical exposure and understand the contemporary medical challenges that need research focus. The interdisciplinary setting at the Yenepoya research Centre shall allow the students to take courses from other postgraduate departments under the CBCS scheme.

Programme Outcome (PO)

PO 1	Have knowledge and understanding of the basic concepts of Biochemistry, Microbiology, Genetics, Cell and Molecular Biology, Immunology and Toxicology and laboratory skills as applicable to the life science skill sector.
PO 2	Competent enough to use the basic understanding and skills for the emerging areas of Nanobiotechnology, Stem cell Biology, Omics Technology, Bioinformatics and Genetic engineering.
PO 3	Understand the key concepts of research methodology including regulatory and ethical issues and applications of statistics.
PO 4	Able to generate new knowledge through research projects and analyze, interpret and report the data collected through a research project.

General Regulation

1. Title of the programme:

   Master of Science in Bioscience (M.Sc. Bioscience)

2. The commencement of the programme:

The programme was introduced August 2018

3. Eligibility for admission:

   Bachelor's degree in any branch of Biological Science with a minimum of 50% marks in aggregate. Selection of candidates shall be on merit basis.

4. Duration of the programme:

   Two years with four semesters.

5. Course pattern:

   Choice based credit System with 4 semesters Total

Credits:	96 credits
Core courses:	66 credits
Open elective papers-	6 credits
Project:	24 credits

1 credit=1 hour of lecture per week/ 2 hours of Laboratory or practical Course pattern is given in Table 1.

2. Definitions of Key Words

i. Academic Year: Two consecutive (one odd + one even) semesters constitute one academic year.

ii. Choice Based Credit System: The CBCS provides choice for students to select from the prescribed courses (core, elective or minor or soft skill courses).

iii. Course: Usually referred to, as 'papers" is a component of a programme. The courses shall define learning objectives and learning outcomes. A course shall comprise lectures/ tutorials/ laboratory work/ field work/ outreach activities/ project work/ vocational training/viva/ seminars/ term papers/assignments/ presentations/ self-study etc. or a combination of some of these.

iv. Credits: Credit defines the quantum of contents/syllabus prescribed for a course and determines the number of hours of instruction required per week. Thus, normally in each of the courses, credits will be assigned on the basis of the number of lectures/tutorial laboratory work and other forms of learning required, to complete the course contents in a 16-20 week schedule: One credit=1 hour of lecture per week/two hours of Laboratory or practical/three hours of clinical rotation, field work/posting. All courses need not carry the same credits.

v. Grade Point: It is a numerical weight allotted to each letter grade on a 10-point scale.

vi. Credit Point: It is the product of grade point and number of credits for a course.

vii. Cumulative Grade Point Average (CGPA): It is a measure of overall cumulative performance of a student over all semesters. The CGPA is the ratio of total credit points secured by a student in various courses in all semesters and the sum of the total credits of all courses in all the semesters. It is expressed up to two decimal places.

viii. Letter Grade: It is an index of the performance of students in a said course. Grades are denoted by letters: A+, A, B+, B, C, P and F.

ix. Semester Grade Point Average (SGPA): It is a measure of performance of work done in a semester. It is ratio of total credit points secured by a student in various courses registered in a semester and the total course credits taken during that semester. It shall be expressed up to two decimal places.

x. Transcript or Grade Card or Certificate: Based on the grades earned, a grade certificate shall be issued to all the registered students after every semester. The grade certificate will display the course details (code, title, number of credits, grade secured) along with SGPA of that semester.

4. Semesters

An academic year shall consist of two semesters;

Odd Semester 1^{st}& 3^{rd}	July/August to December/January
Even semester 2^{nd}& 4^{th}	January/February to June/July

5. Types of Courses

i. Core course: a course that should compulsorily be studied by a candidate as a requirement is termed as a core course this can be hard core or soft core.

ii. Open Elective: Generally a course which can be chosen from a pool of courses and which may be very specific or specialized or advanced or supportive to the discipline/ subject of study or which provides an extended scope or which enables an exposure to some other discipline or subject or domain or nurtures the candidates proficiency skill.

- The open elective courses shall be offered in the second and third semesters only.
- The list of open elective courses offered shall be displayed in the University website.
- A student shall not take the courses offered by the department in which she/he is enrolled.
- Registration for the open elective courses shall be at least one week prior to the commencement of the course with the CBCS coordinator.

6. Attendance:

Each course (theory, practical, etc.) shall be treated as an independent unit for the purpose of attendance.

A student shall attend a minimum of 80% of the total instruction hours in a course including tutorials and seminars in each semester.

Table 1. Course Scheme of instruction and examination for Semester-wise

Course code	Type of Course	Course name	Hrs/ Week	Exam (hours)	IA Marks	SE Marks	Max marks	Credits
First Semester								
AP02BS-1C1	Core -Theory	Biochemistry	4	3	40	60	100	4
AP02BS-1C2	Core -Theory	Cell and Molecular Biology	4	3	40	60	100	4
AP02BS-1C3	Core - Theory	Microbiology	4	3	40	60	100	4
AP02BS-1C4	Core- Theory	Genetics	4	3	40	60	100	4
AP02BS-1C5	Core -Practical	Biochemistry	4	3	20	30	50	2
AP02BS-1C6	Core -Practical	Cell and Molecular Biology	4	3	20	30	50	2
AP02BS-1C7	Core - Practical	Microbiology	4	3	20	30	50	2
AP02BS-1C8	Core -Practical	Genetics	4	3	20	30	50	2
Total							600	24
Second Semester								
AP02BS-2O1	Open Elective	Environment and Health	3	3	40	60	100	3
AP02BS-2C1	Core- Theory	Toxicology	4	3	40	60	100	4
AP02BS-2C2	Core - Theory	Stem cell and Developmental Biology	4	3	40	60	100	4
AP02BS-2C3	Core- Theory	Immunology	4	3	40	60	100	4
AP02BS-2C4	Core -Theory	Nanobiotechnology	3	3	40	60	100	3
AP02BS-2C5	Core -Practical	Nanobiotechnology and Toxicology	4	3	20	30	50	2
AP02BS-2C6	Core -Practical	Stem Cell and Developmental Biology	4	3	20	30	50	2
AP02BS-2C7	Core - Practical	Immunology	4	3	20	30	50	2
Total							650	24
Third Semester								
AP02BS-3O1	Open Elective	Scientific Communication	3	3	40	60	100	3
AP02BS-3C1	Core -Theory	Research Methodology	4	3	40	60	100	4
AP02BS-3C2	Core - Theory	Omics Technology and Systems Biology	4	3	40	60	100	4
AP02BS-3C3	Core -Theory	Genetic Engineering	4	3	40	60	100	4
AP02BS-3C4	Core- Practical	Biostatistics	6	4	20	30	50	3
AP02BS-3C5	Core -Practical	Bioinformatics and Omics Technology	6	4	20	30	50	3
AP02BS-3C6	Core -Practical	Cell culture techniques	6	3	20	30	50	3
Total							550	24
Fourth Semester								
AP02BS-4PR	Project work	Full time 14 weeks			100	300*	400	24

7. Assessment of a Course:

Evaluation for a course shall be done on a continuous basis. Two continuous internal assessments (CIA) followed by one semester end university examination (SEE) for each course. The components of CIA may include sessional tests, Seminar / Journal Cub /other related activities, Review/Assignment/Social involvement and other activities relevant to the course. The weightage of CIA shall be 40% and SEE shall be 60%.

Registering for examination:

Candidates having ≥80% attendance in each of the courses can only qualify to appear for the semester end examinations. The candidate shall register for all the papers in the subject of a semester when he/she appears for the examination of that semester for the first time.

Scheme of Examinations

i. Internal Assessment: Marks for internal assessment shall be awarded on the basis of seminars, Journal paper presentations, tests, assignments etc. The assessment gives importance to continuous and comprehensive evaluation. The internal assessment marks shall be notified be communicated to the Controller of Examinations before the commencement of the University examinations.

Components of CIA	Details	Weightage
Sessional Tests	Average of the two tests	10%
Seminar/ Journal Cub/other related activities	One Seminar/ course One Journal paper relevant to the core courses	15%
Creativity /Skill enhancing Exercise	Short project/ Blogs//Developing Experimental Video/outreach activities/other creative activities	10%
Review/Assignment/	Discipline specific as required by the course	5%

ii. Semester End Examination:

There shall be examinations at the end of each semester ordinarily during December/January for odd semesters and during June/July for even semesters. The SEE duration shall be three hours. Semester IV will be assessed on the project outcome.

Pattern of question paper for semester end examination

Sl. No	Key Criteria	No. Of questions and Marks	Max marks
1	Short questions (6 out of 8 questions)	6 X 2	12
2	Problems/concepts (4 out of 6 questions)	4 X 6	24
3	Descriptive problems/questions (2 out of 3 questions)	2 X 12	24
	TOTAL		60

Pattern for Practical examination

Sl. No	Key Criteria	No. Of questions and Marks	Max marks
1	Category (a) –Perform and report	1 X 10	10
2	Category (b) - Perform and report	1 X 5	05
3	Spotters- Identify and report	5 X 1	05
4	Viva	5	05
5	Records	5	5
	TOTAL		30

CIA shall be based on the quality of the records and performance in laboratory practical sessions during the semester (20 Marks).

iii. Valuation of answer scripts:

a. Each theory examination shall be evaluated by one internal and one external examiner. There shall be a third evaluation if the difference is more than 15%.
b. Practical examination shall be jointly conducted and evaluated by one internal examiner and one external examiner.

iv. Evaluation of Project

The internal assessment marks shall be allotted by the supervisor based on the work progress and attendance.

Dissertation: Dissertation shall be evaluated by an external and internal examiner on the following criteria;

Sl. No	Key Criteria	Max marks
1	Outline of the work and adequacy of the methodology	40
2	Rationale of the study and Contribution to skill enhancement	40
3	Appropriateness of instruments and data analysis tools applied	60
4	Quality of data interpretations and reporting style	60
TOTAL		200

Viva-voce: Viva voce shall be conducted by a Common Viva-Board consisting of the Chairman (BOE), internal guide and one external expert as approved by the Controller of Examinations. Viva duration shall be of one hour for 100 marks.

Sl. No	Key Criteria	Max marks
1	Justification on the work done and its relevance	25
2	Clarity of presentation	25
3	Knowledge on the subject	25
4	Communication skills	25
TOTAL		100

8. Letter Grades

The results of successful candidates at the end of each semester shall be declared in terms of Grade Point Average (GPA) and alpha sign grade. The results at the end of the fourth semester shall be classified on the basis of the Cumulative Grade Point Average (CGPA) obtained in all the four semesters and the corresponding overall alpha-sign grade. The letter grade as described below shall be adopted.

Letter Grade	Grade Point	Range of marks
A+(Outstanding)	10	95-100
A (Excellent)	9	85-94
B+ (Very Good)	8	75-84
B (Good)	7	65-74
C (Average)	6	55-64
P (pass)	5	50-54
F (Fail)/ RA (Reappear)	0	Less than 50

9. Calculation of Cumulative Grade Point Average (CGPA):

The Cumulative Grade Point Average (CGPA) at the end of the fourth semester shall be calculated as the weighted average of the semester GPW. The CGPA is obtained by dividing the total of GPW of all four semesters by the total credits for the programme.

The following is the sample illustration of computing semester grade point averages (GPA), cumulative grade point average (CGPA) and the letter grades assigned.

CGPA Range	Letter Grade
9.0-10.0	A+(Outstanding)
8.0 – 8.99	A (Excellent)
7.0 - 7.99	B+ (Very Good)
6.0 - 6.99	B (Good)
5.5 - 5.99	C (Average)
5.0 – 5.49	P (pass)
<5.0	F (Fail)

10. Marks qualifying for a pass

i. A candidate shall be declared to have passed the PG program if he/she secures at least a CGPA of 5.0 (Course letter Grade P) in the aggregate of both internal assessment and semester end examination marks.

ii. For each course the total of 100% is determined from the CIA evaluation and the SEE weighted at 40% and aggregate of CIA and SEE at 50% as minimum for pass.

iii. The candidates who pass all the semester examinations in the first attempt in two years are eligible for ranks provided they secure at least a CGPA of 6.0 (at least letter Grade B).

iv. The results of the candidates who have passed the fourth semester examination but not passed the lower semester examinations shall be declared as NCL (Not Completed Lower semester examinations). Such candidates shall be eligible for the degree only after completion of all the lower semester examinations.

v. A candidate who passes the semester examinations in parts is eligible for only CGPA and letter Grade but not for ranking.

vi. Carry over shall be allowed for candidate who failed in not more than two courses in a semester.

vii. Candidate who fails in any of the unit/project work/Project Report/ dissertation shall reappear in that unit/project work/Project Report/ dissertation and pass the examination subsequently.

11. Re-Entry after Break of the study

    a. Students admitted to a program abstaining for more than 3 months must seek readmission into the appropriate semester.
    b. The student shall follow the syllabus in vogue (currently approved/is being followed) for the program
    c. All re admissions of students are subject to the approval of the Vice- -Chancellor.

12. Maximum period for completion of the Programme

    A candidate shall complete the four semesters (two years) programme within five years from the date of admission.

13. Detailed syllabus

    Detailed syllabus enclosed as Annexure –I

Annexure 1: Syllabus

SEMESTER-I Courses and scheme

Course code	Type of Course	Course name	Hrs/ Week	Credits
AP02BS-1C1	Core -Theory	Biochemistry	4	4
AP02BS-1C2	Core -Theory	Cell and Molecular Biology	4	4
AP02BS-1C3	Core - Theory	Microbiology	4	4
AP02BS-1C4	Core - Theory	Genetics	4	4
AP02BS-1C5	Core -Practical	Biochemistry	4	2
AP02BS-1C6	Core -Practical	Cell and Molecular Biology	4	2
AP02BS-1C7	Core - Practical	Microbiology	4	2
AP02BS-1C8	Elective -Practical	Genetics	4	2
Total				24

Course Name: BIOCHEMISTRY Credits: 4 (56 hours)

Course Code: AP02BS-1C1

CO 1	Student will be able to differentiate the major biomolecules and their importance in the biological system
CO 2	Know the different techniques used for studying biomolecules
CO 3	Know the importance of metabolic pathways and law of thermodynamics
CO 4	Know the importance of enzymes, enzyme kinetics and mechanism of action
CO 5	Know the nutritional values of macromolecules & vitamins and minerals and their importance in the biological systems.

Unit 1: Chemistry of Biomolecules 10 hrs

Chemistry of Biomolecules (carbohydrate, protein, lipid), Carbohydrates: classification, basic chemical structures, general reactions and properties, biological significance. Lipids: classification, structure and function of major lipid subclasses. Formation of micelles, monolayers, bilayer. Amino acids: classification, properties and reactions (N/C terminal reactions, ninhydrin reaction).
Digestion and absorption. Vitamins and Coenzymes: Classification, water-soluble and fat- soluble vitamins, coenzyme forms and their significance.

Unit 2: Analytical Biochemistry 12 hrs

Concept of pH, dissociation and ionization of acids and bases, pKa, buffers and buffering mechanism, Henderson Hasselbalch equation, ionization of amino acids and proteins, measurement of pH. General principle and different types of chromatography, Sedimentation: sedimentation velocity, preparative and analytical ultracentrifugation techniques, differential and density gradient centrifugation, subcellular fractionation. Basic principal of radioactivity, spectrophotometry: Beer-Lamberts law, extinction coefficient and its importance.

Unit 3: Metabolism 10 hrs

Concepts of metabolism (carbohydrate metabolism, lipid metabolism, amino acid metabolism) Metabolic pathways- catabolic and anabolic, regulation of metabolic pathways. Glycolysis; energetic and its regulation; PFK, gluconeogenesis carbohydrate metabolisms: Glycogen biosynthesis and its regulation. Role of enzymes in synthesis and degradation of glycogen, role of cAMP. Citric acid cycle: energetics, regulation and significance, Role of PDH. Electron transport chain and oxidative phosphorylation., biological oxidation, oxidative phosphorylation, Heme metabolism, Purine and Pyrimidine metabolism, acid base balance and disorders detoxification.

Unit 4: Enzymology 12 hrs

Isolation and purification, Classification and nomenclature of enzymes. Enzyme catalysis: enzyme specificity and the concept of active site, determination of active site. Stereo specificity of enzymes. Enzyme kinetics: Factors affecting rates of enzyme catalyzed reactions, unisubstrate reactions, concept of Michaelis - Menten, Briggs - Haldane relationship, Determination and significance of kinetic constants, catalytic rate constant and specificity constant, Limitations of Michaelis-Menten Kinetics. Reversible and irreversible inhibition, competitive, non competitive and uncompetitive inhibition. Mechanism of enzymes action: mechanism of action of lysozyme, chymotrypsin, carboxypeptidase. Multienzyme system, Mechanism of action, regulation and coenzymes of pyruvate dehydrogenase and fatty acid synthetase complexes. Allosteric enzymes.

Unit 5: Nutritional & Clinical Biochemistry 12 hrs

Food calories, Respiratory quotient, Basal metabolic rate, Calorie requirement, Adult consumption unit, Nutritional aspects of Proteins, carbohydrates, lipids, vitamins and minerals. Balance diet. Disorders related to the nutrition -Protein energy malnutrition, Starvation, obesity. Collection and preservation of biological fluids and their significance, chemical analysis of CSF and its significance. Disorders of carbohydrate metabolism (Diabetes, Glycosuria, Glycated haemoglobin, Microalbuminuria), Postprandial and Glucose tolerance test. Biochemical changes in diabetes mellitus, Hypoglycemia, Ketone bodies. Lipids, lipoproteins and apolipoproteins-role in diseases. Structure of Hb, derivatives and abnormal Hb. Detection by spectrophotometry and by fluorescence. Enzymes in differential diagnosis of diseases and their clinical significance. Detoxification, phase I and phase II reactions, Enzymes of detoxification.

Recommended books for reference

1. Lehninger, Nelson and Cox. (2017) Principles of Biochemistry. (12th Ed.) CBS publishers and distributors.
2. Rodwell V, Bender D, P. Anthony Weil, Peter Kennelly and Kathleen Botham (2015) Harper's Biochemistry. (30th Ed.) Appleton and Lange, Stamford, Connecticut.
3. Keith Wilson and John Walker (2000) Principles and techniques of practical biochemistry. Cambridge University Press.
4. Satyanarayan U (2017) Biochemistry. Books & Allied Publisher (p) Ltd.
5. Donald Voet and Judith G. Voet. (2010) Biochemistry. (4th Ed.) John Wiley & sons, Inc.
6. Debjyothi Das (2010) Text Book of Biochemistry. Academic Publishers.

Course Name: CELL AND MOLECULAR BIOLOGY Credits: 4 (56 hours)

Course Code: AP02BS-1C2

CO 1	Appreciate a single cell as a complete system.
CO 2	Understand the sub cellular organelles and the molecular players for sustaining and functioning of the smallest unit- The Cell.
CO 3	Students will be able to understand the importance and maintenance of the genetic material and code through several divisions and the players involved in this function.
CO 4	Concepts of the central dogma will be well developed. They will have a clear idea on replication, transcription and translation, post translation and functionality of the genetic material
CO 5	Understand and differentiate the gene regulation in prokaryotes, viruses and eukaryotic cell and will be able to explain the roles of repressors and inducers in gene regulation
CO 6	Understand the modulation of gene expression via transmission of signal from the receptor to the intracellular regions.

Unit 1: Introduction 10 hrs

The Cell: An overview, cell communication and cellular respiration. Cell membranes and transport. Cell division- Mitosis and Meiosis, Cell cycle- different phases, cell cycle arrest, cytokines, growth factors, apoptosis, necrosis, senescence. Types of cells- stem cells, quiescent cells, cellular differentiation, structural features and characteristics. Sub cellular fractionation, ultra centrifugal analysis, flow cytometry, FISH.

Unit 2: Genome 12 hrs

History of molecular biology. Genome organization: Genome overview at the chromosome level- eukaryotic and bacterial chromosomes, nucleus, nucleolus, centromeres, telomeres, chromatin. Histones and nucleosomes, chromosomes in cell cycle, gene, genome, gene dosage, genome size, repetitive DNA contents of genome, mobile DNA elements. DNA Structure and types, Replication, enzymes and protein factors, cellular control. Cell cycle check points check points (S-phase, G2 phase, M phase), DNA repair, SOS response. Eukaryotic genome C-value paradox, Repetitive DNA, General concept of a gene, Gene families, Non-coding genes, classical experiments in molecular genetics, genetic material, molecular structure of genes.

Unit 3: Transcription and translation 12 hrs

Transcription (prokaryotes and eukaryotes) and its regulation, RNA polymerase, transcription factors (polymerases, p53, IFs, EFs, TRF I, II & III). Differences between prokaryotic and eukaryotic transcription, post transcriptional modification of mRNA, tRNA, rRNA, RNA splicing, spliceosome machinery, types of splicing, exon shuffling, catalytic RNAs, RNA editing. Genetic Code, triplet code, incorporation of novel aminoacids, Translation – initiation, elongation, termination of protein synthesis, components required at each stage, sequence of reaction, inhibitors of protein synthesis, post translational modifications of proteins.

Unit 4: Regulation Gene Expression 12 hrs

Regulation of gene expression in prokaryotes and virus, Bacterial and Viral Genetics, constitutive and inducible enzymes in bacteria, induction and repression Operon model- Lac operon - Tryptophan operon- arabinose operon. Regulatory RNA gene silencing, RNAi, microRNAs, regulation of gene expression in bacteriophage. Regulation of gene expression in eukaryotes, interaction with RNA, DNA binding proteins regulatory transcription factors, Histones acetylation and deacetylation, epigenetic effects. Transport and targeting of RNA, Post-transcriptional gene silencing, Translational control and targeting of protein Mechanism of steroid hormone and stress induced gene expressions.

Unit 5: Cell signalling 10 hrs

Introduction to cell signaling, types of signaling, types of receptors, other function, G protein coupled receptros: Heterotrimeric G protein, Second messengers cAMP, lipid derived second messengers, calcium signaling, Receptor tyrosine kinase (RKT): insulin receptors, General RTK's, Ras and the MAP kinase cascade Integrin signaling and apoptosis, Relationship between signaling pathways.

Recommended books for reference:

1. Alberts A. Johnson, J.Lewis, M. Raff, K.Roberts, and P. Walter (2008) Molecular biology of cell. Garland Science, Taylor & Francis Group.
2. Russell P. J., P.E. Hertz, C. Starr, S. L. Wolfe and B. McMillan (2009) Cell and Molecular Biology. (1st Ed.) Cengage Learning.
3. Wilson K. & J. Walker. (2006) Principle & Techniques of Practical Biochemistry and Molecular Biology. Cambridge University Press.
4. Friefielder D. (1982) Physical Biochemistry: Applications to Biochemistry and Molecular Biology. W. H. Freeman.
5. Walt Ream Katharine G. Field. (1998) Molecular Biology Techniques: An Intensive Laboratory Course. Academic Press.
6. Brown T. A. (2000) Essential Molecular Biology: A Practical Approach, Oxford University Press.
7. Brown T. A (2002) Genomes (2nd Ed.) UK. Oxford: Wiley-Liss.
8. Benjamin Lewin (2014) Lewin's Gene XI. Jones & Bartlett Publishers.
9. Lodish (2016) Molecular Cell Biology (8th Ed.) Macmillan Learning.
10. James D. Watson (2013) Molecular Biology of the Gene (7th Ed.), Harvard University/ Pearson Publishing.
11. Joseph Sambrook. Molecular Cloning: A Laboratory Manual. Cold Spring Harbour Laboratory Press

Course Name: MICROBIOLOGY Credits: 4 (56 hours)

Course code: AP02BS-1C3

CO 1	Able to distinguish between major classes of microorganisms belonging to prokaryotes and eukaryotes
CO 2	To acquire skills in culturing methods, different sterilization techniques and microscopic techniques
CO 3	To know the important metabolic pathways of different groups of microorganisms
CO 4	Able to apply microbial genetics relevant to modern biology and able to assign microorganisms systematically into taxonomical ranks
CO 5	Shall be able to distinguish and demonstrate the beneficial and harmful effect of microorganisms in different fields such as agriculture, medicine and biotechnology

Unit 1: Introduction 10hrs

History and scope of Microbiology: Discovery of micro organisms, Germ theory of diseases, Contributions of Antony van Leeuwenhock, Louis Pasteur, Robert Koch, Edward Jenner, Winogradsky, Beijerink, Alexander Flemming and Anand chakraborty. Ultra structure of prokaryotic cell: Cell wall organization on Prokaryotes, Eukaryotes and Archaea. Different group's microorganism: General characters and reproduction of Bacteria, Fungi, Protozoa, Virus, Mycoplasma.

Unit 2: Growth, Nutrition and Methods of studying microorganisms 12 hrs

Physical and chemical methods of sterilization: Nutritional classification of microorganisms, Types of culture media, Microbial culture techniques, Method of identification, Preservation and Maintenance of microbial cultures, Microbial growth kinetics, Batch and continuous cultures. Measurement of microscopic objects: Principles and working of different types of microscopes and their applications. Biological safety cabinets, Autoclave, Hot air oven Incubator and other important equipments used in standard microbiology laboratory.

Unit 3: Microbial metabolism and Genetics 12hrs

Metabolic diversity of microbes: Classification and types of microbial metabolism. Metabolic Cycles: Aerobic (Glycolysis, The Krebs Cycle, Electron Transport and Oxidative Phosphorylation) and Anaerobic respiration (Fermentation), Alternative metabolic pathways in microorganisms. Microbial Genomes and extra-chromosomal elements (Plasmids and transposons) Mechanisms of Gene Transfer: Transformation, Transduction, Conjugation, Evolutionary Significance of gene transfer.

Unit 4: Microbial Taxonomy 12hrs

Systematic position of microorganisms in the living world, Basic classification of Bacteria, Fungi (Alexopoulos) and Virus (Baltimore), Nomenclature rules, taxonomic ranks. Major characteristics used in identification: Morphological, physiological, biochemical, ecological, genetic and molecular. Numerical taxonomy. Historical account of bacterial, viral and fungal classification. Detailed account of bacterial classification according to the Bergey's Manual of Systematic Bacteriology.

Unit5: Beneficial and Harmful Effects of Microbes 10hrs

Beneficial role of microbes in Agriculture: Nitrogen-fixing bacteria, Mycorrihiza, Biocontrol agents, Biofertilizers. Role of microbes in Food and Industry: Fermentation processes, Major industrial products from microbes: Beverages, Secondary metabolites and Recombinant products, Role of microbes in Environment problems and biotechnological application of microbes in extreme environments. Microbes and Infectious diseases, Bacterial, fungal, viral and protozoans pathogens and emerging infectious diseases, Important Human diseases caused by Microbes: bacterial, fungal, viral and emerging infectious diseases. Animal diseases caused by Microbes (Anthrax, Bovine tuberculosis, Foot and Mouth Disease, Avian Influenza, Mycosis). Plant diseases disease caused by Microbes (blight, wilt, crown gall, canker, damping off, mildew, rust and mosaic).

Recommended books for reference:

1. Prescott, L. M., Harley, J. P and Klein, D.A, (2017) Microbiology (10th Ed.), McGrow Hill Publications
2. Madigan, M. T., Mrtinko, J. M. and Parker, J. (2017) Brock Biology of Microbiology (15th Ed.), Prentice Hall International, Inc.
3. Ananthanarayanan R. and Jayaram Paniker C. K (2009) Textbook of Microbiology (6th Ed.) Orient Lomgman.
4. Jacquelyn Black and Laura J. Black (2014). Microbiology: Principles and Explorations (9th Ed.) Wiley publications.
5. Dubey, R. C and Maheshwari, D. K (2005) A text book of Microbiology (2nd Ed.), S. Chand and Company Ltd.
6. Dubey, R. C. (2014) A text book of Biotechnology (5th Ed.), S Chand and Company Ltd.
7. Michael J. Pelczar, Noel R. Krieg, Chan E.C.S and Krei N. R (1993) Microbiology, McGraw Hill, New York.
8. Gerard J. Tortora, Berdell R. Funke and Christine L. Case (2018) Microbiology: An Introduction, Benjamin-Cummings Publishing Company.
9. Logan, A. and Niall A. Logan (1994) Bacterial Systematics, Wiley-blackwell.
10. Albert G. Moat and John W. Foster (2002) Microbial Physiology (3rd Ed.), John Wiley and Sons.
11. Atlas R. M. and Bartha R. (2002) Microbial Ecology, Benjamin Cummings Publishing Co, Redwood City, CA.
12. Mitchel R. (2009) Environmental Microbiology (2nd Ed.), Wiley-Blackwell.
13. George N. Agrios (2005) Plant pathology (5th Ed.), Academic press, NewYork.
14. Crueger W. and Crueger A. (2000) Biotechnology: A Text Book of Industrial Microbiology, Panima Publishing Corporation, New Delhi.
15. Mansi E. L. and Bryce. (2007) Fermentation Microbiology and Biotechnolog, Taylor &Francis, London, Philadelphia.
16. Stanbury, P. F, Whitaker W. and Hall, S. J. (1997) Principles of Fermentation Technology, Aditya Books (P) Ltd., NewDelhi.
17. Okafer N. (2007) Modern Industrial Microbiology & Biotechnology, Scientific Publishers, Enfield, USA.
18. Michael P. Doyle, Larry R. Beuchat and Thomas J. Montville (2001) Food Microbiology: Fundamentals and Frontiers (2nd Ed.), ASM press.
19. Larry Snyder and Wendy Champness (2007) Molecular Genetics of Bacteria (3rd Ed.), ASM press.
20. William C Frazier and Dennis C Westoff (2004) Food Microbiology (5th Ed.), McGraw-Hill Education.
21. Stanier, R.Y, Ingraham J. L, Wheelis M. L and Painter P. R (2005) General Microbiology (5th Ed.) McMillan.
22. Srivastava S and Srivastava P. S Kluwer (2003) Understanding Bacteria, Academic Publishers, Dordrecht.

Course Name: GENETICS Credits: 4 (56 hours)

Course Code: AP02BS-1C4

CO 1	Understand model systems for genetic studies. Learn about transmission genetics, mutations & chromosomal aberrations.
CO 2	Learn Human molecular genetics, historical facts, genome analysis and mapping, mutations, transgenics.
CO 3	Learn about the Genetics of diseases, Cytogenetics, Syndromes, Prevalence, Epigenetics, Theranostics.
CO 4	Learn about Population quantitative genetics, Genetic variation, Allele frequency, Genetic Drift, Hardy Weinberg, Migration
CO 5	Appreciate Diagnostics genetics, Genetic inheritance, variation at genetic level, pedigree, forensics, treatment options.

Unit 1: Transmission Genetics 10 hrs

Model systems in Genetic Analysis (Bacteriophage, E. coli, *Neurospora crassa*, yeast, Arabidopsis, maize, Drosophila, *C. elegans*, Zebra fish, mouse, Homo sapiens-general outline of life cycle, importance in Genetic analysis), Laws of inheritance, Allelic and non-allelic interactions, autosomal, Sex-linked inheritance, non- Mendelian inheritance, Cytoplasmic inheritance, Mutation (Classification, mechanism, repair, roleingenetic analysis and evolution) Changes in Chromosome number and structure (Polyploidy, aneuploidy, chromosomal rearrangements - deletion, duplication, inversion, and translocation. Properties and evolution of genetic material, flow of genetic information.

Unit 2: Molecular and Human Genetics 12 hrs

Introduction to Human Genetics (History; Early perception, development and documentation; Genome organization; Chromosome structure, function and implications for disease), Study tools in Human Genetics: Mendelian inheritance and exceptions; Gene identification using positional and functional cloning approach. Chromosomal analysis (in vitro, in vivo), Biochemical analysis; Somatic cell genetics (somatic cell hybrids, monochromosome hybrid panels, gene mapping); Molecular genetic analysis. Human genome analysis: Conception, mapping, cloning and sequencing, Outcome-Generation of 'OMICS' era, significant leads. Human genome mapping methods: Physical mapping: Introduction to physical map markers-Chromosomal, G/Q-banding, radiation hybrid mapping. Functional genomics and animal models in human disease: An overview; cDNA/gene cloning; site-directed mutagenesis; mammalian tissue culture; cell line transfections; functional assays; Use of model organisms, methods for generation of transgenic animals/knock-in, knock out models (microinjection, ES cell transformation); ENU mutagenesis; RNAi approach; Some examples.

Unit 3: Genetic Diseases 12 hrs

Congenital and common genetic diseases, prevalence and databases. Common syndromes due to numerical chromosome changes (Downs, Patau, Edwards, Turner, Klinefelter, Jacobs syndromes), Common syndromes due to structural alterations (translocations, duplications, deletions, microdeletion, fragilesites). Genetic variation in health and disease. Pedigree analysis,

Positional/structural and functional cloning; Diseases and disorders: Structural and numerical; Autosomal/sex chromosomal/sex reversal; Mechanisms – mitotic/meiotic non-disjunction/chromosomal rearrangements; Some examples (Syndromes/Cancer/Infertility); Single gene and disease: In born errors of metabolism, Haemoglobinopathies; Multifactorial disorders: Introduction; Methods of study (Epidemiological, Twin/adoption andFamilystudies);Etiology-genetic and non-genetic determinants; Common examples. Epigenetics and disease: Mechanisms (Imprinting/methylation; chromatin remodeling); Current understanding; examples. Mitochondrial myopathies. Personalised medicine/Theronostics, Pharmacogenomics

Unit 4: Population Genetics 12 hrs

Variation at the genetic level: DNA markers-VNTR, STR, microsatellite, SNP and their detection techniques-RFLP, genotyping, RAPD, AFLP etc. Organization and measure of genetic variation: Random mating population, Hardy-Weinberg principle, complications of dominance, special cases of random mating–multiplealleles, different frequencies between sexes (autosomal and X-linked). Linkage andlinkage disequilibrium. Sources responsible for changes in gene frequencies: Mutation, selection, migrationand isolation; random genetic drift; insights into human migration, natural selection and evolution. Population substructure: Hierarchical population, isolate breaking, Inbreeding, Assortative mating. Quantitative Genetics: Johannsen pure-line theory, multiple factor hypotheses, type of quantitative traits, components of phenotypic variation and genetic models for quantitative traits, concept of heritability, artificial selection and realized heritability.

Unit 5: Medical Genomics 10 hrs

Identification and Isolation of disease genes: Single gene disorders- conventional and contemporary methods: Characterisation; Mutation detection, diagnosis and therapy (with examples from autosomal dominant, autosomal recessive, X-linked dominant, X-linked recessive and complex disease conditions); Multifactorial disorders: Familial forms- Linkage analysis, Candidate gene identification; Genetic polymorphism and disease susceptibility; Sporadic cases- Association studies- markers from candidate gene/pathways; whole genome association (Single nucleotide polymorphism, CNVs); Gene dosage, gene amplification, molecular combing /fibre analysis. Diagnostic genetics: Cytogenetics/ Molecular Cytogenetics/Biochemical/Molecular methods; Screening for mutation/ chromosomal anomaly - Adult/Prenatal/Newborn screening; Preimplatation screening (Assisted reproductive technology-in vitro fertilization and Embryo transfer); Fluorescence in-situ hybridization, comparative genome hybridization Forensic testing - DNA fingerprinting, paternity testing, individual identification. Treatment of genetic disorders: Methods of therapy - Drug (recombinant proteins);Diet; Gene (Viral vectors, delivery methods, efficacy); Some examples (Thalassemia, Phenylketonuria, Cysticfibrosis, DMD etc). Genetic counselling.

Recommended books for reference:

1. Strickberger (2015). Genetics. (3rd Ed.) Pearson publications, India.
2. Gangane (2017). Human Genetics. Elsevier publications.
3. Gardner , Simmons and Snustad (2006) Principles of Genetics. John Wiley&Sons, Inc.
4. Benjamin Pierce (2016) Genetics: A Conceptual Approach. W. H. Freeman, New York, NY.
5. Klug, Cummings, Spencer and Palladino (2015) Concepts of Genetics. Pearson publications.
6. T. A. Brown (2016) Gene Cloning and DNA Analysis: An Introduction (7th Ed.) Wiley-Blackwell.
7. James D. Watson, A. Baker Tania, P. Bell Stephen and Gann Alexander (2016) Molecular Biology of the Gene (7th Ed.) Wiley-Blackwell.

8. Jocelyn E. Krebs, Elliott S. Goldstein and Stephen T. Kilpatrick (2017) Lewin's GENES XII (12th Ed.) Jones & Bartlett Learning.
9. T. A. Brown (2017) Genomes (4th Ed.) Garland Science.
10. Russell (2016) iGenetics: A Molecular Approach Mass Market (3rd Ed.) Pearson.
11. Peter Turnpenny (2017) Emery's Elements of Medical Genetics (11th Ed.) Churchill Livingstone.
12. Daniel L. Hartl (1999) A Primer of Population Genetics (3rd Ed.) Sinauer Associates.
13. Sean B. Carroll, John Doebley, Anthony J.F. Griffiths and Susan R. Wessler (2015) An Introduction to Genetic Analysis (11th Ed.) W. H. Freeman.
14. R P Meyyan , L M Narayanan, A M Selvaraj , Padmalatha Singh and N Arumugam A Mani (2014) Genetics and Genetic Engineering (1st Ed.) Oxford University Press.
15. D. Cutter (2019) A Primer of Molecular Population Genetics (5th Ed.) Sinauer Associates.

PRACTICAL PAPERS

Course Name: BIOCHEMISTRY Credits: 2 (56 hours)
Course code: AP02BS-1C5

SL. No	Laboratory Exercises:	Hours
A.	Qualitative Experiments	
1	Reactions of carbohydrates, proteins and lipids	8
2	Reactions of non-protein nitrogenous (NPN) substances	4
3	Identification of substances of physiological importance	4
4	Qualitative analysis of normal urine	4
5	Analysis of urine for abnormal constituents	4
B.	Quantitative experiments	
1	Estimation of blood sugar and blood urea	4
2	Estimation of serum inorganic phosphate, total serum protein and albumin	4
3	Estimation of urine creatinine	4
4	Paper chromatography	4
5	Glucose tolerance test	4
5	Fractionation of total lipid (glycolipid, neutral lipid and phospholipid) by column chromatography	4
6	Determination of enzyme activity: malate dehydrogenase and catalase activities	4
7	Study of enzyme kinetics, K_m and V_{max} for enzyme	4

Course Name: CELL AND MOLECULAR BIOLOGY Credits: 2 (56 hours)
Course Code: AP02BS-1C6

SL. No	Laboratory Exercises:	Hours
1	Microscopy: Parts of phase contrast microscope and its Maintenance.	4
2	Study the cells under phase contrast microscope.	4
3	Density gradient separation of human blood cells.	4
4	Different staining techniques for cells DAPI Staining and Giensa staining, staining of actin/microtublues	8
5	Isolation of DNA from cultured cells and its quantification	4
6	Isolation of RNA from cultured cells and quantification	8
7	Agarose Gel Electrophoresis for the separation of DNA	8
8	Design of primers and PCR analysis	8
9	Southern, and Northern Blotting	8

Course Name: MICROBIOLOGY Credits:2(56hours)

Subject code: AP02BS-1C7

Sl. No	Laboratory Exercises:	Hours
1	Safety and occupational Health in a Microbiology Laboratory; Principles of safety; safety cabinets–use and maintenance; Incident report and action	4
2	Isolation and cultivation of microorganisms: A) Serial dilution, spread and pour plate methods B) Mixed culture and pure cultures	4
3	Isolation and culturing from soil/water/food and other samples A) Bacteria, B) Fungi (yeasts, molds and macofungi)	8
4	Staining techniques for bacteria –Simple, differential, special staining and fungal staining	4
5	Laboratory identification of bacteria of clinical importance: Gram Positive cocci; Gram negative bacilli; Gram positive bacilli	4
6	Antibiotic sensitivity and MIC testing Kirby-Bauer Disc diffusion method Broth micro-dilution test for MIC	8
7	Evaluation of bacterial growth in liquid media: Sigmoid curve and Diauxic growth curve	4
8	Anaerobic culture techniques	4
9	Culturing of fungi of industrial importance and downstream processing of the metabolite	4
10	Extraction of genomic DNA and PCR amplification of 16S rRNA	8
11	Extraction of plasmid from bacteria	4

Course Name: GENETICS Credits: 2 (56 hours)

Course Code: AP02BS-1C8

SL. No	Laboratory Exercises:	Hours
1	Study of mitosis and meiosis	4
2	Cytogenetics – study of chromosomes, sex chromatin in somatic cells, barr body analysis in cheek epithelium.	4
3	Metaphase preparation and Karyotyping.	8
4	Genetic model organism: Budding yeast (*Saccharomyces cerevisiae*) Life cycle, genetic experiments, crossing over, segregation of genes through tetrad.	4
5	Generation of mutations by insertion and deletion in yeast.	8
6	Mendelian genetics: monohybridism, Dihybridism and Polyhybridism.	4
7	Determining the segregation of trait through Chi Square Test (use in genetics).	4
8	Branching methods: determining the segregation of traits through Punnett Square.	4
9	Analyzing the segregation pattern of polymorphic genes and gene interactions	4
10	Inheritance: sex linked, genetic linkage	4
11	Population genetics: determining allele frequency, genotype frequency, Hardy-Weinberg equilibrium with two or multiple alleles.	4
12	Quantitative genetics: Analyzing the inheritance of quantitative traits.	4

SEMESTER-II Scheme and Courses

Course code	Type of Course	Course name	Hrs/ Week	Credits
AP02BS-2O1	Open Elective	Environment and Health	3	3
AP02BS-2C1	Core -Theory	Nanobiotechnology	4	3
AP02BS-2C2	Core - Theory	Stem cell and Developmental Biology	4	4
AP02BS-2C3	Core- Theory	Immunology	4	4
AP02BS-2C4	Core- Theory	Toxicology	3	4
AP02BS-2C5	Core -Practical	Nanobiotechnology and Toxicology	4	2
AP02BS-2C6	Core -Practical	Stem Cell and Developmental Biology	4	2
AP02BS-2C7	Core - Practical	Immunology	4	2
Total				24

Course Name: ENVIRONMENT AND HEALTH Credits: 3 (42 hours)

Course Code: AP02BS-2O1 (Open elective)

CO 1	To understand environment, biodiversity and natural resources
CO 2	To understand biodiversity, biogeochemical cycle, natural resources and impact of toxicants on health and environment
CO 3	To know different types of air pollutants and associated health risks
CO 4	To describe sources and types of water pollution, epidemiology, infectious diseases and water treatment technology

Unit 1: Fundamentals of Environmental Health 12 hrs

Global environmental change: an introduction, Health Risks of Biodiversity loss, Human impact on environment, Basic concept in Environmental Toxicology, Environmental pollution; solid waste and hazardous waste, Biogeochemical cycle and Health impacts, Environment-human interaction: Important environmental toxicants: Pesticides, Heavy metals, Organic pollutants, Endocrine disruptor, Carcinogenesis, mutagenesis and genotoxicity, Ionizing and Nonionizing Radiation. Environmental and biological indicators, Natural resources, conservation and sustainable development. Flouride and thoron toxicity, health impact

Unit 2: Air pollution and health 10 hrs

Chemical composition of Air: Classification of elements, Impact of air quality, aeroallergens and degraded air quality, respiratory diseases, Thermochemical and photochemical reactions in the atmosphere. Global warming and climate change, Stratospheric ozone depletion and Public Health, Photochemical smog. Air pollution, Climate change epidemiology: Problems and Challenges, Health exposures: weather, climate variability, Indoor and outdoor air pollution: Thermal extremes and their health impacts.

Unit 3: Water pollution and health 10 hrs

Types, sources and consequences of water pollution. Physico-chemical and Bacteriological sampling and analysis of water quality. Water quality standards. Environmental Epidemiology, Infectious

diseases: Climate and Its Impacts on Vector-Borne and Zoonotic Diseases, Food security: Challenges of Climate Change to Food Security, Safety, and Nutrition, Food- and water-borne diseases. Sources of marine pollution and control. Criteria employed for disposal of pollutants in marine system–coastal management. Biotechnological approaches and steps involved in conventional and advanced water treatment technology.

Unit 4: Land pollution and health 10 hrs

Physico-chemical and bacteriological assessment of soil quality, Soil pollution, Industrial waste effluents and heavy metals, their interactions with soil components. Different kinds of synthetic fertilizers and their interactions with different components of soil. Effects of mercury, lead, chromium, cadmium, arsenic and nitrate on human health. Radioactive pollution. Microbiological management of hazardous waste and wastelands, Biomagnification, Bio-degradation of different insecticides, fungicides and weedicides in soil. Environmental laws

Recommended books for reference

1. Koren H and Bisesi M. S (2011) Handbook of Environmental Health. (4th Ed.) CRC Press.
2. Spellman F. R and Bieber R. M. (2012) Environmental Health and Science Desk Reference. The Scarecrow Press, INC.
3. Robert Friis (2007) Essentials of environmental health. Jones and Bartlett Publishers.
4. Howard Frumkin (2016) Environmental Health: From Global to Local. (3rd Ed.) John Wiley & Sons
5. Koren H. (1980) Handbook of environmental health and safety: principles and practices. Pergamon Press Inc., New York.
6. Battersby S (2016) Clay's handbook of environmental health. Routledge.
7. Brunner R. C (1989) Hazardous Waste Incineration. McGraw Hill Inc.
8. Trivedi R. K (2010) Handbook of Environmental Laws, Rules Guidelines, Compliances and Stadards, Vol I and II. Enviro Media (R).

Course Name: NANOBIOTECHNOLOGY Credits: 3 (42 hours)

Course Code: AP02BS-2C4

CO 1	Understanding the concept of nanomaterials and their preparative methods
CO 2	To acquire knowledge on polymeric science
CO 3	Understanding the polymer synthesis using different polymerization techniques
CO 4	Gain a knowledge on chemical characterizations of bio/polymeric nanomaterials using different analytical techniques
CO 5	Understanding the biological application of nanomaterials for drug development

Unit 1: Introduction to nanomaterials 8hrs

Nanotechnology -history and scope-nanosize and properties-classification of nanostructured materials-bio nanotechnology-biological and biomimetic nanostructures-functional biological nanomaterials-impact of nanotechnology on medicine-medical nanotechnology-nanomedicine.

Unit 2: Synthesis of nanomaterials 8hrs

Synthesis of nanomaterials: physical methods-high energy ball milling-mechanical, evaporation-sputterdeposition-chemicalvapourdeposition-electricarc deposition. Chemical methods; synthesis of nanoparticles by colloidal route-microemulsion-sol-gel method-hydrothermal process-sonochemical synthesis-chemical precipitation-microwave synthesis and pyrolysis. Biological methods; synthesis using microorganism-plant extracts-use of protein and template like DNA.

Unit 3: Characterization Techniques for nanomaterials 8hrs

UV-Visible spectroscopy-fourier transform infrared spectroscopy-fluorescence spectroscopy-differential thermal analysis-thermo gravimetric analysis-dynamic light scattering-X-ray diffraction-X-ray photoelectron spectroscopy-atomic force microscopy-field emission scanning electron microscopy-transmission electron microscopy-energy dispersive X-ray diffraction.

Unit 4: Biomacromolecules 10hrs

History of macromolecular science and concept of macromolecules; Basic concepts in polymer science-classification-monomer structure and polymerizability-concept of functionality-measurement of molecular weight and size-degree of polymerization-molecular weight distribution and polydispersity-biodegradable and water soluble polymers-polymer nanogels-bioresponsive polymers and natural biopolymers.

Unit 5: Use of nanomaterials 8hrs

Fundamentals of nanotechnology in bio sensing-cosmetics-imaging-drug delivery system for small molecules and proteins-tissue repair-antibacterial-antifungal-antiviralagents-biopolymersinmedicine-role of nanotechnology in environmental applications and toxicity.

Recommended books for reference:

1. Shastri V. P., Altankov, G., Lendlein, A. (2010) Advances in Regenerative Medicine: Role of Nanotechnology, and Engineering Principles. (1st Ed.) Springer.
2. Harry F. Tibbals. (2010) Medical Nanotechnology and Nanomedicine. (1st Ed.) CRC Press.
3. Mark A. Ratner and Daniel Ratner (2003) Nanotechnology: A Gentle Introduction to the Next Big Idea. Pearson education Inc.
4. C. N. R. Rao, A. Mu Ï ler, A. K. Cheetham (2004) The Chemistry of Nanomaterials: Synthesis, Properties and Applications. (Volume 1) Wiley-VCH, Verlag GmbH, Germany.
5. Zhongwei Gu (2015) Bioinspired and Biomimetic Polymer Systems for Drug and Gene Delivery. Chemical Industry Press and Wiley-VCH Verlag GmbH & Co. KGaA.
6. Rob Burgess (2012) Understanding Nanomedicine: An Introductory Textbook (1st Ed.) CRC Press, Singapore.
7. Sulabha K. Kulkarni (2009) Nanotechnology; Principals and Practices, Capital Publishing company, New Delhi.
8. Michael Stroscio and Mitra Dutta (2004) Biological Nanostructures and Application of Nanostructures in Biology. Kulwer Academic Publishers.
9. Elisabeth S. Papazoglou and AravindParthasarathy (2007) BioNanotechnology (1st Ed.) Morgan & Claypool Publishers' series.
10. David S. Goodsell (2004) Bionanotechnology. John Wiley & Sons, Inc, Publication.
11. Krzysztof Matyjaszewski and Thomas P. Davis. Hand book of radical polymerization. Wiley Publications.

Course Name: STEM CELLS AND DEVELOPMENTAL BIOLOGY Credits: 4 (56 hours)
Course Code: AP02BS-2C2

CO 1	Appreciate the mammalian developmental biology in the right perspective
CO 2	Understand the importance of energetics in mammalian development
CO 3	Understand the cellular potencies
CO 4	Understand the regenerative potential and translational aspect using regenerative stem cells and for cancer therapeutics
CO 5	Global and National ethics involving various kinds of stem cell research and therapeutics

Unit 1: Introduction, origin of stem cells and types 12hrs

Developmental biology-Historical perspective. Mammalian development with special emphasis on mouse and human developmental biology, pre-embryonic development, patterning of vertebrate development, axis and body plans, development of germlayers. Development with special emphasis to neuroectodermal, mesodermal and endodermal specification during pre-embryonic mammalian development. Mechanism of differentiation and cross-talk between various cell lineages during mammalian development. Diversification of potency of stem cells during mammalian development. Concepts of regenerative and cancer stem cells in correlation to development and/or developmental imbalance, pre-and postembryonic.

Unit 2: Stem Cell metabolism, Metabolic differences between somatic cells, stem cells and cancer cells, Stem Cell Energetics 10 hrs

Cellular metabolism in mammalian system. ROS generation and management by somatic versus stem cells. Cellular imbalance in relation to oxidative stress in cancer cells, somatic cells and stem cells. Oxidative phosphorylation versus glycolysis, stem cell energetic.

Unit 3: Basics and applications of stem cells 12 hrs

Embryonic stem cells-historical perspective.Induced pluripotent stemcells as groundbreaking discovery. Adult stem cells-historical perspective. Research using embryonic stem cells and its advantages and disadvantages. Research using adult stem cells and its advantages and disadvantages.

Unit 4: Clinical applications and status of clinical research/trials using regenerative stem cells: embryonic/pluripotent and adult stem cells; Regenerative stem cell based cancer therapeutics 10hrs

Status of research for regenerative applications using regenerative stem cells. Status of pre- clinical and clinical trials using regenerative stem cells. Principles of Cancer therapeutics using regenerative stem cells. Status of pre-clinical and clinical trials for cancer therapeutics using regenerative stem cells.

Unit 5: Ethical considerations for the research and clinical use of various kinds of stem cells

12hrs

Need for ethical considerations for research and clinical use of various kinds of stem cells. Regulatory requirements as per Indian and global standards for carrying out stem cell research. Regulatory requirements for clinical use of stem cells as per Indian and global standards, introduction to c-GMP facility, overview of various stem cell products Safety issues related to various stem cell therapies. Stem cell banking, informed consent and regulatory issues. Stem cell products obtained from pluripotent stem cells, adult stem cells for regenerative applications versus applications for cancer therapeutics-Similarities, differences and ethical considerations

Recommended books for reference:

1. William (2002) Stem Cells from a Biological Perspective: What They Are, Where They Are Found, and What Can Be Done with Them. Vol. 65. Springer.
2. Cohen (2007) Renewing the Stuff of Life: Stem Cells, Ethics, and Public Policy. Oxford University Press.
3. Tomizawa (2016) Pluripotent Stem Cells - From the Bench to the Clinic. Edited by Minoru Tomizawa.
4. Demirer (2015) Progress in Stem Cell Transplantation, Edited by Taner Demirer.
5. Wislet-Gendebien (2014) Adult Stem Cell Niches, Edited by Sabine Wislet-Gendebien.
6. Atwood and Meethal (2014) Pluripotent Stem Cell Biology - Advances in Mechanisms, Methods and Models, Edited by Craig S. Atwood and Sivan Vadakkadath Meethal.
7. Bhartiya and Lenka (2013) Pluripotent Stem Cells, Edited by Deepa Bhartiya and Nibedita Lenka.
8. Alimoghaddam (2013) Stem Cell Biology in Normal Life and Diseases, Edited by Kamran Alimoghaddam.
9. Bonfanti (2013) Neural Stem Cells - New Perspectives, Edited by Luca Bonfanti.
10. Gilbert and Singer (2006) Developmental Biology (8^{th} Ed.) Sinauer Associates Inc., U.S.A.

Course Name: IMMUNOLOGY Credits: 4 (56 hours)
Course Code: AP02BS-2C3

CO 1	Understanding of the various component of immune system
CO 2	Familiarization with mechanism of immune system and its regulation
CO 3	Be competent to interpret the importance of immunological response
CO 4	Familiarization with various animal models used for immunological studies
CO 5	Familiarization with various immunological techniques

Unit 1: Introduction to Immune system 10 hrs

Introduction to immune system, Cells, Organs and Tissues of immune system. Types of Immunity - Innate immunity, Acquired immunity, Mechanisms of barrier to entry of microbes/pathogens (Protective and Destructive), Antibodies. Complement system, T Cell Receptors and MHC Molecules

Unit 2: Immune Effecter mechanism 13 hrs

Hematopoiesis and its regulation, Cytokines in immunity, interferons, interleukins, tumor necrosis factors, Transforming Growth Factor, chemokines and adhesion molecules. Complement system (classical and alternative pathways), (Cytotoxic T cells, Natural Killer Cells, ADCC, NK cell receptors, inverse correlation with target MHC expression, missing self hypothesis, cytotoxicity reaction), leukocyte activation and migration, phagocytosis and microbicidal mechanisms. Hypersensitivity. Immediate hypersensitivity. Asthma. IgEreceptor, prostaglandins and leukotrienes. Antibody structure and function, antibody mediated effector functions, antibody classes and biological activities monoclonal antibody, immunotoxins, abzymes.

Unit 3: Cell mediated immunity 12 hrs

Antigens, antigenicity, and immunogenicity. B and T cell epitopes. Generation, activation and differentiation of B-lymphocyte, Immunoglobulin superfamily, Expression of Immunoglobulin genes (Genetic model compatible with immunoglobulin structure, Antibody diversity, VDJ recombination, class switching of Ig).Antigen-Antibody reactions, Major Histocompatibility Complex(genetic organization of H2 and HLA complexes. Class I and class II MHC molecules, structure and function), Differentiation and activation of B cells,BCR and pre BCR, receptor editing, T cell help , T-cell receptor, Antigen processing andpresentation and T-cell antigen recognition. T-cell maturation, activation and differentiation,Th1/Th2 cells and cytokines. – Applications in Diagnostics.

Unit 4: Immune system in health and disease 11 hrs

Auto immunity and immunodeficiency, molecular mimicry, immune therapy, Tumor and Transplant immunology, Parasitic immunology, Phage display, Animal models and transgenic animals and their use in immunological studies. Routes of Inoculation Transgenic animals, Experimental immunology: Vaccine development (Recombinant, Combined and polyvalent vaccines) Immuno- diagnostics, CarT cell therapy and dendritic cell vaccines.

Unit 5: Immunological Techniques10 hrs

Hybridoma, monoclonal antibodies, and antibody engineering Antibody(mAb, pAb), Chimeric antibodies, Evaluation of immune response by using ELISA, RIA, Western blot, immunoprecipitation, flowcytometry, immunofluorescence, Qualitative, quantitative and kinetic modes of expression: Real-time PCR, Microarray, Immune-seq.

Recommended books for reference:

1. Delves, P., Martin, J.S., Burton, R.D., and Roitt, M.I. Roitt's Essential Immunology.
2. Janeway, C. Immunobiology: The immune system in health and disease.
3. Owen, J., Punt, J., and Stranford, S. (2013). Kuby Immunology, International Edition.
4. Paul, W.E. (2012). Fundamentals of Immunology. (7^{th} Ed.).
5. Peter J. Delves, Seamus J. Martin, Dennis R. Burton, Ivan M. Roitt (2017) Roitt's Essential Immunology. (13^{th} Ed.) Wiley Publications.
6. Relevant review articles/research papers/handouts provided during the course.

Course Name: TOXICOLOGY Credits: 4 (56 Hours)

Course code: AP02BS-2C1

CO 1	Learn the basic concepts, different forms of toxicity and biotransformation mechanisms
CO 2	Describe common pollutants and their mechanism of action
CO 3	Know the key concepts of pharmacokinetics and pharmacodynamics, also understand the various form of drug toxicity
CO 4	Assess the applications of toxicology in various fields - Food toxicology, Forensic toxicology, Cosmetic toxicology and Occupational toxicology
CO 5	Understand the various techniques of toxicity evaluation and learn the guidelines for regulatory requirements

Unit 1: Introduction to Toxicology 14 hrs

History, introduction, basic principles and scope of toxicology. Dose response relationships LD50, ED50, LC50, EC50. General mechanisms of toxicity. Disposition oftoxicants- adsorption, distribution and elimination of toxicants. Biotransformation of xenobiotics- basic properties, categories and distribution of xenobiotic biotransforming enzymes. Risk Assessment (Hazard Identification, Dose Response Assessment). Determination of harmful effects of chemicals, adverse effects of chemicals, understanding the fate ofchemicals.

Unit 2: Health effects and indicators of toxic agents 12 hrs

Toxic agents: toxic effects of pesticides and metals with special reference to DTT, lindane, cyclodienes, lead, arsenic, mercury, cadmium, aluminium. Health effects of radiation and radioactive materials. Important radiation episodes. Bioindicators: Overview of bioindicators – theory, practices and problems; biondicators of air, water and soil pollution. Biomonitoring of heavy metals, biomontoring of air pollution around urban and industrial sites; organisms used as indicator of population.

Unit 3: Drugs interactions and toxicity 14 hrs

Classification of drug interaction, Drug interactions with vitamins (interactions of retinoids with Vitamin A , levodopa with Vitamin B6 , warfarin with vitamin E and vitamin K , methotrexate with folic acid), Drug interactions with minerals (interactions of tetracyclins and fluoroquinolones with calcium, aluminium and magnesium, methyldopa and proton pump inhibitors with iron, angiotensin receptor blockers and diuretics with potassium). Drug-nutrient interactions - Mechanism based classification system (ex-vivo bioinactivations, absorption phase associated interactions, physiological action associated interactions, elimination phase associated interactions). Drug- dietary supplement interactions (interactions of coenzyme Q10, fish oil and herbal supplements with drugs) Drug toxicity – Mutagenecity, teratogenecity and carcinogenicity

Unit 4: Applications in various fields 10 hrs

Food toxicology: Introduction, safety standards for food, food ingredients and contaminants. Forensic toxicology: analytic role, toxicologic investigations of poison death, criminal poisoning of

the living. Clinical toxicology: strategy for treatment of the poisoned patient. Cosmetic toxicology: introduction. Occupational toxicology: introduction, occupational diseases, worker health surveillance, exposure monitoring.

Unit 5: Toxicity evaluation and guidelines 6 hrs

Various techniques for toxicity evaluation (in vitro, in vivo, molecular, epidemiological): Assessment of genetic toxicity (COMET assay, micronucleus assay), in vitro toxicity assays (MTT assay, Neutral red uptake assay), carcinogenicity (transgenic mice models, initiation/promotion models) and mutagenecity testing (Ames test, mouse lymphoma thymidine kinase assay). OECD Guidelines for the Testing of Chemicals

Recommended books for reference:

1. Barile, F.A. (2010). Clinical Toxicology. Principles and mechanisms. (2nd Ed.) CRC Press, London.
2. Calow, P. (1994). Handbook of Ecotoxicology. Blackwell Scientific Publications, London.
3. Chatterji, M., M.Munasinghe, and Ganguly, R. (1998). Environment and Health in Developing Countries. A.P.H. Publishing House, New Delhi.
4. Forbes, V., and Forbes, T. (1994). Ecotoxicology in Theory and Practice. Chapman & Hall, London
5. Hayes, W. (2001). Principles and Methods of Toxicology. CRC press, USA.
6. Jacobson, and Kram, D. (2006). Toxicological testing handbook: Principles, Applications and Data Interpretation. Taylor and Francis, New York.
7. Klaassen, C.D., and Watkins, J.B. (2015). Casarette and Doull'sEssentials of Toxicology. (3rd Ed.) McGraw-Hill Professional, New Delhi.
8. Levin, S.A., Harwell, M.A., Kelley, J.R., and Kemball, K.D. (1989). Ecotoxicology: Problems and Approaches. Springer-Verlag, New York.
9. Li, A. (1997). Drug-Drug interactions: Scientific and regulatory perspectives. (1st Ed.) Academic Press.
10. Manahan, S.E. (2000). Environmental Chemistry. Lewis Publishers, New York.
11. Pery, G. (1980). Introduction to Environmental Toxicology. Elsevier, Amsterdam.
12. Walker, C.H., Sibly, R.M., Hopkin, S.P., and Peakall, D.B. (2012). Principles of Ecotoxicology. CRC Press, New York.
13. Wright, D.A., and Welbourn (2002). Environmental Toxicology. Cambridge University Press, London.

Practical Papers

Course Name: NANOBIOTECHNOLOGY AND TOXICOLOGY Credits: 2 (56 hours)
Course code: AP02BS-2C5

SL. No	Laboratory Exercises:	Hours
1	Fabrication of nanomaterials	4
2	Synthesis of nanoparticles using biological processes	4
3	Detection of nanoparticles in colloidal solutions using UV-vis absorption technique.	4
4	Radical polymerization of functional monomers	4
5	Synthesis of bioresponsive polymers	8
6	Fabrication of bio-nano composites	4
7	Fluorescent nanomaterials for bioimaging	4
8	Cytogenetic evaluation of chromosomal damage (Chromosomal Aberration Test)	8
9	Chemical toxicity: Micronucleus assay	4
10	Toxicity of nano materials	4
11	Estimation of chlorine in drinking water	4
12	OECD guidelines and Safety evaluation	4

Course Name: STEM CELLS AND DEVELOPMENTAL BIOLOGY Credits: 2 (56 hours)
Course code: AP02BS-2C6

SL. No	Laboratory Exercises:	Hours
A.	**Cell culture experiments**	
1.	Basic mammalian stem cell culture-Media preparation	4
2.	Thawing and Seeding of cells and Cell passaging	8
3.	Cell counting	4
4.	Isolation of mouse bone marrow mesenchymal stem cells(MSC)	4
5.	Harvesting of tissues, digestion and processing for preplate culture	8
6.	Isolation of adipose stem cells/muscle stem cells from mouse tissue Isolation of mouse bone marrow mesenchymal stem cells and human Wharton's Jelly Mesenchymal stem cells	8
7.	Cancer stem cells	4
B.	**Characterization experiments**	
8.	Analytical flow cytometry for stem cell Immuno phenotyping of	4
9.	Human MSC as per International Society for Cell Therapy (ISCT) guidelines, Immunofluorescence staining of MSCs	4
10.	Fluorescent Assisted Sorting (FACS) of Stem Cells	4
C.	**Cell Imaging and Quantification**	
11.	Cell imaging using fluorescent imagers (EVOS M5000-Thermo Fisher Scientific, USA) and ZOE (Bio-Rad, USA), Image Quantification for various parameters such as nuclei and positively stained cells using Image J	4

Course Name: IMMUNOLOGY Credits: 2 (56 hours)

Course code: AP02BS-2C7

SL. No	Laboratory Exercises:	Hours
1	Immune system and organs in a mammalian animal model	8
2	H & E staining of spleen	4
3	Lymphocyte isolation and staining	4
4	ELISA	8
5	Single Radial immuno-diffusion	4
6	Ouchterlony diffusion on gels	4
7	Counter current immune electrophoresis	4
8	Rocket immunoelectrophoresis	4
9	Latex agglutination kit	4
10	Blood typing	4
11	Immunocytochemistry (Light, Fluorescent Microscopy)	8

SEMESTER-III – Scheme and Courses

Course code	Type of Course	Course name	Hrs/ Week	Credits
AP02BS-3O1	Open Elective	Scientific Communication	3	3
AP02BS-3C1	Core -Theory	Research Methodology	4	4
AP02BS-3C2	Core - Theory	Omics Technology and Systems Biology	4	4
AP02BS-3C3	Core -Theory	Genetic Engineering	4	4
AP02BS-3C4	Core -Practical	Biostatistics	4	3
AP02BS-3C5	Core - Practical	Bioinformatics and Omics Technology	4	3
AP02BS-3C6	Core -Practical	Cell culture techniques	4	3
Total Credits				24

Course Name: SCIENTIFIC COMMUNICATION Credits: 3 (42 hours)

Course code: AP02BS-3O1 (Open elective)

CO 1	Understanding the research practices and good laboratory practices
CO 2	Understanding the advanced software tools, and maintenance scientific record.
CO 3	Enhance their communication skills and provide them a platform to overcome their shortcomings and strengthen them to face the competitive world.
CO 4	Understanding about innovations, entrepreneurship, startup companies and product development

Unit 1: Research Practices and Applications 10 hours

The review of literature–Approaches to research - How to use the search engines such as PubMed, Scopus, and Science Direct etc.– Planning the research -Development of hypothesis and research ideas–Designing a research work or projects-Selecting methods of data collection - Organizing the research notes and logbooks-Interpretation of results–Ethics and integrity in research - Learning Good Laboratory Practices (GLP).

Unit 2: Effective Writing and Presentation Skills 10 hours

Writing research and review paper – Documenting the paper – Drafting and revising – Preparing the final draft – How to communicate the manuscript to journals - How to make power point presentation- How to present the scientific findings in front of scientific peers- How to present the oral poster presentation in symposium and conference-Attending the web based webinar, TED talks, podcasts etc.

Unit 3: Skill Advancement Programs 10 hours

Learning and utilization of advanced software such as EndNote, Adobe Photoshop, Origin Lab, Sigma Plot, and Graph Pad Prism etc. – Development of quality figures for publications, research proposals, and presentations-Introduction to Microsoft Offices (Word, Excel and Power Points)-Creative writing and publishing-How to write a research proposal.

Unit 4: Personality and Career Development 12 hours

Building a motivated research collaboration among the researchers and expertise in the similar research field-Social interaction– Developing self in work and career -Dress code- Management in health, mindfulness and time -How to prepare and attend the interview-How to make resume – Do and Don'ts-Innovation and entrepreneurship-Industrial visits-How to do research based projects-How to develop startup companies.

Recommended books for reference:

1. Bell, Judith, Waters, and Stephen (2014). Doing Your Research Project: A Guide for First Time Researchers. McGraw-Hill Open University Press.
2. Boffito, Daria, C., Patience, Gregory, S., Patience, and Paul, A. (2015). Communicate Science Papers, Presentations, and Posters Effectively. Academic Press.
3. Carter, M. (2013). Designing Science Presentations. A Visual Guide to Figures, Papers, Slides, Posters, and More. Academic Press.
4. Hamper, R., and Baugh, L. (2010). Handbook for Writing Proposals. (2nd Ed.) McGraw-Hill.
5. Kenneth, H., Rubin, William, M., Bukowski, and Brett, L. (2008). Handbook of Peer Interactions, Relationships, and Groups (Social, Emotional, and Personality Development in Context). The Guilford Press.
6. Mamishev, A., and Sargent, M. (2013). Creating Research and Scientific Documents Using Microsoft Word. Microsoft Press.
7. O'Leary, Z. (2017). The Essential Guide to Doing Your Research Project. SAGE Publications Ltd.
8. Paul, J., Hartung, Linda, M., and Subich (2010). Developing Self in Work and Career: Concepts, Cases, and Contexts. American Psychological Association.
9. Pulkkinen, L. (2002). AvshalomCaspi. Paths to Successful Development: Personality in the Life Course. Cambridge University Press.
10. Shaffer, D.R. (2008). Social and Personality Development. (6th Ed.) Wadsworth Publishing .
11. Specht, J. (2017). Personality Development Across the Lifespan. Academic Press.
12. Victoria, E., and McMillan (2011). Writing Papers in the Biological Sciences. Bedford St. Martin's Macmillan.

Course Name: RESEARCH METHODOLOGY Credits: 4 (56 hours)

Course code: AP02BS-3C1

CO 1	Introductory understanding of research methodology, its significance and scientific methods used in research
CO 2	Basic understanding on how to define a Research Problem
CO 3	Understand Ethical and regulatory bodies and their role in shaping Research
CO 4	Learn about Intellectual Property Rights and their issues in Research

Unit 1: Introduction to Research Methodology 14 hrs

Definition of Research and objectives, General Characteristics of Research; Types of Research, Research Approach: Qualitative and Quantitative; Significance of Research, Research and Scientific Methods. Important Research designs: Experimental (randomized, non-randomized, single blind and double blind) and observational (cross-sectional, prospective, retrospective and case control).

Unit 2: Defining the Research Problem 14 hrs

Concept and Identification of Research problem, Understanding lacunae in research, Defining a research problem, Literature review, types of research articles**,** Search tools (Databases, Pubmed, Google Scholar, Keyword search), Basis of systematic review (filtering criteria). Research Questions and Hypothesis: Basis and characteristics for good hypothesis.

Unit 3: Ethical and regulatory aspects in Research 14 hrs

ICMR guidelines: National ethical guidelines For biomedical and health research Involving human participants. Declaration of Helsinki Ethical Principles for Medical Research Involving Human Subjects. CPCSEA guidelines for use of animals in research. Central Drugs Standard Control Organization (CDSCO). National Guidelines For Stem Cell Research (ICMR and DBT). DBT guidelines for biosafety. GLP guidelines (OECD)

Unit 4: IPR (Intellectual Property Rights)issues in Research 14 hrs

Patent, designs, trademarks**:** IPR- intellectual property rights and patent law, commercialization, trade related aspects of intellectual property rights (TRIPS). Inventions and patentskey differences. Understanding the inventorship, ownership and rights, royalty. Novelty, inventive step and industrial applicability. Introduction to patent specifications; provisional and complete specifications. Patent filling procedure, Patent granting organizations, Geographical indications in patent. Copy right and Plagiarism. Start-up and entrepreneurship.

Recommended books for reference:

1. Garg, B.L., Karadia, R., Agarwal, F. and Agarwal, U.K., (2002). An introduction to Research Methodology, RBSA Publishers.
2. Kothari, C.R. (1990). Research Methodology: Methods and Techniques. New Age International.
3. Sinha, S.C. and Dhiman, A.K. (2002). Research Methodology. Volume 2. Ess Publications.
4. Trochim, W.M.K. (2005). Research Methods: the concise knowledge base, Atomic Dog Publishing.
5. Fink, A. (2009). Conducting Research Literature Reviews: From the Internet to Paper. Sage Publications.

6. Day, R.A. (1992). How to Write and Publish a Scientific Paper, Cambridge University Press.
7. Coley, S.M. and Scheinberg, C. A. (1990). "Proposal Writing", Sage Publications.
8. Leedy, P.D. and Ormrod, J.E. (2004) Practical Research: Planning and Design, Prentice Hall.
9. Kargad, P. (2018). How to Patent an Idea in India: From Idea to Granted Patent in Quickest Time, Saving Costs and Making Money with Your Patented Invention; A Step by ... Rights (Intellectual Property in India) (1st Ed.).
10. Singh, R., Kumar, S., and Kumar, S.S. (2019). Unfolding Intellectual Property Rights: A Practical Patent Guide for Researchers, Academicians and start-ups. (1st Ed.) Notion Press.

Course Name: BIOSTATISTICS Credits: 3 (72 hours)

Course code: AP02BS-3C4

CO1	Students will learn how to collect, organize and represent data; determine the range and variation in the data
CO2	Students will learn how to form statistical hypothesis and differentiate it from research hypothesis; testing statistical hypothesis against real-life biological data

Sl. No.	Topics	Hours
1	Understanding the data (Categorical vs. Continuous Variables), Arrangement of data in Tabular formats using Microsoft Excel,	6
2	Presentation and visualization of data using Microsoft Excel/GraphPad Prism/SPSS (Histogram, Bar diagram, Pie chart etc.)	6
3	Calculation of the Measures of central tendencies and measures of dispersion (Mean, Median, Mode, Standard Deviation, Standard Error and Coefficient of Variation) using Microsoft Excel	6
4	Understanding and computing the Degrees of Freedom, Estimate of parameters and their confidence intervals (CIs), Understanding and computing 95% Confidence Intervals	6
5	Hypothesis Testing Ia : Comparison of two groups using parametric statistics (Student's t-Test, paired t-Test) using Microsoft Excel/ SPSS/ GraphPad Prism, Computation of P-values and Understanding its significance, Determination of Power for Statistical analysis	6
6	Hypothesis Testing Ib : Comparison of two groups using non-parametric statistics (Mann-Whitney U test, Wilcoxon signed-rank test) manually and using Microsoft Excel/SPSS/GraphPad Prism	6
7	Hypothesis Testing II: Comparison of more than two groups using parametric and non-parametric statistics (one-way ANOVA, Kruskal Wallis test) using Microsoft Excel/GraphPad Prism Multiple comparisons using Tukey's, Bonferroni and Dunn's posthoc tests, Computation of P-values and Understanding its significance	12
8	Hypothesis Testing III: Goodness of Fit tests (Chi square test) using Microsoft Excel/SPSS/GraphPad Prism	6
9	Understanding Covariance: Drawing scatter plots and Trend's line using Microsoft Excel/ SPSS/GraphPad Prism	6
10	Parametric and Nonparametric Correlation analysis (Karl Pearson's and Spearman's rank) and simple Linear Regression analysis using Microsoft Excel-add ins/SPSS/ GraphPad Prism	12

Recommended books for reference:

1. Bernard Rosner (2011): Fundamentals of Biostatistics. (7th Ed).
2. B.K. Mahajan, Arun Bhadra Khanal (2008): Methods in Biostatistics for medicalstudents and research workers (7th Ed.) Jaypee Brothers Medical Publishers.
3. Wayne W. Daniel and Chad L. Cross (2012); Biostatistics- A Foundation for Analysis in the HealthSciences (7th Ed.) Wiley.
4. Olive. J. Dunn and Virginia A. Clark. (2009)- Basic statistics: A primer for the Biomedical Sciences, Wiley.
5. Asha Kamath, Meleth, S., and Sathiakumar, N. R (2014) Manual for Health Science Researchers Book. Manipal University Press.
6. Daniel, W.W., and Cross, C.L. (2000) Biostatistics: A Foundation for Analysis in the Health Sciences. (11th Ed.)
7. Sokal, R.R., and Rohlf, J.F. (1995). Biometry. W. H. Freeman.

Course Name: Omics Technology and Systems Biology Credits: 4 (56 hours)
Course Code: AP02BS-3C2

CO 1	Understanding the basics of gene expression analysis and genome sequencing technologies
CO 2	Familiarization with technologies to analyse transcriptome and epigenome
CO 3	Understanding the basics of proteomics experimental pipeline and data analysis
CO 4	Be competent to perform mass spectrometry based proteomics experiment
CO 5	Familiarization with Multi-omics data integration
CO 6	Familiarization with Basics of metabolomics experimental workflow and data analysis
CO 7	Be competent to perform mass spectrometry based metabolomics experiment

Unit 1: Genomics 12 hrs

Sanger sequencing-principle, methodology and applications, History of genome sequencing, Human Genome sequencing project; Analysis of gene expression- qPCR, northern blot, southern blot; exome sequencing; DNA microarrays; Copy number variation, sequence repeats, SNV, haplotype, and their relevance in diseases, Next Generation Sequencing (NGS)technology, Whole genome - de novo sequencing, comparative genomics, metagenomics

Unit 2: Transcriptomics 10 hrs

RNA-seq analyses, Transcriptome profiling; RNA sequencing; small RNA sequencing; Differential expression, Alternate splicing.

Unit 3: Proteomics 12 hrs

Basics of chromatography, mass spectrometry– ionization methods (MALDI, electrospray, mass analysers, protease digestion, peptide mass fingerprinting, tandem mass spectrometry, sample preparation strategies, fractionation strategies; search algorithms/engines, Proteomic data repositories, Introduction to quantitative proteomics and Targeted proteomics

Unit 4: Metabolomics 12 hrs

Metabolomics-an overview, basic sample preparation strategies- extraction, derivatization, Introduction to small molecules and lipidomics; Targeted Vs Untargeted metabolomics; development of targeted assays for small molecules; Metabolic pathways, metabolite profiling, inborn errors of metabolism.

Unit-5: Data analysis and Multi-omics data integration 10 hrs

Genomic, transcriptomic, proteomic and metabolomics data file format and standards, Bioinformatics tools for data analysis, curation and gene accession mapping, Quality control for data integration, Analysis and visualization, gene set Enrichment analysis, Pathway analysis, Network analysis.

Recommended books for reference:

1. Baxevanis, A., and Ouellette, B. (2005). Bioinformatics – A practical guide to the analysis of genes and proteins. (3rd Ed.) Wiley India.
2. Brown, T.A. (2010). Gene cloning and DNA analysis: An introduction. Wiley- Blackwell.
3. Fan, T.M. (2012). The handbook of metabolomics. Humana Press.
4. Green, M.R., and Sambrook, J. (2012). Molecular cloning – A laboratory manual. Cold Spring Harbor Laboratory Press.
5. Gross, J. (2011). Mass spectrometry – A textbook. Springer.
6. Karp, G. (2009). Cell and molecular biology: Concepts and experiments. (7th Ed.) John Wiley & Sons.
7. Kulkarni, S., and Pfeifer, J. (2014). Clinical genomics. Academic Press.
8. Leung, H. (2012). Integrative proteomics. InTech Publishers.
9. Lindon, J. (2007). The handbook of metabonomics and metabolomics. Elsevier.
10. Lodish, H. (2008). Molecular cell biology. W. H. Freeman.
11. Miller, K., and Levine, J. (2010). Biology. Pearson.
12. Primrose, S.B., and Twyman, R. (2006). Principles of gene manipulation and genomics. Blackwell Publishing.
13. Reece, R. (2004). Analysis of genes and genomes. John Wiley & Sons Ltd.
14. Simpson, R. (2002). Proteins and proteomics: A laboratory manual. Cold Spring Harbor Laboratory Press.
15. Wilson, K., and Walker, J. (2010). Principles and techniques of biochemistry and molecular biology. (7th Ed.) Cambridge University Press.

Course Name: GENETIC ENGINEERING Credits: 4 (56 hours)

Course Code: AP02BS-3C3

CO 1	Learn about Enzymes and Vectors in Gene Cloning
CO 2	Develop knowledge on Polymerase Chain Reaction
CO 3	Understand the Gene Cloning Methods
CO 4	Familiarise with Gene and Promoter isolation
CO 5	Gain insights into the concepts of Genetic Engineering of living organisms

Unit 1: Enzymes and Vectors in gene cloning 12 hrs

Restriction enzymes, methylases, DNA polymerases, reverse transcriptase, terminal transferase, alkaline phosphatase, polynucleotide kinase, ligase, DNase and RNase, Plasmid vectors, Vectors based on the lambda Bacteriophage, Cosmids, M13 vectors, Expression vectors, Vectors for cloning and expression in Eukaryotic cells, Super vectors, YACs and BACs.

Unit 2: Polymerase chain reaction 12 hrs

PCR, gene isolation by PCR, primer design – gene specific primers, nested primers, degenerate primers, optimization of PCR components and thermal conditions, PCR set up with proper controls, types of PCR – inverse PCR, multiplex PCR, nested PCR, TAIL PCR, LAMP, semi quantitative RT-PCR, real-time PCR with SYBR and Taqman probe, site directed mutagenesis- PCR based site directed mutagenesis, Random mutagenesis.

Unit 3: Gene Cloning Methods 12hr

Cohesive end cloning, cloning using adapters, linkers and homopolymer tailing, TOPO cloning, cloning of PCR products – TA cloning, blunt end cloning, cloning with added restriction sites, GATEWAY cloning, ligation free cloning, Construction of cDNA library, subtractive cDNA library, normalized cDNA library, genomic DNA library.

Unit 4: Gene and Promotor isolation 10 hrs

Methods of screening the libraries using nucleic acid and antibody probes, functional screening, screening by complementation, cloning of genes by PCR, RT-PCR, RACE-PCR, artificial gene synthesis, constitutive and inducible promoters, tissue specific promoters, promoter identification from gene expression data, promoter deletion studies, reporter genes for promoter deletion studies.

Unit 5: Genetic Engineering of living organisms 10 hrs

Expression and purification of recombinant proteins in *E. coli*, yeast, Baculovirus, animal cell lines, transgenic plants and transgenic animals, Gene manipulation (silencing, types of small non translated RNA), Changing genes, Use of Phage display techniques to facilitate the selection of mutant peptides, Gene shuffling, production of chimeric proteins.

Recommended books for reference:

1. Ausubel (2002). Short Protocols in Molecular Biology. Wiley.
2. Brown (1995). Gene Cloning - An Introduction Stanley Thornes.
3. Brown (2000). Essential Molecular Biology. Vol I & II. AP Publications.
4. Glick, and Pasternak (1998). Molecular Biotechnology. ASM Press.
5. Kracher Molecular Biology - A Practical Approach.
6. Krenzer, and Massey (2000). Recombinant DNA and Biotechnology. ASM Press.
7. Micklos, and Freyer (2000). DNA Science. CSHL Publications.
8. Primrose (2001). Molecular Biotechnology. Panima Publications.
9. Robertson (1997). Manipulation & Expression of Recombinant DNA. AP Publications.
10. Sambrook (2001). Molecular Cloning. CSHL.
11. Watson Recombinant DNA. Freeman Publications.

Course Name: BIOINFORMATICS and OMICS TECHNOLOGY

Credits: 3 (72 hours)

Course Code: AP02BS-3C5

CO 1	Learn basics of programming, search databases, phylogenetics, next gen sequencing
CO 2	Appreciate structural bioinformatics, molecular docking, protein databases,
CO 3	Perform Proteomic, Metabolomic data analysis, normalization techniques, metabolite identification

	Topics	Hours
1.	Basics of programming	6
2.	DNA sequence databases: Sequence Alignment and Searching, Data base similarity search-BLAST. Phylogenetics: Methods of tree construction	6
3.	Next Generation Sequencing data–quality control, alignment Phredscore; Fast QC and FastX toolkits, data analysis tools and pipeline, Read length, read depth, sequence coverage.	12
4.	Structural Bioinformatics; Homology modelling and Visualization of 3-Dstructure	6
5.	Molecular Docking and drug interaction.	6
6.	Protein sequence databases; PDB file formats	6
7.	Normalization Techniques for quantitative proteomics.	6
8.	Proteomic data analysis-Search algorithms, False Discovery rate	12
9.	Metabolomics Data analysis–identification of molecular features, metabolite identification; structural confirmation of metabolites.	12

Course Name: CELL CULTURE TECHNIQUES Credits: 3 (72 hours)
Course Code: AP02BS-3C6

CO 1	Will understand the basics of animal cell culturing including infrastructure, equipments and materials and sterile technology
CO 2	Will be able to prepare mammalian cell culture media under sterile conditions
CO 3	Will be able to plate the mammalian cells of established cell lines, trypsinize the cells and cryopreserve the cells followed by cell revivals
CO 4	Will be able to perform a lymphocyte culture and karyotype analysis
CO 5	Will be able to perform basic cell culture analytics such as cell counting using Trypan blue, MTT assays and clonogenic assays for cell proliferation

	Topics	Hours
1.	Basics of animal cell culturing: Infrastructure, equipments and materials needed for animal cell culture technology Sterile Techniques	6
2.	Media components and their significance: balanced salt solutions and growth medium, Chemical, physical and metabolic functions of different constituents of culture medium, Role of carbon-di-oxide Preparation Different media used in cell culture	6
3.	Mammalian cellculture: Primary and established cell lines: Microscopic characterization imaging	12
4.	Revival, Seeding of the cells and passaging using established cell lines. Cell synchronization	6
5.	Cell preservation techniques: cryopreservation	6
6.	Lymphocyte culture andKaryotypeAnalysis.	12
7.	Measurement of viability and cytotoxicity, Apoptosis: MTT and Trypan blue assays	12
8.	Clonogenic assay for cell proliferation	6
9.	Flow cytometry and Cell cycle analysis	6

Recommended books for reference:

1. Clynes, M. (2012). Animal cell culture techniques. Springer Science & Business Media.
2. Freshney, R. (2015). Culture of animal cells: a manual of basic technique and specialized applications. John Wiley & Sons.
3. Masters, J.R. (2000). Animal cell culture: a practical approach. Oxford Publishers.
4. Wilson, L., Matsudaira, P.T., Mather, J.P., and Barnes, D. (1998). Animal cell culture methods. Academic Press.

SEMESTER –IV

Scheme

Course Code	Details	Duration	Credits
AP02BS-4PR	Project work	14 weeks	24