SHRI GURU RAM RAI UNIVERSITY

[Estd. by Govt. of Uttarakhand, vide Shri Guru Ram Rai University Act no. 03 of 2017 & recognized by UGC u/s (2f) of UGC Act 1956]

SYLLABUS FOR

B. Sc. (Hons.)Biotechnology

(Three Year Course- Semester System)

School of Basic and Applied Sciences

(Effective from Academic Session 2021-2022-Onward)

VISION AND MISSION- DEPARTMENT OF BIOTECHNOLOGY

Vision

1. To be producing technical manpower through excellence in research and development, teaching, learning and training, with concern for worldwide environment and human society.
2. To provide well and quality education in the field of Life Sciences and Applied Sciences with proper training and practical expertise responsive to the needs of present and future century so that students excel and enhance in their professional life.

Mission

1. Providing friendly learning ambience to develop competence in diversified areas to create excellence in industrial, educational, research and technical areas.
2. Provide an efficient educational environment where students and research scholars can realize their full potential in their chosen disciplinary subjects and attain quality education to face the challenges of the future.
3. Establish networks collaborations and linkages with industries and academic institutes to produce ethically and morally strong workforce contributing to the development of knowledge economy.
4. Harness the skills of the students and assist them to excel in their professional life by providing life long leaning skills, sound theoretical knowledge, practical experience and all-round development with the help of well qualified and experienced faculty. Inculcate moral and ethical values for character building.

C U R R I C U L U M

B. Sc. (Hons.) BIOTECHNOLOGY GRADUATE DEGREE PROGRAMME
(2021-22 Onward)

1. Nomenclature:

There will be full time Biotechnology honour's Degree Programme named as B. Sc. (Hons.) in Biotechnology which will be written as B. Sc. (Hons.) Biotechnology. The duration of this programme shall be of three years (three full academic years) which shall be divided into six semesters. Each semester will be of six. months. Actual teaching in each semester is required minimum of 90 days. The examination for the first, third and fifth semester will normally be held in the month of December and for the second, fourth and sixth semester in the month of May or as convenient to the University.

2. The Medium of Instruction:

The medium of Instruction will be English.

3. The Medium of Examination:

The medium of examination will be English.

4. Intake:

The intake to B. Sc. (Hons.) Biotechnology course is 60 students. It may increase or decrease as per provisions of the University.

5. Eligibility to apply for Admission:

No candidate shall be eligible for admission to three year Full Time B. Sc. (Hons.) Biotechnology unless he/she has successfully completed higher secondary or Intermediate (with any biological subject) with prescribed number of credits or percentage through the examinations conducted by a National/State Board. Such qualifications as recognized by the University. Any candidate who has passed the plus two of the higher secondary board of Examinations in any state recognized as equivalent to the plus two of the Higher Secondary Board in with not less than 45 % marks in aggregate is eligible for admission, However, SC/ST, OBC and other eligible communities shall be given relaxation as per University rules.

Duration of the Programme : 3 Years

6. Selection Procedure for Admission: A candidate willing to seek admission to B. Sc. (Hons.) Biotechnology will have to appear in written entrance Test conducted by the University or on behalf of the University and followed by the counseling as per University norms. The selection for admission will be made on merit basis or as per University norms.

7. Semesters:

(a) An academic year shall consist of two semesters :

Odd Semester (I, III and V Semester) : generally July to November/December

Even Semester (II, IV and VI Semester): generally January to May/ June

The academic calendar for each semester shall be notified well before the commencement of the semester by the Dean, School of Basic and Applied Sciences.

(b) A semester shall normally extend over a period of 15 weeks. Each week shall have 30 hours of instruction including lab/ field work as applicable.

8. Credits:

(a) Credit defines the quantum of contents/ syllabus prescribed for a course and determines the number of hours of instruction required per week. Thus credits shall be assigned on the basis of the number of lectures/ tutorials / laboratory work/ project work and other forms of learning required to complete the course contents in a 15 week schedule.

(b) 1 Credit = 1 hour of lecture for theory and 1 Credit = 2 hour of laboratory for practicals.

(c) Motivate students with industrial visit, educational trip, seminar/conference during semester (not mandatory).

9. Roll Numbers and Enrollment Numbers:

The University shall allot a Roll Number to the students after payment realization, thorough scrutiny/ verification of the required documents for the course. After the completion of the admission procedure the enrolment number for the students shall be allotted by the University at the entry point which shall remain same for the entire period of study in the University.

10. The Credit Based Course Structure: B. Sc. (Hons.) Biotechnology- Three Year Programme- Choice Based Credit System (CBCS)

B. Sc. (Hons.) Biotechnology program shall be based on the choice based credit system in which credit defines the quantum of content/ syllabus prescribed for a course system and determines the number of hours of instruction per week.

Total Credits: 84 (Core Course) +8 (AECC) +8 (SEC) +24 (GE) +24(DSE) =148
C= Core Course
AECC= Ability Enhancement Compulsory Course
SEC= Skill Enhancement Course
GE= Generic Elective
DSE= Discipline Specific Elective

11. Student Advisor:

Every student shall have a teacher of the Department as his/her student advisor. All teachers of the department shall function as student advisors and will have more or less equal number of students with them. The student advisor will advise the students in choosing elective courses and offer all possible student support services.

12. Attendance:

a. The teacher handling a course shall be responsible for maintaining a record of attendance of students who have registered for the course.
b. All teachers shall intimate the Head of the Department at least seven calendar days before the last instruction day in the semester, the particulars of all students who have less than 75% attendance in one or more courses.
c. A candidate who has less than 75% attendance shall not be permitted to sit for the end-semester examination in the course in which the shortfall exists. However, it shall be open to the Dean/ HOD to grant exemption to a candidate who has failed to obtain the prescribed 75% attendance for valid reasons on payment of prescribed fee and such exemptions shall not under any circumstances be granted for attendance below 65%.
d. A candidate who fails to put in least 75% attendance in I semester shall not be allowed to pursue the studies in next semester. Such candidates may apply to the Dean/HOD for re-registration in the II semester in the next academic session.

Note : Rest of the provisions will be as framed by the University.

13. Fee and Resource Generation

As per decision of the University.

14. Examination and Evaluation

(a) Evaluation will be done on a continuous basis. Three times during each semester. For the purpose of uniformity, there will be a uniform procedure of examination to be adopted by all teachers. There will be two sessional tests (Three if any student are unable to attend any sessional test) and one end-semester examination.

(b) Sessional tests (of one to two hours duration) may employ one or more assessment tools such as objective tests, assignments, paper presentation, laboratory work, etc suitable to the course. This requires an element of openness. The students are to be informed in advance about the nature of assessment. It will be obligatory for the Students to attend the both Sessional tests, failing which they will not be allowed to appear in the concerned semester examination. The sessional test as part of the continuous internal assessment shall be conducted and evaluated by the teacher offering the course. A Student cannot repeat sessional tests (without permission from HOD). However, if for any compulsive reason the student could not attend the test, the prerogative of arranging a special test lies with the teacher with the approval of the Head of the Department. In case of students who could not attend any of the sessional tests due to medical reason or under extraordinary circumstances, a separate test shall be conducted before the concerned semester

examinations by the concerned faculty member after the approval of the Head of the Department and the Dean concerned.

(c) The sessional tests will carry 30% of total marks for the course. The marks of the two Sessional Tests shall be taken into account for the computation of Grades.

(d) There shall be a written end semester examination which shall be of 2/3 hours duration carrying 70% of total marks assigned for the course, covering the entire syllabus prescribed for the course.

(e) The end semester practical examinations (field tour report, project report and training report) shall normally be held before the theory examination/or as per convenience by the Department . The internal faculty shall associate themselves with the examination process.

OUTCOME BASED EDUCATION

Programme outcomes (POs)

Students will be able to

PO 1	Knowledge of Biotechnology and Applied sciences: Students have the basic knowledge of Biotechnology, Biochemistry (Biomolecules), Microbiology, Plant Biotechnology, environmental science, chemistry, Common biology (Botany and Zoology) and understand its applicability or correlate these applied science to nature.
PO2	Problem analysis: Identify, express, analyze the problems related to Applied (Biotechnology), basic and natural sciences.
PO3	Design/development of solutions: Students will be able to design or generate solutions of common problems of Applied Sciences (Biotechnology) and its output is to improve public and environmental health.
PO4	Modern tool usage: Generate, select, and apply appropriate modern techniques and resources for understanding the concept of Biotechnology.
PO5	Environment and sustainability: Understand the impact of the Applied science and Biotechnology to improve the environmental health and aware about the knowledge and need of sustainable development.
PO6	Project management, lab culture and Communication : Acquired the skills in handling scientific instruments, planning and performing in laboratory experiments. Communicate effectively on complex Biotechnological activities with the other science community and with society at large, such as being able to comprehend and write effective reports and design documentation, make effective presentations and give and receive clear instructions.
PO7	Future prospective, Individual and Team Work: After the completion of this course students have the option to go for higher studies i.e. M. Sc. and then do some research for the welfare of mankind or prepare for other competitive examination**.** Function effectively as an individual, and as a member or leader in diverse teams and in multi-disciplinary settings followed with the knowledge of Biotechnology.
PO8	Life-long and interdisciplinary approach of learning: Realized how developments in any Biotechnological subject helps in the development of other science subjects and vice-versa and how interdisciplinary approach helps in providing better solutions and new ideas for the sustainable developments. Recognize the need for and have the preparation and ability to Engage in independent and life- long learning in the broadest context of Biotechnological Change.
PO9	Effective Writing: Got Skill for Write up in scientific literature and other social media platform related to life science.
PO10	Effective Communication: Speak, read, write and listen clearly in person and through electronic media in English and in one Indian language, and make meaning of the world by connecting people, ideas, books, media and technology.
PO11	Social Interaction and Ethics: Elicit views of others, mediate disagreements and help reach conclusions in group. Recognize different value systems including your own, understand the moral dimensions of your decisions, and accept responsibility for them settings conclusions in group settings.
PO12	Interdisciplinary approach and Practical learning: Analyse the relationships among animals, plants, microbes and Industry. Perform procedures as per laboratory standards in the areas of Biochemistry, Bioinformatics, Genomics, industrial biotechnology and fermentation technology.

Program Specific Outcomes (PSOs)

PSO 1	The students will understand the basic metabolic and molecular processes required for normal cellular functions.
PSO2	The students will learn about different tools and techniques required for genetic manipulation, microbial culture and biochemical analysis.
PSO3	The students will be able to execute basic experiments related to biochemistry, microbiology, cell biology, recombinant DNA technology, etc.
PSO4	The students will be able to pursue higher studies in diverse areas of biological sciences or take up jobs in various biotechnology sectors.

Eligibility for admission:

Any candidate who has passed Plus Two (10+2) of the Higher Secondary Board Board of Examinations in any state recognized as equivalent to the Plus Two of the Higher Secondary Board in with not less than 45 % marks in aggregate is eligible for admission, However, SC/ST, OBC and other eligible communities shall be given relaxation in marks as per University rules.

Duration of the Programme : 3 Years

STUDY & EVALUATION SCHEME
Choice Based Credit System /ECS
Bachelor of Science (Hons.) Biotechnology

First Semester

S. No.	Course Category	Couse Code	Course Name	Periods				Evaluation scheme		Subject Total
				L	T	P	C	Sessional (Internal)	External (ESE)	
Theory										
1	Core	HBTC 101	Biochemistry and Metabolism	4	0	0	4	30	70	100
2	Core	HBTC 102	Cell Biology	4	0	0	4	30	70	100
3	Generic Elective	HBTG 103	Developmental Biology	4	0	0	4	30	70	100
4	Ability Enhancement Compulsory Course	AECC 101	Environmental Science	4	0	0	4	30	70	100
Practical										
1	Core	HBTL 101	Lab course based on course HBTC 101	0	0	2	2	30	70	100
2	Core	HBTL 102	Lab course based on course HBTC 102	0	0	2	2	30	70	100
3	Generic Elective	HBTL 103	Lab course based on course HBTG 103	0	0	2	2	30	70	100
			Total	16	0	6	22	210	490	700

L – Lecture, T – Tutorial, P – Practical, C – Credit

Second Semester

S. No.	Course Category	Couse Code	Course Name	Periods				Evaluation scheme		Subject Total
				L	T	P	C	Sessional (Internal)	External (ESE)	
										Theory
1	Core	HBTC 201	Mammalian Physiology	4	0	0	4	30	70	100
2	Core	HBTC 202	Plant Physiology	4	0	0	4	30	70	100
3	Generic Elective	HBTG 203	Entrepreneurship Development	4	0	0	4	30	70	100
4	Ability Enhancement Compulsory Course	AECC 201/**202**/203	English Communication	4	0	0	4	30	70	100
										Practical
1	Core	HBTL 201	Lab course based on course HBTC 201	0	0	2	2	30	70	100
2	Core	HBTL 202	Lab course based on course HBTC 202	0	0	2	2	30	70	100
3	Generic Elective	HBTL 203	Lab course based on course HBTG 203	0	0	2	2	30	70	100
			Total	16	0	6	22	210	490	700

L – Lecture, T – Tutorial, P – Practical, C – Credit

Third Semester

S. No.	Course Category	Couse Code	Course Name	Periods				Evaluation scheme		Subject Total
				L	T	P	C	Sessional (Internal)	External (ESE)	
										Theory
1	Core	HBTC 301	Genetics	4	0	0	4	30	70	100
2	Core	HBTC 302	General Microbiology	4	0	0	4	30	70	100
3	Core	HBTC 303	Chemistry-I	4	0	0	4	30	70	100
4	Generic Elective	HBTG 304	Bioethics and Biosafety	4	0	0	4	30	70	100
5	Skill enhancement course (Any one)	HBTS 305/306/307/308	Industrial Fermentations/ Molecular Diagnostics/ Basics of Forensic Science/ Green Chemistry	4	0	0	4	30	70	100
										Practical
1	Core	HBTL 301	Lab course based on course HBTC 301	0	0	2	2	30	70	100
2	Core	HBTL 302	Lab course based on course HBTC 302	0	0	2	2	30	70	100
3	Core	HBTL 303	Lab course based on course HBTC 303	0	0	2	2	30	70	100
	Generic Elective	HBTL 304	Lab course based on course HBTG 304	0	0	2	2	30	70	100
			Total	20	0	8	28	270	630	900

L – Lecture, T – Tutorial, P – Practical, C – Credit

Fourth Semester

S. No.	Course Category	Couse Code	Course Name	Periods				Evaluation scheme		Subject Total
				L	T	P	C	Sessional (Internal)	External (ESE)	
										Theory
1	Core	HBTC 401	Molecular Biology	4	0	0	4	30	70	100
2	Core	HBTC 402	Immunology	4	0	0	4	30	70	100
3	Core	HBTC 403	Chemistry-2	4	0	0	4	30	70	100
4	Generic Elective	HBTG 404	Biotechnology and Human Welfare	4	0	0	4	30	70	100
5	Skill enhancement course (Any one)	HBTS 405/406/407	Enzymology/ Drug Designing/ Evolutionary Biology	4	0	0	4	30	70	100
										Practical
1	Core	HBTL 401	Lab course based on course HBTC 401	0	0	2	2	30	70	100
2	Core	HBTL 402	Lab course based on course HBTC 402	0	0	2	2	30	70	100
3	Core	HBTL 403	Lab course based on course HBTC 403	0	0	2	2	30	70	100
	Generic Elective	HBTL 404	Lab course based on course HBTG 404	0	0	2	2	30	70	100
			Total	20	0	8	28	270	630	900

L – Lecture, T – Tutorial, P – Practical, C – Credit

Fifth Semester

S. No.	Course Category	Couse Code	Course Name	Periods				Evaluation scheme		Subject Total
				L	T	P	C	Sessional (Internal)	External (ESE)	
										Theory
1	Core	HBTC 501	Bioprocess technology	4	0	0	4	30	70	100
2	Core	HBTC 502	Recombinant DNA Technology	4	0	0	4	30	70	100
3	Discipline Centric Subjects (Any one)	HBTD 503/504/505a/ 505b	Animal Diversity-I/ Animal Biotechnology/ Ecology and Environment Management/ Intellectual Property Rights	4	0	0	4	30	70	100
4	Discipline Centric Subjects (Any one)	HBTD 506/507/508a/ 508b	Plant Diversity I/Plant Biotechnology/ Bioinformatics/ Advance Forensic Science	4	0	0	4	30	70	100
										Practical
1	Core	HBTL 501	Lab course based on course HBTC 501	0	0	2	2	30	70	100
2	Core	HBTL 502	Lab course based on course HBTC 502	0	0	2	2	30	70	100
3	Discipline Centric Subjects (Any one)	HBTL 503/504/505a/ 505b	Lab course based on course HBTD 503/504/505a/ 505b	0	0	2	2	30	70	100
	Discipline Centric Subjects (Any one)	HBTL 506/507/508a/ 508b	Lab course based on course HBTD 506/507/508a/ 508b	0	0	2	2	30	70	100
			Total	16	0	8	24	240	560	800

L – Lecture, T – Tutorial, P – Practical, C – Credit

Sixth Semester

S. No.	Course Category	Couse Code	Course Name	Periods				Evaluation scheme		Subject Total
				L	T	P	C	Sessional (Internal)	External (ESE)	
										Theory
1	Core	HBTC 601	Bio Analytical Tools	4	0	0	4	30	70	100
2	Core	HBTC 602	Genomics & Proteomics	4	0	0	4	30	70	100
3	Discipline Centric Subjects	HBTD 603/604/605	Animal Diversity-II/ Microbial Physiology/ Biostatistics	4	0	0	4	30	70	100
4	Discipline Centric Subjects	HBTD 606/607/608	Plant diversity-II/ Medical Microbiology/ Environment Biotechnology	4	0	0	4	30	70	100
										Practical
1	Core	HBTL 601	Lab course based on course HBTC 601	0	0	2	2	30	70	100
2	Core	HBTL 602	Lab course based on course HBTC 602	0	0	2	2	30	70	100
3	Discipline Centric Subjects	HBTL 603/604/605	Lab course based on course HBTD 603/604/605	0	0	2	2	30	70	100
	Discipline Centric Subjects	HBTL 606/607/608	Lab course based on course HBTD 606/607/608	0	0	2	2	30	70	100
			Total	16	0	8	24	240	560	800

L – Lecture, T – Tutorial, P – Practical, C – Credit

Total Credits: 84 (C) +8 (AECC) +8 (SEC) +24 (GE) +24(DSE) =148

C= Core Course

AECC= Ability Enhancement Compulsory Course

SEC= Skill Enhancement Course

GE= Generic Elective

DSE= Discipline Specific Elective

List of Electives

S. No	Subject Code	Subject Name	Semester
GENERIC ELECTIVE SUBJECTS			
1	HBTG 103	Developmental Biology	**I**
2	HBTG 203	Entrepreneurship Development	**II**
3	HBTG 304	Bioethics and Biosafety	**III**
4	HBTG 404	Biotechnology and Human Welfare	**IV**
SKILL ENHANCEMENT COURSES			
1	HBTS 305	Industrial Fermentations	**III**
2	HBTS 306	Molecular Diagnostics	**III**
3	HBTS 307	Basics of Forensic Science	**III**
4	HBTS 308	Green Chemistry	**III**
5	HBTS 405	Enzymology	**IV**
6	HBTS 406	Drug Designing	**IV**
7	HBTS 407	Evolutionary Biology	**IV**
DISCIPLINE CENTRIC SUBJECTS			
DISCIPLINE CENTRIC SUBJECTS -1			
1	HBTD 503	Animal Diversity-I	**V**
2	HBTD 504	Animal Biotechnology	**V**
3	HBTD 505a	Ecology and Environment Management	**V**
4	HBTD 505b	Intellectual Property Rights	**V**
DISCIPLINE CENTRIC SUBJECTS -2			
5	HBTD 506	Plant Diversity-I	**V**
6	HBTD 507	Plant Biotechnology	**V**
7	HBTD 508a	Bioinformatics	**V**
8	HBTD 508b	Advance Forensic Science	**V**
DISCIPLINE CENTRIC SUBJECTS -3			
9	HBTD 603	Animal Diversity-II	**VI**
10	HBTD 604	Microbial Physiology	**VI**
11	HBTD 605	Biostatistics	**VI**
DISCIPLINE CENTRIC SUBJECTS -4			
12	HBTD 606	Plant diversity-II	**VI**
13	HBTD 607	Medical Microbiology	**VI**
14	HBTD 608	Environmental Biotechnology	**VI**

Examination Scheme:

Components	Ist internal	IInd Internal	External (ESE)
Weightage (%) Theory	Marks 15	Marks 15	Marks 70
Practical	Marks 15	Marks 15	Marks 70

B. Sc. (Hons.) Biotechnology

Course code	**: HBTC 101**
Course Name	**: Biochemistry and Metabolism**
Semester	**: I**

L	T	P	C
4	4	0	4

Course objective: This course is aimed to introduce the knowledge of biomolecules and their role in metabolic pathways. Also, it deals with the structure and function of enzymes.

UNIT I: Introduction to Biochemistry (10 Periods)

A historical prospective. Amino acids & Proteins**:** Structure & Function. Structure and properties of Amino acids. Carbohydrates: Structure, Function and properties of Monosaccharides, Disaccharides and Polysaccharides. Homo & Hetero Polysaccharides, Mucopolysaccharides, Bacterial cell wall polysaccharides, Glycoprotein's and their biological functions.

UNIT II (10 Periods)

Lipids: Structure and functions –Classification, nomenclature and properties of fatty acids, essential fatty acids. Phospholipids, sphingolipids, glycolipids, cerebrosides, gangliosides, Prostaglandins, Cholesterol. Nucleic acids: Structure and functions: Physical & chemical properties of Nucleic acids, Nucleosides & Nucleotides, purines & pyrimidines,. Biologically important nucleotides, Double helical model of DNA structure and forces responsible for A, B & Z – DNA.

UNIT III (20 Periods)

Enzymes: Nomenclature and classification of Enzymes, Holoenzyme, apoenzyme, Cofactors, coenzyme, prosthetic groups, metalloenzymes, monomeric & oligomeric enzymes, activation energy and transition state, enzyme activity, specific activity, common features of active sites.

UNIT IV (20 Periods)

Carbohydrates Metabolism: Reactions, energetics and regulation. Glycolysis: Fate of pyruvate under aerobic and anaerobic conditions. Pentose phosphate pathway and its significance, Gluconeogenesis, Glycogenolysis and glycogen synthesis. TCA cycle, Electron Transport Chain, Oxidative phosphorylation. ß-oxidation of fatty acids.

SUGGESTED READING AND TEXT BOOKS

1. Buchanan, B., Gruissem, W. and Jones, R. (2000) Biochemistry and Molecular Biology of Plants.American Society of Plant Biologists.
2. Nelson, D.L., Cox, M.M. (2004) Lehninger Principles of Biochemistry, 4th Edition, WH Freeman and Company, New York, USA.
3. Hopkins, W.G. and Huner, P.A. (2008) Introduction to Plant Physiology. John Wiley and Sons.
4. Salisbury, F.B. and Ross, C.W. (1991) Plant Physiology, Wadsworth Publishing Co. Ltd.
5. Berg, JM, Tymoczko, JL and Stryer, L 2006. Biochemistry. 6th ed. WH Freeman and Co.

Course Outcomes (COs): On completion of this course, the students will be:

CO	Descriptin	Bloom's Taxonomy Level
CO1	**Remember** the define the terms and basic concepts of Biochemistry and Metabolism and their different roles in biological systems, Nucleic Acid Metabolism	1 Remembering
CO2	**Understand** and Remember the principle, mechanism of basic and advanced Biochemistry and Metabolism, Nucleic Acid Metabolism.	1,2 Remembering, Understanding
CO3	**Applying,** understanding and remembering the detailed process of structure and function of biomolecules and enzymes, Nucleic Acid Metabolism.	1,2,3 Remembering, Understanding, Demonstrating
CO4	**Analyzing,** applying, remembering, understanding the coordinated regulation of carbohydrate, Protein and lipid metabolic pathway, nucleic acid metabolism.	1,2,3,4 Remembering, Understanding, Analyzing
CO5	**Evaluating, analyzing, Applying, remembering, and understanding** the principle, methods, properties and functions of Biochemical enzymes and molecules, nucleic acid metabolism.	1,2,3,4,5 Remembering, Understanding, Analyzing, Evaluating
CO6	**Constructing (Creating),** evaluating, analyzing, demonstrating, remembering, and understanding the Biomolecules and Enzymes, nucleic acid metabolism	1,2,3,4,5,6 Remembering, Understanding, Analyzing, Evaluating, Creating

Mapping of COs with POs & PSOs

Course Outcomes	Program Outcomes (POs)												Program Specific Outcomes (PSOs)			
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO1	3	3	1	1	1	1	1	1	3	1	1	1	3	2	1	1
CO2	3	3	1	1	1	1	1	1	3	1	1	1	3	2	1	1
CO3	2	3	3	3	3	3	2	2	3	2	2	2	3	2	2	1
CO4	3	2	3	3	3	3	1	1	3	1	0	1	3	3	2	1
CO5	3	2	3	1	1	1	2	2	3	3	2	1	3	2	1	1
CO6	1	1	1	1	1	1	1	1	2	2	2	1	3	2	2	1

3: High, 2: Medium, 1: Low

B. Sc. (Hons.) Biotechnology

Course code	**: HBTL 101**
Course Name	**: Lab Course Based on HBTC 101**
Semester	**: I**

L	T	P	C
0	0	2	2

Practicals

1. Preparation of solutions: percentage solution, Molar solution, Nornal solution. Preparation ofbuffers.
2. Qualitative tests for Carbohydrates like Molisch's test, Anthrone test, Iodine test, Seliwanoff'stest, and Fehling's test.
3. Principles of Colorimetry: Verification of Beer-Lambert Law; Study relation between absorbanceand % transmission.
4. Estimation of blood glucose by glucose oxidase method.
5. Preparation of buffers.
6. Sugar estimation by Anthrone method.
7. Protein estimation by Bradford method.
8. Nucleic acid estimation by Diphenylamine reagent.
9. Study activity of any enzyme under optimum conditions.
10. Study the effect of pH, temperature on the activity of salivary amylase enzyme.
11. Separation of Amino acids by paper chromatography.
12. JMol via Spoken Tutorial: Visualization of geometrical structure of simple molecules likecarbohydrates, fatty acids, amino acids and proteins.

B. Sc. (Hons.) Biotechnology

Course code	**: HBTC 102**
Course Name	**: Cell Biology**
Semester	**: I**

L	T	P	C
4	4	0	4

Course Objective: Cell is the structural and functional unit of life. It is often referred to as the building block of life as well. The course on cell biology aims to impart knowledge of cell structure and functions of diverse cellular organelles.

UNIT-I (10 Periods)

Cell: Introduction and classification of organisms by cell structure, cytosol, compartmentalization of eukaryotic cells, cell fractionation. Cell Membrane and Permeability: Chemical components of biological membranes, organization and Fluid Mosaic Model, membrane as a dynamic entity, cell recognition and membrane transport.

UNIT II (15 Periods)

Membrane Vacuolar system, cytoskeleton and cell motility: Structure and function of microtubules, Microfilaments, Intermediate filaments. Endoplasmic reticulum: Structure, function including role in protein segregation. Golgi complex: Structure, biogenesis and functions including role in protein secretion.

UNIT III (20 Periods)

Lysosomes: Vacuoles and micro bodies: Structure and functions Ribosomes: Structures and function including role in protein synthesis. Mitochondria: Structure and function, Genomes, biogenesis. Chloroplasts: Structure and function, genomes, biogenesis Nucleus: Structure and function, chromosomes and their structure.

UNIT IV (15 Periods)

Extracellular Matrix: Composition, molecules that mediate cell adhesion, membrane receptors for extra cellular matrix, macromolecules, regulation of receptor expression and function. Signal transduction. Cancer: Carcinogenesis, agents promoting carcinogenesis, characteristics and molecular basis of cancer.

SUGGESTED READING AND TEXT BOOKS

1. Karp, G. 2010. Cell and Molecular Biology: Concepts and Experiments. 6th Edition. John Wiley & Sons. Inc.
2. De Robertis, E.D.P. and De Robertis, E.M.F. 2006. Cell and Molecular Biology. 8th edition.Lippincott Williams and Wilkins, Philadelphia.
3. Cooper, G.M. and Hausman, R.E. 2009. The Cell: A Molecular Approach. 5th edition. ASMPress & Sunderland, Washington, D.C.; Sinauer Associates, MA.
4. Becker, W.M., Kleinsmith, L.J., Hardin. J. and Bertoni, G. P. 2009. The World of the Cell. 7th edition. Pearson Benjamin Cummings Publishing, San Francisco.

Course Outcomes (COs): On completion of this course, the students will be:

CO	Descriptin	Bloom's Taxonomy Level
CO1	**Remember** the define the terms and basic concepts of cell biology and their different roles in biological systems	1 Remembering
CO2	**Understand** and **Remember** the principle, mechanism of cellular reaction like cell membrane functions, membrane vacuolar system, intracellular campartmentization and extracellular complexes.	1, 2 Remembering, Understanding
CO3	**Applying, understanding and remembering** the detailed processes of structure and function of Cell membrane, cytoplasmic organelles and different components of cells.	1, 2,3 Remembering, Understanding, Demonstrating
CO4	**Analyzing, Applying, remembering, Understanding** the detailed processes of structure and function of Membrane carbohydrates, lipids and proteins, cytoplasmic organelles and different components of cells.	1, 2,3,4 Remembering, Understanding, Analyzing
CO5	**Evaluating, Analyzing, Applying, remembering, and understanding** the principle, methods, properties, functions and isolation of Biochemical cell's components and organelles.	1, 2,3,4,5 Remembering, Understanding, Analyzing, Evaluating
CO6	**Constructing (Creating), Evaluating, Analyzing, demonstrating, remembering, and understanding** the cell biology and cancer biology. Create awareness to different cellular functions.	1,2,3,4,5,6 Remembering, Understanding, Analyzing, Evaluating, Creating

Mapping of COs with POs & PSOs

Course Outcomes	Program Outcomes (POs)												Program Specific Outcomes (PSOs)			
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO1	2	2	2	1	2	2	2	2	3	1	1	1	3	2	1	2
CO2	3	2	2	2	2	2	1	1	3	1	1	1	3	2	1	2
CO3	3	2	3	3	3	3	2	2	3	2	2	2	3	2	2	2
CO4	2	2	3	3	3	3	1	1	3	1	0	1	3	3	2	2
CO5	2	2	3	1	1	1	2	2	3	3	2	1	3	2	2	2
CO6	2	2	1	1	1	1	1	1	3	2	2	1	3	2	2	2

3: High, 2: Medium, 1: Low

B. Sc. (Hons.) Biotechnology

Course code	**: HBTL 102**
Course Name	**: Lab Course Based on HBTC 102**
Semester	**: I**

L	T	P	C
0	0	2	2

Practicals

1. Study the effect of temperature and organic solvents on semi permeable membrane.
2. Study the working and functioning of microscope.
3. Demonstration of dialysis.
4. Study of plasmolysis and de-plasmolysis.
5. Cell fractionation and determination of enzyme activity in organelles using sprouted seed or any other suitable source.
6. Study of structure of any Prokaryotic and Eukaryotic cell.
7. Microtomy: Fixation, block making, section cutting, double staining of animal tissues like liver, oesophagus, stomach, pancreas, intestine, kidney, ovary, testes.
8. Cell division in onion root tip/ insect gonads.
9. Preparation of permanent slides of transverse sections (TS) of stem, root and leaf.
10. Demonstrate the structure of biomolecule using Cell Designer via Spoken Tutorial.
11. Preparation of Nuclear, Mitochondrial & cytoplasmic fractions.

B. Sc. (Hons.) Biotechnology

Course code	**: HBTG 103**
Course Name	**: Developmental Biology**
Semester	**: I**

L	T	P	C
4	4	0	4

Course objectives: The course aims to teach the principles and molecular biology of eukaryotic development, from zygote to embryo development and differentiation. The specific objectives of the course are:

1. To understand the history and basic concepts of embryology
2. To become familiar with the process of fertilization, spermatogenesis and oogenesis
3. To understand the process of organogenesis.
4. To understand the molecular basis of development.

UNIT I: Gametogenesis and Fertilization (10 Periods)

Definition, scope & historical perspective of development Biology, Gametogenesis– Spermatogenesis, Oogenesis Fertilization - Definition, mechanism, types of fertilization. Different types of eggs on the basis of yolk.

UNIT II: Early embryonic development (20 Periods)

Cleavage: Definition, types, patterns & mechanism Blastulation: Process, types & mechanism Gastrulation: Morphogenetic movements– epiboly, emboly, extension, invagination, convergence, de-lamination. Formation & differentiation of primary germ layers, Fate Maps in early embryos.

UNIT III: Embryonic Differentiation (20 Periods)

Differentiation: Cell commitment and determination- the epigenetic landscape: a model of determination and differentiation, control of differentiation at the level of genome, transcription and post-translation level Concept of embryonic induction: Primary, secondary & tertiary embryonic induction, Neural induction and induction of vertebrate lens.

UNIT IV: Organogenesis (10 Periods)

Neurulation, notogenesis, development of vertebrate eye. Fate of different primary germlayers Development of behaviour: constancy & plasticity, Extra embryonic membranes, placenta in Mammals**.**

SUGGESTED READING AND TEXT BOOKS

1. Gilbert, S. F. (2006). Developmental Biology, VIII Edition, Sinauer Associates, Inc., Publishers, Sunderland, Massachusetts, USA.

2. Balinsky, B.I. (2008). An introduction to Embryology, International Thomson Computer Press.

3. Kalthoff, (2000). Analysis of Biological Development, II Edition, McGraw-Hill Professional.

Course Outcomes (COs): On completion of this course, the students will be:

CO	Descriptin	Bloom's Taxonomy Level
CO1	**Remember** the define the terms and basic concepts of Developmental biology and their different roles in biological systems	1 Remembering
CO2	**Understand** and **Remember** the principle, mechanism of cellular reaction like Gametogenesis and Fertilization, Early embryonic development, Embryonic Differentiation and organogenesis.	1,2 Remembering, Understanding
CO3	**Applying, understanding and remembering** the detailed processes of Gametogenesis and Fertilization, Early embryonic development, Embryonic Differentiation and organogenesis.	1,2,3 Remembering, Understanding, Demonstrating
CO4	**Analyzing, Applying, remembering, Understanding** the detailed processes of structure and function of Gametogenesis and Fertilization, Early embryonic development, Embryonic Differentiation and organogenesis.	1,2,3,4 Remembering, Understanding, Analyzing
CO5	**Evaluating, Analyzing, Applying, remembering, and understanding** the principle, methods, properties and functions of developmental biology.	1,2,3,4,5 Remembering, Understanding, Analyzing, Evaluating
CO6	**Constructing (Creating), Evaluating, Analyzing, demonstrating, remembering, and understanding** the developmental biology.	1,2,3,4,5,6 Remembering, Understanding, Analyzing, Evaluating, Creating

Mapping of COs with POs & PSOs

Course Outcomes	Program Outcomes (POs)												Program Specific Outcomes (PSOs)			
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO1	3	3	1	2	2	2	2	2	3	1	1	1	3	2	1	2
CO2	2	2	2	2	2	2	1	1	3	1	1	1	3	2	1	2
CO3	2	2	3	3	3	3	2	2	2	2	2	2	2	2	2	2
CO4	2	2	3	3	3	3	1	1	3	1	1	1	2	3	2	2
CO5	2	2	3	1	1	1	2	2	3	3	2	1	2	2	2	2
CO6	2	2	1	1	1	1	1	1	3	2	2	1	3	2	2	2

3: High, 2: Medium, 1: Low

B. Sc. (Hons.) Biotechnology

Course code	**: HBTL 103**
Course Name	**: Lab Course Based on HBTG 103**
Semester	**: I**

L	T	P	C
0	0	2	2

Practicals

1. Study of different types of eggs.
2. Development of fate maps in the early embryos.
3. Observation of frog embryos, different developmental stages and life cycle of frog.
4. Identification of developmental stages of chick embryo using permanent mounts.
5. Preparation of a temporary stained mount of chick embryo.
6. Study developmental stages of Anopheles.
7. Demonstration of developmental stages of Drosophila.
8. Study of different types of placenta.
9. Examine the sections of mammalian skin, salivary glands, cartilage and bones.
10. Stages of flower development in plants.

B. Sc. (Hons.) Biotechnology

Course code	**: AECC 101**
Course Name	**: Environmental Science**
Semester	**: I**

L	T	P	C
4	4	0	4

Course Objective: The basic objective of the environmental studies is to enable the students for interdisciplinary approach to complex environmental problems using basic tools of the natural and social sciences including ecosystem, geosystems, biology, chemistry and global process. They will acquire an attitude of concern for the environment and will be able to critically evaluate the science and policy ramifications of diverse portfolios on air and water quality, natural resources etc.

Unit 1: Introduction to Environmental Sciences

Multidisciplinary nature of Environmental Sciences; Scope and importance; Concept of sustainability and sustainable development.

Unit 2: Ecosystems

What is an ecosystem? Structure and function of ecosystem; Energy flow in an ecosystem: food chains, food webs and ecological succession. Case studies of the ecosystems; Forest ecosystem, Grassland ecosystem, Desert ecosystem, Aquatic ecosystems (ponds, streams, lakes, rivers, oceans, estuaries)

Unit 3: Natural Resources: Renewable and Non-renewable Resources

Land resources and land use change; Land degradation, soil erosion and desertification.

Deforestation: Causes and impacts due to mining, dam building on environment, forests, biodiversity and tribal populations. Water: Use and over-exploitation of surface and ground water, floods, droughts, conflicts over water (international & inter-state). Energy resources: Renewable and non renewable energy sources, use of alternate energy sources, growing energy needs, case studies.

Unit 4: Biodiversity and Conservation

Levels of biological diversity : genetic, species and ecosystem diversity; Biogeographic zones of India; Biodiversity patterns and global biodiversity hot spots, India as a mega-

biodiversity nation; Endangered and endemic species of India, Threats to biodiversity: Habitat loss, poaching of wildlife, man-wildlife conflicts, biological, invasions; Conservation of biodiversity: In-situ and Ex-situ conservation of biodiversity. Ecosystem and biodiversity services: Ecological, economic, social, ethical, aesthetic

and Informational value.

Unit 5: Environmental Pollution

Environmental pollution : types, causes, effects and controls; Air, water, soil and noise pollution, Nuclear hazards and human health risks, Solid waste management: Control measures of urban and industrial waste.Pollution case studies.

Unit 6: Environmental Policies & Practices

Climate change, global warming, ozone layer depletion, acid rain and impacts on human communities and agriculture. Environment Laws: Environment Protection Act 1986; Air (Prevention & Control of Pollution) Act 1981; Water (Prevention and control of Pollution) Act 1974; Wildlife Protection Act 1972; Forest Conservation Act 1980. International agreements: Montreal protocol, Kyoto protocol and Convention on Biological Diversity (CBD). Nature reserves, tribal populations and rights, and human wildlife conflicts in Indian context.

Unit 7: Human Communities and the Environment

Human population growth: Impacts on environment, human health and welfare. Resettlement and rehabilitation of project affected persons; case studies. Disaster management: floods, earthquake, cyclones and landslides. Environmental movements:Chipko, Silent valley, Bishnois of Rajasthan.

Environmental ethics: Role of Indian and other religions and cultures in environmentalconservation.

Environmental communication and public awareness, case studies (e.g., CNG vehicles inDelhi).

SUGGESTED READING AND TEXT BOOKS

1. Agarwal, K.C. 2001 Environmental Biology, Nidi Publ. Ltd. Bikaner.
2. Bharucha Erach, The Biodiversity of India, Mapin Publishing Pvt. Ltd., Ahmedabad – 380 013, India, Email:mapin@icenet.net (R).
3. Brunner R.C., 1989, Hazardous Waste Incineration, McGraw Hill Inc. 480p.
4. Clark R.S., Marine Pollution, Clanderson Press Oxford (TB).
5. Cunningham, W.P. Cooper, T.H. Gorhani, E & Hepworth, M.T. 2001, Environmental Encyclopedia, Jaico Publ. House, Mumabai, 1196p

Course Outcomes (COs): On completion of this course, the students will be:

CO	Descriptin	Bloom's Taxonomy Level
CO1	**Remember** the define the terms and basic concepts of environmental biology and their different roles to inflence biological systems.	1 Remembering
CO2	**Understand** and **Remember** the principle, mechanism of cellular reaction like Gametogenesis and Fertilization, Early embryonic development, Embryonic Differentiation and organogenesis.	1,2 Remembering, Understanding
CO3	**Applying, understanding and remembering** the detailed processes of Gametogenesis and Fertilization, Early embryonic development, Embryonic Differentiation and organogenesis.	1,2,3 Remembering, Understanding, Demonstrating
CO4	**Analyzing, Applying, remembering, Understanding** the detailed processes of structure and function of Gametogenesis and Fertilization, Early embryonic development, Embryonic Differentiation and organogenesis.	1,2,3,4 Remembering, Understanding, Analyzing
CO5	**Evaluating, Analyzing, Applying, remembering, and understanding** the principle, methods, properties and functions of developmental biology.	1,2,3,4,5 Remembering, Understanding, Analyzing, Evaluating
CO6	**Constructing (Creating), Evaluating, Analyzing, demonstrating, remembering, and understanding** the developmental biology.	1,2,3,4,5,6 Remembering, Understanding, Analyzing, Evaluating, Creating

Mapping of COs with POs & PSOs

Course Outcomes	Program Outcomes (POs)												Program Specific Outcomes (PSOs)			
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO1	3	3	1	2	2	2	2	2	3	1	1	1	3	2	1	2
CO2	2	2	2	2	2	2	1	1	3	1	1	1	3	2	1	2
CO3	2	2	3	3	3	3	2	2	2	2	2	2	2	2	2	2
CO4	2	2	3	3	3	3	1	1	3	1	1	1	2	3	2	2
CO5	2	2	3	1	1	1	2	2	3	3	2	1	2	2	2	2
CO6	2	2	1	1	1	1	1	1	3	2	2	1	3	2	2	2

3: High, 2: Medium, 1: Low

B. Sc. (Hons.) Biotechnology

Course code	**: HBTC 201**
Course Name	**: Mammalian Physiology**
Semester	**: II**

L	T	P	C
4	4	0	4

Course objective: The objectives of the course are as follows:

1. To examine basic concepts of mammalian physiology
2. To understand mechanisms of digestion, respiration, circulation and endocrine function
3. To explore the physico-chemical basis and operation of each organ system.

UNIT I: Digestion and Respiration (15 Periods)

Digestion: Mechanism of digestion & absorption of carbohydrates, Proteins, Lipids and nucleic acids. Composition of bile, Saliva, Pancreatic, gastric and intestinal juice. Respiration: Exchange of gases, Transport of O2 and CO2, Oxygen dissociation curve, Chloride shift.

UNIT II: Circulation (15 Periods)

Composition of blood, Plasma proteins & their role, blood cells, Haemopoisis, Mechanism of coagulation of blood. Mechanism of working of heart: Cardiac output, cardiac cycle, Origin & conduction of heart beat.

UNIT III: Muscle physiology and osmoregulation (15 Periods)

Structure of cardiac, smooth & skeletal muscle, threshold stimulus.
Physical, chemical & electrical events of mechanism of muscle contraction.
Excretion: modes of excretion, Ornithine cycle, Mechanism of urine formation.

UNIT IV: Nervous and endocrine coordination (15 Periods)

Mechanism of generation & propagation of nerve impulse, structure of synapse, synaptic conduction.

Different endocrine glands– Hypothalamus, pituitary, pineal, thymus, thyroid, parathyroid and adrenals, hypo & hyper-secretions.

SUGGESTED READING AND TEXT BOOKS

1. Guyton, A.C. & Hall, J.E. (2006). Textbook of Medical Physiology. XI Edition. Hercourt Asia PTE Ltd. /W.B. Saunders Company.
2. Tortora, G.J. & Grabowski, S. (2006). Principles of Anatomy & Physiology. XI Edition. John wiley & sons,Inc.

Course Outcomes (COs): On completion of this course, the students will be:

CO	Descriptin	Bloom's Taxonomy Level
CO1	**Remember** the define the terms and basic concepts of mammalian physiology and their different roles to inflence biological body systems.	1 Remembering
CO2	**Understand** and **Remember** the principle, mechanism of cellular reaction like digestion and respiration, muscular system, nervous, endocrine and osmoregulation.	1,2 Remembering, Understanding
CO3	**Applying, understanding and remembering** the detailed processes of digestion and respiration, muscular system, nervous, endocrine and osmoregulation.	1,2,3 Remembering, Understanding, Demonstrating
CO4	**Analyzing, Applying, remembering, Understanding** the detailed structure and function of digestion and respiration, muscular system, nervous, endocrine and osmoregulation.	1,2,3,4 Remembering, Understanding, Analyzing
CO5	**Evaluating, Analyzing, Applying, remembering, and understanding** the principle, methods, properties and functions of mammalian physiology.	1, 2,3,4,5 Remembering, Understanding, Analyzing, Evaluating
CO6	**Constructing (Creating), Evaluating, Analyzing, demonstrating, remembering, and understanding** the mammalian physiology and the awareness and appreciation for mammals/animals in environment, and their diverse physiological functions.	1,2,3,4,5,6 Remembering, Understanding, Analyzing, Evaluating Creating

Mapping of COs with POs & PSOs

Course Outcomes	Program Outcomes (POs)												Program Specific Outcomes (PSOs)			
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO1	3	3	1	2	2	2	2	2	3	1	1	1	3	2	1	2
CO2	2	2	2	2	2	2	1	1	3	1	1	1	3	2	1	2
CO3	2	2	3	3	3	3	2	2	2	2	2	2	2	2	2	2
CO4	2	2	3	3	3	3	1	1	3	1	1	1	2	3	2	2
CO5	2	2	3	1	1	1	2	2	3	3	2	1	2	2	2	2
CO6	2	2	1	1	1	1	1	1	3	2	2	1	3	2	2	2

3: High, 2: Medium, 1: Low

B. Sc. (Hons.) Biotechnology

Course code	**: HBTL 201**
Course Name	**: Lab Course Based on HBTC 201**
Semester	**: II**

L	T	P	C
0	0	2	2

Practicals

1. Determination of Haemoglobin
2. Preparation of temporary slide of a mammalian tissue sample
3. Estimation of bleeding time and clotting time of the human being
4. Identification of blood cells by differential staining
5. Perform differential leukocyte count (DLC) in the blood sample
6. Counting of mammalian RBCs
7. Estimation of blood glucose level by glucometer
8. Identification of blood group in humans
9. Demonstration of action of an enzyme (catalase enzyme)
10. Separation of plasma and serum from the whole blood
11. Study pulmonary function test via online video tutorial

B. Sc. (Hons.) Biotechnology

Course code	**: HBTC 201**
Course Name	**: Plant Physiology**
Semester	**: II**

L	T	P	C
4	4	0	4

Course Objective: The objectives of the course are as follows:

1. To provide detailed information about the basic principles of plant function
2. To teach the plant-water relationships
3. To teach principles of plant cell physiology and plant growth and development
4. To teach carbon and nitrogen metabolism
5. To provide information about plant secondary metabolites and their role in plant stressphysiology

UNIT I: Anatomy (10 Periods)

The shoot and root apical meristem and its histological organization, simple & complex permanent tissues, primary structure of shoot & root, secondary growth, growth rings, leaf anatomy (dorsi-ventral and isobilateral leaf)

UNIT II: Plant water relations and micro & macro nutrients (12 Periods)

Plant water relations: Importance of water to plant life, diffusion, osmosis, plasmolysis, imbibition, guttation, transpiration, stomata & their mechanism of opening & closing. Micro & macro nutrients: criteria for identification of essentiality of nutrients, roles and deficiency systems of nutrients, mechanism of uptake of nutrients, mechanism of food transport

UNIT III: Carbon and nitrogen metabolism (20 Periods)

Photosynthesis- Photosynthesis pigments, concept of two photo systems, photphosphorylation, calvin cycle, CAM plants, photorespiration, compensation point

Nitrogen metabolism- inorganic & molecular nitrogen fixation, nitrate reduction and ammonium assimilation in plants.

UNIT IV: Growth and development (18 Periods)

Growth and development: Definitions, phases of growth, growth curve, growth hormones (auxins, gibberlins, cytokinins, abscisic acid, ethylene) Physiological role and mode of action, seed dormancy and seed germination, concept of photoperiodism

and vernalization

SUGGESTED READING AND TEXT BOOK

1. Dickinson, W.C. 2000 Integrative Plant Anatomy. Harcourt Academic Press, USA.
2. Esau, K. 1977 Anatomy of Seed Plants. Wiley Publishers.
3. Fahn, A. 1974 Plant Anatomy. Pergmon Press, USA and UK.
4. Hopkins, W.G. and Huner, P.A. 2008 Introduction to Plant Physiology. John Wiley and Sons.
5. Mauseth, J.D. 1988 Plant Anatomy. The Benjammin/Cummings Publisher, USA.

Course Outcomes (COs): On completion of this course, the students will be:

CO	Description	Bloom's Taxonomy Level
CO1	**Remember** and define the terms and basic concepts of plant physiology and their different roles to influence biological plant body systems.	1 Remembering
CO2	**Understand** and **Remember** the principle, mechanism of Anatomy, Plant water relations and micro & macro nutrients, Carbon and nitrogen metabolism and Growth and development.	1,2 Remembering, Understanding
CO3	**Applying, understanding and remembering** the detailed processes of Anatomy, Plant water relations and micro & macro nutrients, Carbon and nitrogen metabolism and Growth and development.	1,2,3 Remembering, Understanding, Demonstrating
CO4	**Analyzing, Applying, remembering, Understanding** the detailed study related to Anatomy, Plant water relations and micro & macro nutrients, Carbon and nitrogen metabolism and Growth and development.	1,2,3,4 Remembering, Understanding, Analyzing
CO5	**Evaluating, Analyzing, Applying, remembering, and understanding** the principle, methods, properties and functions of plant physiology.	1, 2,3,4,5 Remembering, Understanding, Analyzing, Evaluating
CO6	**Constructing (Creating), Evaluating, Analyzing, demonstrating, remembering, and understanding** the plant physiology and the awareness and appreciation for plants in environment, and their diverse physiological functions.	1,2,3,4,5,6 Remembering, Understanding, Analyzing, Evaluating Creating

Mapping of COs with POs & PSOs

Course Outcomes	Program Outcomes (POs)												Program Specific Outcomes (PSOs)			
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO1	2	3	1	2	3	3	3	2	3	1	1	1	3	2	1	2
CO2	3	2	2	2	2	2	1	1	3	3	3	3	3	2	1	2
CO3	3	3	3	3	3	3	2	2	3	2	2	2	2	2	2	2
CO4	2	2	3	3	3	3	1	1	3	1	1	1	2	3	2	2
CO5	2	2	3	1	1	1	2	2	3	3	2	1	2	2	2	2
CO6	2	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1

3: High, 2: Medium, 1: Low

B. Sc. (Hons.) Biotechnology

Course code	**: HBTL 202**
Course Name	**: Lab Course Based on HBTC 202**
Semester	**: II**

L	T	P	C
0	0	2	2

Practicals

1. Demonstration of plasmolysis in *Tradescantia* leaves.
2. Determination of water potential of plant tissue.
3. Study stomatal distribution on leaf surfaces and calculation of stomatal index.
4. Study of ascent of sap in plants.
5. Study aerobic respiration in germinating seeds.
6. Separation of photosynthetic pigments by paper chromatography.
7. Chlorophyll and carotenoid quantification via spectrophotometric analysis.
8. Demonstration of photosynthesis in aquatic plant.
9. Determine the presence of starch and sucrose in plants.
10. Determination of transpiration from foliar surface.

B. Sc. (Hons.) Biotechnology

Course code	**: HBTG 203**
Course Name	**: Enterpreneurship Development**
Semester	**: II**

L	T	P	C
4	4	0	4

Course Learning Objectives:

1. To understand the meaning and importance of Entrepreneurship .
2. To understand the various forms of business organisation .
3. To analyze the importance of finance in an enterprise .
4. To analyze the importance of marketing management in an enterprise.
5. To understand the meaning of international business.

UNIT I

INTRODUCTION (10 Periods)

Meaning, Needs and Importance of Entrepreneurship, Promotion of entrepreneurship, Factors influencing entrepreneurship, Features of a successful Entrepreneurship.

UNIT II

ESTABLISHING AN ENTERPRISE (12 Periods)

Forms of Business Organization, Project Identification, Selection of the product, Project formulation, Assessment of project feasibility.

UNIT III

FINANCING THE ENTERPRISE (15 Periods)

Importance of finance / loans and repayments, Characteristics of Business finance, Fixed capital management: Sources of fixed capital, working capital its sources and how to move for loans, Inventory direct and indirect raw materials and its management.

UNIT IV

MARKETING MANAGEMENT (13 Periods)

Meaning and Importance, Marketing-mix, product management – Product line, Product mix, stages of product like cycle, marketing Research and Importance of survey, Physical Distribution and Stock Management.

UNIT V

ENTREPRENEURSHIP AND INTERNATIONAL BUSINESS (10 Periods)

Meaning of International business, Selection of a product, Selection of a market for international business, Export financing, Institutional support for exports.

SUGGESTED READING AND TEXT BOOKS

1. Holt DH. Entrepreneurship: New Venture Creation.
2. Kaplan JM Patterns of Entrepreneurship.
3. Gupta CB, Khanka SS. Entrepreneurship and Small Business Management, Sultan Chand & Sons.

Course Outcomes (COs): On completion of this course, the students will be:

CO	Description	Bloom's Taxonomy Level
CO1	**Remember** and define the terms and basic concepts of entrepreneurship development and their different roles to influencing entrepreneurship, features of a successful Entrepreneurship	1 Remembering
CO2	**Understand** and Remember the introduction and principle, mechanism of entrepreneurship, features, financing the enterprise, marketing management and entrepreneurship and international business.	1,2 Remembering, Understanding
CO3	**Applying,** understanding and remembering the detailed processes of mechanism of entrepreneurship, features, financing the enterprise, marketing management and entrepreneurship and international business.	1,2,3 Remembering, Understanding, Demonstrating
CO4	**Analyzing,** Applying, remembering, understanding the detailed and complete study related to Biotechnological entrepreneurship features for the growth or individual person and society	1,2,3,4 Remembering, Understanding, Analyzing
CO5	**Evaluating,** analyzing, applying, remembering, and understanding the properties of mechanism of entrepreneurship, features, financing the enterprise, marketing management and entrepreneurship and international business.	1, 2,3,4,5 Remembering, Understanding, Analyzing, Evaluating
CO6	**Constructing (Creating), Evaluating, Analyzing, demonstrating, remembering, and understanding** the entrepreneurship and the awareness, appreciation and applicability in environment, and their diverse functions.	1,2,3,4,5,6 Remembering, Understanding, Analyzing, Evaluating Creating

Mapping of COs with POs & PSOs

Course Outcomes	Program Outcomes (POs)												Program Specific Outcomes (PSOs)			
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO1	2	2	2	2	2	2	2	2	3	1	1	1	3	2	1	2
CO2	2	2	2	2	2	2	1	1	3	2	2	2	2	2	1	2
CO3	2	2	2	2	2	2	2	2	3	2	2	2	2	2	2	2
CO4	2	2	2	2	2	2	1	1	3	1	1	1	2	2	2	2
CO5	2	2	3	1	1	1	2	2	3	2	2	1	2	2	2	2
CO6	2	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1

3: High, 2: Medium, 1: Low

B. Sc. (Hons.) Biotechnology

Course code	**: HBTL 203**
Course Name	**: Lab Course Based on HBTG 203**
Semester	**: II**

L	T	P	C
0	0	2	2

Practical

1. Assessing entrepreneur potential

2. Assessment of problem solving ability

4. Conducting market survey to know the demands for different products

6. Preparing project proposals

7. Individual and group presentations and evaluation of presentation

9. Conducting meeting – Purpose, procedure, participation, physical arrangements, recording and writing of minutes of meeting

10. Seminar and conferences : Use of body language

11. Conducting mock interviews – testing initiative, team spirit and leadership

12. Group discussion and debates on current topics

13. Visit to entrepreneurship institute/ case study of successful entrepreneurs

14. Presentations by the students

B. Sc. (Hons.) Biotechnology

Course code	**: AECC 202**
Course Name	**: English Communication**
Semester	**: II**

L	T	P	C
4	4	0	4

Course Objectives:

1. To define and explain various techniques of word formation; and develop skills of sensiblewriting and vocabulary building.
2. To illustrate and elaborate fundamental techniques and features of writing skills.
3. To demonstrate and discuss various types of common errors committed by users of English and solve exercises to develop their understanding in use of grammatically correct sentences.
4. To organize language lab activities and workshops to develop oral communication skills

Unit 1: Theory of Communication, Types and Modes of Communication: (8 Periods)

Introduction, Definitions and Function of Communication, Needs for Effective Communication, Process of Communication, Barrier to Communication, Kinds of Communication; Intrapersonal, Personal, Group and Mass, Verbal and Non-verbal Communication.

Unit 2: Listening and Speaking Skills: (8 Periods)

Types of Listening, Developing Effective Listening Skills, Academic Listening (Lectures), Listening to Talks and Presentation, Monologue, Dialogue, Group Discussion, Miscommunication, Interview, Public Speech, Pronunciation, Accent and Intonation and Rhythm.

Unit 3: Reading Skills: (8 Periods)

Skimming, Scanning, Summary, Paraphrasing, Comprehension.

Unit 4: Introductory English Grammar: (8 Periods)

Parts of Speech, Tenses, Punctuation, Common Errors in English.

Unit 5: Writing Skills; Social and Official Correspondence: (8 Periods)

Enquiries, Complaints and Replies, Letters to the Editor, Social Appeals in the Form of Letter/ Pamphlets, Standard Business Letter, Email Drafting and Etiquettes, Preparing Agenda and Writing Minutes for Meetings.

Unit 6: Career Skills: (8 Periods)

Job Application, Cover Letter, Bio-data, CV and Resume and Effective Profiling, Mock Interviews, Group Discussions.

SUGGESTED READINGS AND TEXT BOOKS

1. Fluency in English- Part II, Oxford University Press, 2006.

2. Business English, Pearson, 2008.

3. Language, Literature and Creativity, Orient Blackswan, 2013.

4. Language through Literature (Forthcoming) ed. Dr. Gauri Mishra, Dr. RanjhanaKaul, Dr. Brati Biswas.

Course Outcomes (COs): On completion of this course, the students will be:

CO	Description	Bloom's Taxonomy Level
CO1	**Remember** the different techniques of word formation; and demonstrate knowledge of synonyms, antonyms and skills of sensible writing.	1 Remembering
CO2	**Understand** and remember the principle, mechanism of Communication skills, essential techniques and features of effective writing and **make use of** them in written communication.	1,2 Remembering, Understanding
CO3	**Applying,** understanding and remembering the detailed processes of essential techniques and features of effective writing and make use of them in written communication. Knowledge of synonyms, antonyms and skills of sensible writing.	1,2,3 Remembering, Understanding, Demonstrating
CO4	**Analyzing,** applying, remembering, understanding the detailed study related common errors in English and solve exercises based on them; apply acquired knowledge and skills of oral and written communication in personal and professional life.	1,2,3,4 Remembering, Understanding, Analyzing
CO5	**Evaluating,** analyzing, applying, remembering, and understanding the principle, methods, properties and functions of plant physiology.	1, 2,3,4,5 Remembering, Understanding, Analyzing, Evaluating
CO6	**Constructing (Creating),** Evaluating, Analyzing, demonstrating, remembering, and understanding the **Take part in** individual and group communication activities; and **determine** and **invent** new forms and methods of communication to as per the situation.	1,2,3,4,5,6 Remembering, Understanding, Analyzing, Evaluating Creating

Mapping of COs with POs & PSOs

Course Outcomes	Program Outcomes (POs)												Program Specific Outcomes (PSOs)			
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO1	2	2	3	2	2	3	3	2	3	1	1	1	3	2	1	2
CO2	3	2	2	2	2	2	1	1	3	3	3	3	3	2	1	2
CO3	3	2	3	3	3	3	2	2	3	2	2	2	2	2	2	2
CO4	2	2	3	3	2	3	1	1	3	1	1	1	2	3	2	2
CO5	2	2	3	1	1	1	2	2	3	3	2	1	2	2	2	2
CO6	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2

3: High, 2: Medium, 1: Low

B. Sc. (Hons.) Biotechnology

Course code	**: HBTC 301**
Course Name	**: Genetics**
Semester	**: III**

L	T	P	C
4	4	0	4

Course objectives: The objectives of the course are as follows:

1. To make the student understand the Mendelian and non-Mendelian genetics of inheritance.
2. To make the student understand the allele and gene interactions.
3. To make the student learn the fundamentals of chromosome and gene organization.
4. To impart the knowledge about sex determination among humans and animals.
5. To teach the concepts of extra-chromosomal inheritance

UNIT I (12 Periods)

Introduction: Historical developments in the field of genetics. Organisms suitable for genetic experimentation and their genetic significance. Cell Cycle: Mitosis and Meiosis: Control points in cell-cycle progression in yeast. Role of meiosis in life cycles of organisms. Mendelian genetics : **Mendel's experimental design, monohybrid, di**-hybrid and tri hybrid crosses, Law of segregation & Principle of independent assortment.

UNIT II (18 Periods)

Chromosome and genomic organization: Eukaryotic nuclear genome nucleotide sequence composition –unique & repetitive DNA, satellite DNA.

Structure and characteristics of bacterial and eukaryotic chromosome, chromosome morphology, concept of euchromatin and heterochromatin. packaging of DNA molecule into chromosomes, chromosome banding pattern, karyotype, giant chromosomes, one gene one polypeptide hypothesis, concept of cistron, exons, introns, genetic code, gene function.

UNIT III (15 Periods)

Chromosome and gene mutations: Definition and types of mutations, causes of mutations, Ames test for mutagenic agents, screening procedures for isolation of mutants and uses of mutants, variations in chromosomes structure.

Sex determination and sex linkage: Mechanisms of sex determination, Environmental factors and sex determination, sex differentiation, Barr bodies, dosage compensation, genetic balance theory, Fragile-X-syndrome and chromosome, sex influenced dominance, sex limited gene expression, sex linked inheritance.

UNIT IV (15 Periods)

Genetic linkage, crossing over and chromosome mapping: Linkage and Recombination of genes in a chromosome crossing over, Cytological basis of crossing over, Molecular mechanism of crossing over, Crossing over at four strand stage, Multiple crossing overs Genetic mapping. Extra chromosomal inheritance: Rules of extra nuclear inheritance, maternal effects, maternal inheritance, cytoplasmic inheritance, organelle heredity, genomic imprinting. Evolution and population genetics: In breeding and out breeding, Hardy Weinberg law (prediction, derivation), allelic and genotype frequencies, changes in allelic frequencies, systems of mating, evolutionary genetics, natural selection.

SUGGESTED READING AND TEXT BOOKS

1. Gardner, E.J., Simmons, M.J., Snustad, D.P. (2006). Principles of Genetics. VIII Edition John Wiley & Sons.
2. Snustad, D.P., Simmons, M.J. (2009). Principles of Genetics. V Edition. John Wiley and Sons Inc.
3. Klug, W.S., Cummings, M.R., Spencer, C.A. (2009). Concepts of Genetics. IX Edition. Benjamin Cummings.
4. Russell, P. J. (2009). Genetics- A Molecular Approach. III Edition. Benjamin Cummings.
5. Griffiths, A.J.F., Wessler, S.R., Lewontin, R.C. and Carroll, S.B. IX Edition. Introduction to Genetic Analysis, W. H. Freeman & Co.

Course Outcomes (COs): On completion of this course, the students will be:

CO	Description	Bloom's Taxonomy Level
CO1	**Remember** the different concept of genetics, Mendelian and non-Mendelian genetics of inheritance, Chromosome and genomic organization, Chromosome and gene mutations and Genetic linkage, crossing over and chromosome mapping.	1 Remembering
CO2	**Understand** and remember the different concept of genetics, Mendelian and non-Mendelian genetics of inheritance, Chromosome and genomic organization, Chromosome and gene mutations and Genetic linkage, crossing over and chromosome mapping.	1,2 Remembering, Understanding
CO3	**Applying,** understanding and remembering the detailed processes, essential techniques and features of effective concept of genetics, Mendelian and non-Mendelian genetics of inheritance, Chromosome and genomic organization, Chromosome and gene mutations and Genetic linkage, crossing over and chromosome mapping.	1,2,3 Remembering, Understanding, Demonstrating
CO4	**Analyzing,** applying, remembering and understanding the detailed study related to different concept of genetics, Mendelian and non-Mendelian genetics of inheritance, Chromosome and genomic organization, Chromosome and gene mutations and Genetic linkage, crossing over and chromosome mapping.	1,2,3,4 Remembering, Understanding, Analyzing
CO5	**Evaluating,** analyzing, applying, remembering, and understanding the principle, methods, properties and functions genetics, Mendelian and non-Mendelian genetics of inheritance, Chromosome and genomic organization, Chromosome and gene mutations and Genetic linkage, crossing over and chromosome mapping.	1, 2,3,4,5 Remembering, Understanding, Analyzing, Evaluating
CO6	**Constructing (Creating),** Evaluating, Analyzing, demonstrating, remembering, and understanding the **Take part in** individual and group to different concept of genetics, Mendelian and non-Mendelian genetics of inheritance, Chromosome and genomic organization, Chromosome and gene mutations and Genetic linkage, crossing over and chromosome mapping.	1,2,3,4,5,6 Remembering, Understanding, Analyzing, Evaluating Creating

Mapping of COs with POs & PSOs

Course Outcomes	Program Outcomes (POs)												Program Specific Outcomes (PSOs)			
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO1	3	2	3	2	2	3	3	2	3	1	1	1	3	2	1	2
CO2	3	2	2	2	2	2	1	1	3	3	3	3	3	2	1	2
CO3	2	2	2	2	3	3	2	2	3	2	2	2	2	2	2	2
CO4	2	2	3	3	2	3	2	2	3	1	1	1	2	3	2	2
CO5	2	2	3	2	2	2	2	2	3	3	2	1	2	2	2	2
CO6	2	2	3	3	2	2	2	2	3	3	2	2	2	3	3	2

3: High, 2: Medium, 1: Low

B. Sc. (Hons.) Biotechnology

Course code	**: HBTL 301**
Course Name	**: Lab Course Based on HBTC 301**
Semester	**: III**

L	T	P	C
0	0	2	2

Practicals

1. Safety guidelines of genetics laboratory and good laboratory practices.
2. Bacterial conjugation for genetic recombination.
3. Isolation of *E. coli* mutants by UV irradiation.
4. Pedigree charts of some common characters like blood group, color blindness and PTC tasting.
5. Simulation of genetic drift in an isolated population.
6. Karyotyping with the help of photographs
7. Polyploidy in onion root tip cells by colchicine treatment.
8. Preparation of the pedigree chart of blood group.
9. Permanent and temporary mount of mitosis.
10. Permanent and temporary mount of meiosis.
11. Mendelian deviations in dihybrid crosses
12. Demonstration of - Barr Body -*Rhoeo* translocation.
13. Study of polyploidy in onion root tip by colchicine treatment.

B. Sc. (Hons.) Biotechnology

Course code	**: HBTC 302**
Course Name	**: General Microbiology**
Semester	**: III**

L	T	P	C
4	4	0	4

Course objectives: This course is designed to be an introduction to microbiology that will familiarize students with the diversity within the microbial world, biology of bacteria, their metabolism and genetics, and their control. The specific objectives are:

1. To illustrate the criteria used for classification of microorganisms
2. To explain the structure of a prokaryotic cell
3. To give an overview of growth, nutrition and metabolism in bacteria
4. To illustrate the concepts of bacterial recombination

UNIT I (10 Periods)

Fundamentals, History and Evolution of Microbiology.

Classification of microorganisms: Microbial taxonomy, criteria used including molecular approaches, Microbial phylogeny and current classification of bacteria.

Microbial Diversity: Distribution and characterization Prokaryotic and Eukaryotic cells, Morphology and cell structure of major groups of microorganisms eg. Bacteria, Algae, Fungi, Protozoa and Unique features of viruses.

UNIT II (10 Periods)

Cultivation and Maintenance of microorganisms: Nutritional categories of micro-organisms, methods of isolation, Purification and preservation.

UNIT III (20 Periods)

Microbial growth: Growth curve, Generation time, synchronous batch and continuous culture, measurement of growth and factors affecting growth of bacteria.

Microbial Metabolism: Metabolic pathways, amphi-catabolic and biosynthetic pathways

Bacterial Reproduction: Transformation, Transduction and Conjugation. Endospores and sporulation in bacteria.

UNIT IV (20 Periods)

Control of Microorganisms: By physical, chemical and chemotherapeutic Agents

Water Microbiology: Bacterial pollutants of water, coliforms and non coliforms. Sewage composition and its disposal.

Food Microbiology: Important microorganism in food Microbiology: Moulds, Yeasts, bacteria. Major food born infections and intoxications, Preservation of various types of foods. Fermented Foods.

SUGGESTED READING AND TEXT BOOKS

1. Alexopoulos CJ, Mims CW, and Blackwell M. (1996). Introductory Mycology. 4 th edition. John and Sons, Inc.
2. Jay JM, Loessner MJ and Golden DA. (2005). *Modern Food Microbiology*. 7thedition, CBS Publishers and Distributors, Delhi, India.
3. Kumar HD. (1990). Introductory Phycology. 2nd edition. Affiliated East Western Press.
4. Madigan MT, Martinko JM and Parker J. (2009). Brock Biology of Microorganisms. 12th edition. Pearson/Benjamin Cummings.
5. Pelczar MJ, Chan ECS and Krieg NR. (1993). Microbiology. 5th edition. McGraw Hill Book Company.
6. Stanier RY, Ingraham JL, Wheelis ML, and Painter PR. (2005). General Microbiology. 5th edition. McMillan.
7. Tortora GJ, Funke BR, and Case CL. (2008). Microbiology: An Introduction. 9 th edition. Pearson
8. **Willey JM, Sherwood LM, and Woolverton CJ. (2008). Prescott, Harley and Klein's** Microbiology. 7th edition. McGraw Hill Higher Education.

Course Outcomes (COs): On completion of this course, the students will be:

CO	Description	Bloom's Taxonomy Level
CO1	**Remember** the different concept of fundamentals, History and Evolution of Microbiology, microbial diversity, Cultivation and Maintenance of microorganisms, Microbial growth, Microbial Metabolism, Bacterial Reproduction, Control of Microorganisms, water microbiology and food microbiology.	1 Remembering
CO2	**Understand** and remember the concept of fundamentals, History and Evolution of Microbiology, microbial diversity, Microbial growth, Microbial Metabolism, Bacterial Reproduction, Control of Microorganisms, water microbiology, food microbiology and Cultivation and Maintenance of microorganisms.	1,2 Remembering, Understanding
CO3	**Applying,** understanding and remembering the detailed processes, essential techniques and features of microbiology, genetic recombination in microbiology, diversity and metabolism of microbiology along with Control of pathogenic microorganisms, water microbiology and food microbiology.	1,2,3 Remembering, Understanding, Demonstrating
CO4	**Analyzing,** applying, remembering and understanding the detailed study related to different concept of microbiology, genetic recombination in microbiology, diversity and metabolism of microbiology along with Control of pathogenic microorganisms, water microbiology and food microbiology.	1,2,3,4 Remembering, Understanding, Analyzing
CO5	**Evaluating,** analyzing, applying, remembering, and understanding the principle, methods, properties and functions of essential techniques and features of microbiology, genetic recombination in microbiology, diversity and metabolism of microbiology along with Control of pathogenic microorganisms, water microbiology and food microbiology.	1, 2,3,4,5 Remembering, Understanding, Analyzing, Evaluating
CO6	**Constructing (Creating),** Evaluating, Analyzing, demonstrating, remembering, and understanding the Take part in essential techniques and features of microbiology, genetic recombination in microbiology, diversity and metabolism of microbiology along with Control of pathogenic microorganisms, water microbiology and food microbiology.	1,2,3,4,5,6 Remembering, Understanding, Analyzing, Evaluating Creating

Mapping of COs with POs & PSOs

Course Outcomes	Program Outcomes (POs)												Program Specific Outcomes (PSOs)			
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO1	3	2	3	2	2	3	3	2	3	2	2	2	3	2	1	2
CO2	3	2	2	3	3	2	1	3	3	3	3	3	3	2	1	2
CO3	3	3	2	2	3	3	2	2	3	2	2	2	2	2	2	2
CO4	3	3	3	3	2	3	2	2	3	1	1	1	2	3	2	2
CO5	3	2	3	2	2	2	2	2	3	3	2	3	2	2	2	2
CO6	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

3: High, 2: Medium, 1: Low

B. Sc. (Hons.) Biotechnology

Course code	**: HBTL 302**
Course Name	**: Lab Course Based on HBTC 302**
Semester	**: III**

L	T	P	C
0	0	2	2

Practicals

1. Preparation and sterilization of media for bacterial culture.
2. Isolation of bacteria from the soil.
3. Preparation of pure culture of bacteria.
4. Streaking of bacterial culture.
5. Gram staining of bacteria.
6. Determination of bacterial cell size by micrometry.
7. Enumeration of microorganisms.
8. Preparation of bacterial growth curve.
9. Antimicrobial sensitivity test.
10. Demonstration of flagella staining.

B. Sc. (Hons.) Biotechnology

Course code	**: HBTC 303**
Course Name	**: Chemistry- I**
Semester	**: III**

L	T	P	C
4	4	0	4

Course objectives: The course aims to teach the principles of chemistry. The specific objectives of the course are:

1. To teach students the basic concepts of chemistry.
2. To make students understand the importance of chemistry in sustainable development.
3. To teach students the fundamental principles of biocatalysis, photochemistry and electrochemistry.
4. To teach students about chemistry in daily practice

UNIT I (18 Periods)

Stereochemistry: Writing of Fischer projection, Newmann and Sawhorse projection and Wedge formulae. Interconversion of one type of structural representation into another type. Conformation: Restricted rotation about single bonds, Various conformations of ethane, butane and cyclohexane. Relative stability of different conformations in terms of energy difference is to be discussed for all these compounds. Geometrical Isomerism: Requirements for a molecule to show geometrical isomerism, Cis-Trans and E/ Z notation along with CIP rules for geometrical isomers. Optical Isomerism: Optical activity, specific and molar rotation, chirality, enantiomerism, diastereoisomerism, racemic mixtures and their resolution by salt formation method. Relative and absolute configuration: D / L nomenclature system for configuration of carbohydrates (difference between d/l and D/L notations). Threo and Erythro designation. R and Sconfiguration (upto two chiral centres).

UNIT II (10 periods)

Alkenes and Alkynes: Hydrogenation, addition of halogens, Hydrohalogenation (M**arkovnikov's and** anti-**Markovnikov's addition), hydration, hydroxylation (cis and trans),** oxymercurationdemercuration, hydroboration-oxidation, ozonolysis. Reactivity of alkenes vs alkynes. Aldehydes and ketones: (formaldehyde, acetaldehyde, benzaldehyde, acetone) Addition of sodium bisulphite, hydrogen cyanide and alcohols. Addition- elimination reactions with ammonia and its derivatives Name reactions: Aldol, cross Aldol, Claisen, Knoevengel, Cannizzaro, cross Cannizzaro

UNIT III (15 Periods)

Free radical substitution reactions: Halogenation of alkanes, allylic compounds and alkylbenzenes. Nucleophilic substitution reactions: Alkyl, allyl and benzyl halides – substitution of halogen by some common nucleophiles. Mechanism of SN1 and SN2 reactions (stereochemistry, nature of substrate, nucleophile and leaving group) Benzene diazonium chloride: Replacement of diazo group Alcohols,

amines and phenols: Substitution of active hydrogen, replacement of hydroxyl group in alcohols (using PCl5, SOCl2 and HI) Carboxylic acid derivatives: Hydrolysis Ethers: Cleavage by HI Electrophilic Substitution Reactions (aromatic compounds): General mechanism of electrophilic substitution reactions (nitration, halogenation, sulphonation, Friedel Crafts alkylation and acylation), directive influence of substituents.

UNIT IV (17 Periods)

Elimination Reactions: Alkyl halides (dehydrohalogenation, Saytzeff's rule), vicinal dihalides (dehalogenation), alcohols (dehydration), Quaternary ammonium salts (Hofmann's elimination). Mechanism of E1 and E2 reactions (nature of substrate and base), elimination vs substitution. Oxidation Aromatic side chain: Oxidation with potassium permanganate, potassium dichromate Alcohols: Oxidation with potassium permanganate, potassium dichromate, catalytic dehydrogenation and Oppenauer oxidation. Oxidation of 1,2–diols with periodic acid and lead tetraacetate. Aldehydes: Oxidation with potassium permanganate, chromic acid and Tollen's reagent Ketones: Oxidation with potassium permanganate, sodium hypoiodite (iodoform reaction) and Baeyer–Villiger oxidation Reductions Aldeydes and Ketones: Catalytic hydrogenation, reduction with sodium borohydride, lithium aluminium hydride, Clemmensen, Wolff-Kishner Carboxylic acids and their derivatives: Lithium aluminium hydride, sodium-ethanol and Rosenmund reduction. Nitro compounds: Acidic, alkaline and neutral reducing agents, lithium aluminium hydride and electrolytic reduction.

SUGGESTED READING AND TEXT BOOKS

1. Furniss, B.S.; Hannaford, A.J.; Smith, P.W.G.; Tatchell, A.R. Practical OrganicChemistry, 5th Ed., Pearson (2012).
2. Mann, F.G. & Saunders, B.C. Practical Organic Chemistry, Longman, London & New York.
3. Ahluwalia, V.K.; Dhingra, S. & Gulati, A. College Practical Chemistry, Universities Press.
4. I. L. Finar: Organic Chemistry (Vol. I & II), E. L. B. S.
5. R. T. Morrison & R. N. Boyd: Organic Chemistry, Pearson Education.
6. Arun Bahl and B. S. Bahl : Advanced Organic Chemistry, S. Chand
7. Peter Sykes: A Guide Book to Mechanism in Organic Chemistry, Orient Longman.
8. Eliel, E. L. & Wilen, S. H. Stereochemistry of Organic Compounds; Wiley: London, 1994.
10. **T. W. Graham Solomon's Organic Chemistry, John Wiley and Sons.**
11. P.S. Kalsi, Stereochemistry, Conformation and Mechanism, John Wiley and Sons.

D. Nasipuri, Stereochemistry of Organic Compounds, New Age International Publishers.

Course Outcomes (COs): On completion of this course, the students will be:

CO	Description	Bloom's Taxonomy Level
CO1	**Remember** the different basic concepts of chemistry: stereochemistry, alkenes and alkynes, Aldehydes and ketones, Free radical substitution reactions, Nucleophilic substitution reactions, Electrophilic Substitution Reactions, Elimination Reactions and the different functional groups.	1 Remembering
CO2	**Understand** and remember the **specific** concepts of chemistry: stereochemistry, alkenes and alkynes, Aldehydes and ketones, Free radical substitution reactions, Nucleophilic substitution reactions, Electrophilic Substitution Reactions, Elimination Reactions and the different functional groups.	1,2 Remembering, Understanding
CO3	**Applying,** understanding and remembering the detailed processes, essential techniques and features of concepts of chemistry: stereochemistry, alkenes and alkynes, Aldehydes and ketones, Free radical substitution reactions, Nucleophilic substitution reactions, Electrophilic Substitution Reactions, Elimination Reactions and the different functional groups.	1,2,3 Remembering, Understanding, Demonstrating
CO4	**Analyzing,** applying, remembering and understanding the detailed study related to concepts of chemistry: stereochemistry, alkenes and alkynes, Aldehydes and ketones, Free radical substitution reactions, Nucleophilic substitution reactions, Electrophilic Substitution Reactions, Elimination Reactions and the different functional groups.	1,2,3,4 Remembering, Understanding, Analyzing
CO5	**Evaluating,** analyzing, applying, remembering, and understanding the principle, methods, properties and functions of chemistry: stereochemistry, alkenes and alkynes, Aldehydes and ketones, Free radical substitution reactions, Nucleophilic substitution reactions, Electrophilic Substitution Reactions, Elimination Reactions and the different functional groups.	1, 2,3,4,5 Remembering, Understanding, Analyzing, Evaluating
CO6	**Constructing (Creating),** Evaluating, Analyzing, demonstrating, remembering, and understanding the Take part in essential techniques and features of chemistry: stereochemistry, alkenes and alkynes, Aldehydes and ketones, Free radical substitution reactions, Nucleophilic substitution reactions, Electrophilic Substitution Reactions, Elimination Reactions and the different functional groups.	1,2,3,4,5,6 Remembering, Understanding, Analyzing, Evaluating Creating

Mapping of COs with POs & PSOs

Course Outcomes	Program Outcomes (POs)												Program Specific Outcomes (PSOs)			
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO1	2	2	3	2	2	3	3	2	3	2	2	2	3	2	1	2
CO2	2	2	2	3	3	2	1	3	2	2	2	2	2	2	1	2
CO3	2	3	2	2	3	3	2	2	3	2	2	2	2	2	2	2
CO4	3	2	2	3	2	3	2	2	3	1	1	1	2	3	2	2
CO5	3	2	3	2	2	2	2	2	3	3	2	3	2	2	2	2
CO6	2	2	2	2	2	2	2	2	2	1	1	2	2	2	2	2

3: High, 2: Medium, 1: Low

B. Sc. (Hons.) Biotechnology

Course code	**: HBTL 303**
Course Name	**: Lab Course Based on HBTC 303**
Semester	**: III**

L	T	P	C
0	0	2	2

Practicals

1. Purification of organic compounds by crystallization using the following solvents: (a) Water (b) Alcohol

2. Determination of the melting points of organic compounds (by Kjeldahl method and electrically heated melting point apparatus).

3. Determination of optical- 1g of starting compound. Recrystallize the product and determine the melting point of activity by using polarimeter Organic preparations: Carry out the following preparations using 0.5 the recrystallized sample.

4. To prepare acetanilide by the acetylation of aniline.

5. To prepare p-bromoacetanilide.

6. Benzolyation of aniline or β-naphthol by Schotten-Baumann reaction

7. Hydrolysis of benzamide or ethyl bezoate.

8. Semicarbazone derivative of one the following compounds: acetone, ethyl methylketone, diethylketone, cyclohexanone, benzaldehyde.

9. Nitration of nitrobenzene.

10. Oxidation of benzaldehyde by using alkaline potassium permanganate.

B. Sc. (Hons.) Biotechnology

Course code	**: HBTG 304**
Course Name	**: Bioethics and Biosafety**
Semester	**: III**

L	T	P	C
4	4	0	4

Course Objectives: The objectives of the course are as follows:

1. To understand importance of bioethics and biosafety.
2. To understand legal social and economic impacts of biotechnology.
3. To understand regulatory guidelines and their importance.
4. To understand importance of patent.
5. To understand procedure to apply for patent.
6. To understand procedure of assessment of biosafety for biotech foods.
7. To understand ethical implications of biotechnology.

UNIT-I (15 Periods)

Introduction to Indian Patent Law. World Trade Organization and its related intellectual property provisions. Intellectual/Industrial property and its legal protection in research, design and development. Patenting in Biotechnology, economic, ethical and depository considerations.

UNIT II (20 Periods)

Entrepreneurship: Selection of a product, line, design and development processes, economics on material and energy requirement, stock the product and release the same for making etc. The basic regulations of excise: Demand for a given product, feasibility of its production under given constraints of raw material, energy input, financial situations export potential etc.

UNIT III (10 Periods)

Bioethics – Necessity of Bioethics, different paradigms of Bioethics – National & International. Ethical issues against the molecular technologies.

UNIT IV (15 Periods)

Biosafety– Introduction to biosafety and health hazards concerning biotechnology. Introduction to the concept of containment level and Good Laboratory Practices (GLP) and Good Manufacturing Practices (GMP).

SUGGESTED READING AND TEXT BOOKS

1. Entrepreneurship: New Venture Creation : David H. Holt
2. Patterns of Entrepreneurship : Jack M. Kaplan
3. Entrepreneurship and Small Business Management: C.B. Gupta, S.S. Khanka, Sultan Chand & Sons.
4. Sateesh MK (2010) Bioethics and Biosafety, I. K. International Pvt Ltd.
5. Sree Krishna V (2007) Bioethics and Biosafety in Biotechnology, New age international publishers.

Course Outcomes (COs): On completion of this course, the students will be:

CO	Description	Bloom's Taxonomy Level
CO1	**Remember** the different basic concepts of introduction to Indian Patent Law, IPR Entrepreneurship, the basic regulations of excise, Bioethics and Biosafety.	1 Remembering
CO2	**Understand** and remember the specific and basic concepts of Indian Patent Law, IPR Entrepreneurship, the basic regulations of excise, Bioethics and Biosafety, Good Laboratory Practices (GLP) and Good Manufacturing Practices (GMP).	1,2 Remembering, Understanding
CO3	**Applying,** understanding and remembering the detailed processes, essential techniques and features of Patent Law, IPR Entrepreneurship, the basic regulations of excise, Bioethics and Biosafety, Good Laboratory Practices (GLP) and Good Manufacturing Practices (GMP).	1,2,3 Remembering, Understanding, Demonstrating
CO4	**Analyzing,** applying, remembering and understanding the detailed study related to concepts of Patent Law, IPR Entrepreneurship, the basic regulations of excise, Bioethics and Biosafety, Good Laboratory Practices (GLP) and Good Manufacturing Practices (GMP).	1,2,3,4 Remembering, Understanding, Analyzing
CO5	**Evaluating,** analyzing, applying, remembering, and understanding the principle, methods, properties and functions of Patent Law, IPR Entrepreneurship, the basic regulations of excise, Bioethics and Biosafety, Good Laboratory Practices (GLP) and Good Manufacturing Practices (GMP).	1, 2,3,4,5 Remembering, Understanding, Analyzing, Evaluating
CO6	**Constructing (Creating),** Evaluating, Analyzing, demonstrating, remembering, and understanding the Take part in essential techniques and features of Patent Law, IPR Entrepreneurship, the basic regulations of excise, Bioethics and Biosafety, Good Laboratory Practices (GLP) and Good Manufacturing Practices (GMP).	1,2,3,4,5,6 Remembering, Understanding, Analyzing, Evaluating Creating

Mapping of COs with POs & PSOs

Course Outcomes	Program Outcomes (POs)												Program Specific Outcomes (PSOs)			
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO1	3	2	3	2	2	3	3	2	3	2	2	2	3	2	1	2
CO2	2	3	2	2	2	2	1	3	2	3	3	3	2	2	1	2
CO3	2	3	2	2	3	3	2	2	3	2	3	3	2	2	3	2
CO4	3	2	2	3	2	3	2	2	3	1	1	1	2	3	2	2
CO5	3	2	2	2	2	2	2	2	3	3	2	3	2	2	2	2
CO6	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2

3: High, 2: Medium, 1: Low

B. Sc. (Hons.) Biotechnology

Course code	**: HBTL 304**
Course Name	**: Lab Course Based on HBTG 304**
Semester	**: III**

L	T	P	C
0	0	2	2

Practicals

1. Study of basic laboratories: Biosafety Levels (BSL) 1 and 2.
2. Case study on clinical trials of drugs in India with emphasis on ethical issues.
3. Study of containment laboratories: Biosafety Level (BSL) 3.
4. Case study on women health ethics.
5. Planning of establishing a hypothetical biotechnology industry in India.
6. Study the maximum containment laboratory: Biosafety Level (BSL) 4.
7. Case study on medical errors and negligence.
8. Case study on handling and disposal of radioactive waste.
9. Study laboratory hazards: Fire hazards, Electrical Hazards, Noise, Ionizing hazards.
10. Transgenic animals/plants: Their effects on environment and health of the consumer.

B. Sc. (Hons.) Biotechnology

Course code	**: HBTS 305**
Course Name	**: Industrial Fermentations**
Semester	**: III**

L	T	P	C
4	4	0	4

Course objectives: The specific objectives of the course are as follows:

1. To familiarize students with the production of industrial chemicals.
2. To impart knowledge about metabolic engineering of secondary metabolism.
3. To teach students about the enzyme and cell immobilization techniques relevant to industrialprocessing.
4. To make students understand the different methods of experimental model for design offermentation systems.
5. To teach about the enzyme kinetics used in fermentation technology.

UNIT I (12 Periods)

Production of industrial chemicals, biochemicals and chemotherapeutic products. Propionic acid, butyric acid, 2-3 butanediol, gluconic acid, itaconic acid, Biofuels: Biogas, Ethanol, butanol, hydrogen, biodiesel, microbial electricity, starch conversion processes; Microbial polysaccharides; Microbial insecticides; microbial flavours and fragrances, newer antibiotics, anti cancer agents, amino acids.

UNIT II (15 Periods)

Microbial products of pharmacological interest, steriod fermentations and transformations. Over production of microbial metabolite, Secondary metabolism – its significance and products. Metabolic engineering of secondary metabolism for highest productivity. Enzyme and cell immobilization techniques in industrial processing, enzymes in organic synthesis, proteolytic enzymes, hydrolytic enzymes, glucose isomerase, enzymes in food technology/organic synthesis.

UNIT III (13 Periods)

Purification & characterization of proteins, Upstream and downstream processing, solids and liquid handling. Distribution of microbial cells, centrifugation, filtration of fermentation broth, ultra centrifugation, liquid extraction, ion-exchange recovery of biological products. Experimental model for design of fermentation systems, Anaerobic fermentations.

UNIT IV (20 Periods)

Rate equations for enzyme kinetics, simple and complex reactions. Inhibition kinetics; effect of pH and temperature on rate of enzyme reactions. Mathematical derivation of growth kinetics, mathematical derivations of batch and continuous culture operations; single stage CSTR; mass transfer in aerobic fermentation; resistances encountered; overall mass transfer co-efficient (Ka) determination, factors depending on scale up principle and different methods of scaling up. Metabolic engineering of antibiotic biosynthetic pathways.

SUGGESTED READING AND TEXT BOOKS

1. Casida LE. (1991). Industrial Microbiology. 1st edition. Wiley Eastern Limited.
2. Crueger W and Crueger A. (2000). Biotechnology: A textbook of Industrial Microbiology. 2nd edition. Panima Publishing Co. New Delhi.
3. Patel AH. (1996). Industrial Microbiology. 1st edition, Macmillan India Limited.

Course Outcomes (COs): On completion of this course, the students will be:

CO	Description	Bloom's Taxonomy Level
CO1	**Remember** the different basic concepts of introduction to production of industrial chemicals, biochemicals and chemotherapeutic products, Microbial products of pharmacological interest, Enzyme and cell immobilization techniques in industrial processing, purification of products and enzymes, enzyme kinetics.	1 Remembering
CO2	**Understand** and remember the specific and basic concepts of industrial chemicals, biochemicals and chemotherapeutic products, Microbial products of pharmacological interest, Enzyme and cell immobilization techniques in industrial processing, purification of products and enzymes, enzyme kinetics.	1,2 Remembering, Understanding
CO3	**Applying,** understanding and remembering the detailed processes, essential techniques and features of industrial chemicals, biochemicals and chemotherapeutic products, Microbial products of pharmacological interest, Enzyme and cell immobilization techniques in industrial processing, purification of products and enzymes, enzyme kinetics.	1,2,3 Remembering, Understanding, Demonstrating
CO4	**Analyzing,** applying, remembering and understanding the detailed study related to concepts of industrial chemicals, biochemicals and chemotherapeutic products, Microbial products of pharmacological interest, Enzyme and cell immobilization techniques in industrial processing, purification of products and enzymes, enzyme kinetics.	1,2,3,4 Remembering, Understanding, Analyzing
CO5	**Evaluating,** analyzing, applying, remembering, and understanding the principle, methods, properties and functions of industrial chemicals, biochemicals and chemotherapeutic products, Microbial products of pharmacological interest, Enzyme and cell immobilization techniques in industrial processing, purification of products and enzymes, enzyme kinetics.	1, 2,3,4,5 Remembering, Understanding, Analyzing, Evaluating
CO6	**Constructing (Creating),** Evaluating, Analyzing, demonstrating, remembering, and understanding the Take part in essential techniques and features of industrial chemicals, biochemicals and chemotherapeutic products, Microbial products of pharmacological interest, Enzyme and cell immobilization techniques in industrial processing, purification of products and enzymes, enzyme kinetics.	1,2,3,4,5,6 Remembering, Understanding, Analyzing, Evaluating Creating

Mapping of COs with POs & PSOs

Course Outcomes	Program Outcomes (POs)												Program Specific Outcomes (PSOs)			
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO1	3	2	3	3	3	3	3	2	3	2	2	2	3	2	1	2
CO2	3	3	2	2	2	2	3	3	2	3	3	3	2	2	1	2
CO3	3	3	2	2	3	3	2	2	3	2	3	3	2	2	3	2
CO4	3	2	2	3	2	3	2	2	3	1	3	3	3	3	3	3
CO5	3	3	3	3	3	2	2	2	3	3	2	3	2	2	2	2
CO6	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2

3: High, 2: Medium, 1: Low

B. Sc. (Hons.) Biotechnology

Course code	**: HBTS 306**
Course Name	**: Molecular Diagnostics**
Semester	**: III**

L	T	P	C
4	4	0	4

Course objectives: The course is designed to give an overview and applications of differentmolecular biology techniques used in disease diagnosis. The specific objectives of the course are:

1. To teach students different molecular techniques used for disease diagnosis.
2. To make students understand the utilization of these techniques in disease diagnosis.
3. To teach the use of different enzyme immunoassay based diagnostic methods.
4. To impart the knowledge about the molecular diagnostic of different human diseases.

UNIT I (15 Periods)

Enzyme Immunoassays:

Comparison of enzymes available for enzyme immunoassays, conjugation of enzymes. Solid phases used in enzyme immunoassays. Homogeneous and heterogeneous enzyme immunoassays. Enzyme immunoassays after immuno blotting. Enzyme immuno histochemical techniques. Use of polyclonal or monoclonal antibodies in enzymes immuno assays. Applications of enzyme immunoassays in diagnostic microbiology

UNIT II (15 Periods)

Molecular methods in clinical microbiology: Applications of PCR, RFLP, Nuclear hybridization methods, Single nucleotide polymorphism and plasmid finger printing in clinical microbiology Laboratory tests in chemotherapy: Susceptibility tests: Micro-dilution and macro-dilution broth procedures. Susceptibility tests: Diffusion test procedures. Susceptibility tests: Tests for bactericidal activity. Automated procedures for antimicrobial susceptibility tests.

UNIT III (18 Periods)

Automation in microbial diagnosis, rapid diagnostic approach including technical purification and standardization of antigen and specific antibodies. Concepts and methods in idiotypes. Antiidiotypes and molecular mimicry and receptors. Epitope design and applications. Immunodiagnostic tests. Immuno florescence. Radioimmunoassay.

UNIT IV (12 Periods)

GLC, HPLC, Electron microscopy, flowcytometry and cell sorting. Transgenic animals.

SUGGESTED READING AND TEXT BOOKS

1. Practical Biochemistry, Principles and Techniques, Keith Wilson and John Walker
2. Bioinstrumentation, Webster
3. Advanced Instrumentation, Data Interpretation, and Control of Biotechnological Processes, J.F. Van Impe,Kluwer Academic
4. Ananthanarayan R and Paniker CKJ. (2005). Textbook of Microbiology. 7th edition (edited by Paniker CKJ). University Press Publication.
5. **Brooks GF, Carroll KC, Butel JS and Morse SA. (2007). Jawetz, Melnick and Adelberg's** Medical

Course Outcomes (COs): On completion of this course, the students will be:

CO	Description	Bloom's Taxonomy Level
CO1	**Remember** the different basic concepts of introduction to Enzyme Immunoassays, Molecular methods in clinical microbiology, Susceptibility tests, standardization of antigen and specific antibodies, GLC, HPLC, Electron microscopy, flowcytometry and cell sorting. Transgenic animals.	1 Remembering
CO2	**Understand** and remember the specific and basic concepts of Enzyme Immunoassays, Molecular methods in clinical microbiology, Susceptibility tests, standardization of antigen and specific antibodies, GLC, HPLC, Electron microscopy, flowcytometry and cell sorting. Transgenic animals.	1,2 Remembering, Understanding
CO3	**Applying,** understanding and remembering the detailed processes, essential techniques and features of Enzyme Immunoassays, Molecular methods in clinical microbiology, Susceptibility tests, standardization of antigen and specific antibodies, GLC, HPLC, Electron microscopy, flowcytometry and cell sorting. Transgenic animals.	1,2,3 Remembering, Understanding, Demonstrating
CO4	**Analyzing,** applying, remembering and understanding the detailed study related to concepts of immunological methods, Enzyme Immunoassays, Molecular methods in clinical microbiology, Susceptibility tests, standardization of antigen and specific antibodies, GLC, HPLC, Electron microscopy, flowcytometry and cell sorting. Transgenic animals.	1,2,3,4 Remembering, Understanding, Analyzing
CO5	**Evaluating,** analyzing, applying, remembering, and understanding the principle, methods, properties and functions of immunological methods, Enzyme Immunoassays, Molecular methods in clinical microbiology, Susceptibility tests, standardization of antigen and specific antibodies, GLC, HPLC, Electron microscopy, flowcytometry and cell sorting. Transgenic animals.	1, 2,3,4,5 Remembering, Understanding, Analyzing, Evaluating
CO6	**Constructing (Creating),** Evaluating, Analyzing, demonstrating, remembering, and understanding the take part in immunological methods, Enzyme Immunoassays, Molecular methods in clinical microbiology, Susceptibility tests, standardization of antigen and specific antibodies, GLC, HPLC, Electron microscopy, flowcytometry and cell sorting. Transgenic animals.	1,2,3,4,5,6 Remembering, Understanding, Analyzing, Evaluating Creating

Mapping of COs with POs & PSOs

Course Outcomes	Program Outcomes (POs)												Program Specific Outcomes (PSOs)			
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO1	2	2	3	3	3	3	3	2	3	2	2	2	3	2	1	2
CO2	2	3	2	2	2	2	3	3	2	3	3	3	2	2	1	2
CO3	2	3	2	2	2	2	2	2	3	2	2	2	2	2	3	2
CO4	3	2	2	3	2	3	2	2	3	1	3	3	2	2	3	3
CO5	3	2	2	2	2	2	2	2	3	3	2	3	2	2	2	2
CO6	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2

3: High, 2: Medium, 1: Low

B. Sc. (Hons.) Biotechnology

Course code	**: HBTS 307**
Course Name	**: Basics of Forensic Science**
Semester	**: III**

L	T	P	C
4	4	0	4

Course objectives: This is an introductory course on forensic sciences withthe following objectives:

1. To familiarize students with the fundamentalprinciples of forensic sciences.
2. To impart knowledge about the injuries and deaths and how they are assessed.
3. To make students understand the process of documentation of crime scenes.
4. To impart the knowledge about the importance of cyber security in forensic sciences.

Unit I (15 Periods)

Introduction and principles of forensic science, forensic science laboratory and its organization and service, tools and techniques in forensic science, branches of forensic science, causes of crime, role of modus operandi in criminal investigation. Classification of injuries and their medico-legal aspects, method of assessing various types of deaths.

Unit II (15 Periods)

Classification of fire arms and explosives, introduction to internal, external and terminal ballistics. Chemical evidence for explosives. General and individual characteristics of handwriting, examination and comparison of handwritings and analysis of ink various samples.

Unit III (15 Periods)

Role of the toxicologist, significance of toxicological findings, Fundamental principles of fingerprinting, classification of fingerprints, development of finger print as science for personal identification,

Unit IV (15 Periods)

Principle of DNA fingerprinting, application of DNA profiling in forensic medicine, Investigation Tools, eDiscovery, Evidence Preservation, Search and Seizure of Computers, Introduction to Cyber security.

SUGGESTED READING AND TEXT BOOKS

1. Molecular Biotechnology- Principles and Applications of recombinant DNA. ASM Press, Washington.
2. B.B. Nanda and R.K. Tiwari, Forensic Science in India: A Vision for the Twenty First Century, Select Publishers, New Delhi (2001). _
3. M.K. Bhasin and S. Nath, Role of Forensic Science in the New Millennium, University of Delhi, Delhi (2002). _
4. S.H. James and J.J. Nordby, Forensic Science: An Introduction to Scientific and Investigative Techniques, 2nd Edition, CRC Press, Boca Raton (2005).
5. W.G. Eckert and R.K. Wright in Introduction to Forensic Sciences, 2nd Edition, W.G. Eckert (ED.), CRC Press, Boca Raton (1997).

Course Outcomes (COs): On completion of this course, the students will be:

CO	Description	Bloom's Taxonomy Level
CO1	**Remember** the different basic concepts of introduction and principles of forensic science, forensic science laboratory and its organization and service, Classification of fire arms and explosives, Role of the toxicologist and findings, Principle of DNA fingerprinting, application of DNA profiling in forensic medicine and introduction to Cyber security.	1 Remembering
CO2	**Understand** and remember the specific and basic concepts of forensic science, forensic science laboratory and its organization and service, Classification of fire arms and explosives, Role of the toxicologist and findings, Principle of DNA fingerprinting, application of DNA profiling in forensic medicine and introduction to Cyber security.	1,2 Remembering, Understanding
CO3	**Applying,** understanding and remembering the detailed processes, essential techniques and features of forensic science, forensic science laboratory and its organization and service, Classification of fire arms and explosives, Role of the toxicologist and findings, Principle of DNA fingerprinting, application of DNA profiling in forensic medicine and introduction to Cyber security.	1,2,3 Remembering, Understanding, Demonstrating
CO4	**Analyzing,** applying, remembering and understanding the detailed study related to concepts of crime scene detection methods, forensic science, forensic science laboratory and its organization and service, Classification of fire arms and explosives, Role of the toxicologist and findings, Principle of DNA fingerprinting, application of DNA profiling in forensic medicine and introduction to Cyber security.	1,2,3,4 Remembering, Understanding, Analyzing
CO5	**Evaluating,** analyzing, applying, remembering, and understanding the principle, methods, properties and functions of forensic science, forensic science laboratory and its organization and service, Classification of fire arms and explosives, Role of the toxicologist and findings, Principle of DNA fingerprinting, application of DNA profiling in forensic medicine and introduction to Cyber security.	1, 2,3,4,5 Remembering, Understanding, Analyzing, Evaluating
CO6	**Constructing (Creating),** Evaluating, Analyzing, demonstrating, remembering, and understanding the take part in forensic science, forensic science laboratory and its organization and service, Classification of fire arms and explosives, Role of the toxicologist and findings, Principle of DNA fingerprinting, application of DNA profiling in forensic medicine and introduction to Cyber security.	1,2,3,4,5,6 Remembering, Understanding, Analyzing, Evaluating Creating

Mapping of COs with POs & PSOs

Course Outcomes	Program Outcomes (POs)												Program Specific Outcomes (PSOs)			
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO1	2	3	3	3	3	3	3	2	3	2	2	2	3	2	3	2
CO2	3	3	2	2	2	2	3	3	2	3	3	3	2	2	3	2
CO3	3	3	2	2	2	2	2	2	3	2	2	3	3	2	3	2
CO4	3	2	2	3	2	3	2	2	3	1	3	3	2	2	3	3
CO5	3	2	2	2	2	2	2	2	3	3	2	3	2	2	2	2
CO6	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2

3: High, 2: Medium, 1: Low

B. Sc. (Hons.) Biotechnology

Course code	**: HBTS 308**
Course Name	**: Green Chemistry**
Semester	**: III**

L	T	P	C
4	4	0	4

Course objectives: The course aims to teach the principles of green chemistry. The specificobjectives of the course are:

5. To teach students the basic concepts of green chemistry.
6. To make students understand the importance of green chemistry in sustainable development.
7. To teach students the fundamental principles of biocatalysis, photochemistry andelectrochemistry.
8. To teach students about green chemistry in daily practice

UNIT I: Introduction and principles [12 Hours]

Introduction to green chemistry and its guiding principles; green chemistry and industry; waste minimization and atom economy; reduction of material use, reduction of energy requirement; energy efficiency improvements; alternative energy sources; alternative solvents.

UNIT II: Green chemistry and sustainable development [12 Hours]

The concept of sustainability; green chemistry and sustainability's parameters; sustainable use of chemical feedstock; sustainable use of water; sustainable use of energy; environmental resilience; life-cycle assessment: Identification of more sustainable products and processes.

UNIT III: Biocatalysis [10 Hours]

Introduction to biocatalysis; chemical production by biocatalysis: bulk chemicals, pharmaceuticals, flavor and fragrance compounds, carbohydrates, enantiomerically pure synthons, polymers; green biocatalytic processes: biocatalysis in supercritical CO_2, biocatalysis in waste treatment, biodesulfurisation.

UNIT IV: Photochemistry, electrochemistry and fuel cells [14 Hours]

Impact of green process technology on the chemical industry; heterogeneous catalysis in practice; homogeneous catalysis in practice; renewables as chemical feedstock and biocatalysis use of renewable feedstock for the production of chemicals; bioproduction of chemicals in industry.

Photons as clean reagents; reduced usage of reagents; photochemical reactors; introduction to green electrochemistry; electrochemical cells; electrochemical waste minimization; recovery and recycling of metal ions; fuel cell electrochemistry; fuel cell applications.

SUGGESTED READIND AND TEXT BOOKS

1. Clark, J and Macquarrie, D 2002. Handbook of Green Chemistry and Technology, 1st ed.Blackwell Science Ltd.
2. Lancaster, M 2010. Green Chemistry: An Introductory Text, 1st ed. Royal Society of Chemistry.
3. Sharma, SK and Mudhoo, A 2010. Green Chemistry for Environmental Sustainability, 1st ed.CRC Press, Boca Raton.

4. Torok, B and Dransfield, T 2017. Green Chemistry: An Inclusive Approach, 1st ed. Elsevier.

Course Outcomes (COs): On completion of this course, the students will be:

CO	Description	Bloom's Taxonomy Level
CO1	**Remember** the different basic concepts of introduction and principles of green chemistry, sustainable development, Biocatalysis, Photochemistry, electrochemistry and fuel cells.	1 Remembering
CO2	**Understand** and remember the specific and basic concepts of green chemistry, sustainable development, Biocatalysis, Photochemistry, electrochemistry and fuel cells.	1,2 Remembering, Understanding
CO3	**Applying,** understanding and remembering the detailed processes, essential techniques and features of green chemistry, sustainable development, Biocatalysis, Photochemistry, electrochemistry and fuel cells.	1,2,3 Remembering, Understanding, Demonstrating
CO4	**Analyzing,** applying, remembering and understanding the detailed study related to concepts of green chemistry, sustainable development, Biocatalysis, Photochemistry, electrochemistry and fuel cells.	1,2,3,4 Remembering, Understanding, Analyzing
CO5	**Evaluating,** analyzing, applying, remembering, and understanding the principle, methods, properties and functions green chemistry, sustainable development, Biocatalysis, Photochemistry, electrochemistry and fuel cells.	1, 2,3,4,5 Remembering, Understanding, Analyzing, Evaluating
CO6	**Constructing (Creating),** Evaluating, Analyzing, demonstrating, remembering, and understanding the take part in green chemistry, sustainable development, Biocatalysis, Photochemistry, electrochemistry and fuel cells.	1,2,3,4,5,6 Remembering, Understanding, Analyzing, Evaluating Creating

Mapping of COs with POs & PSOs

Course Outcomes	Program Outcomes (POs)												Program Specific Outcomes (PSOs)			
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO1	2	3	3	2	2	2	2	2	3	2	2	2	3	2	3	2
CO2	2	2	2	2	2	2	3	3	2	3	3	2	2	2	2	2
CO3	2	3	2	2	2	2	2	2	3	2	2	2	3	2	2	2
CO4	2	2	2	3	2	3	2	2	3	1	3	2	2	2	2	3
CO5	2	2	2	2	2	2	2	2	3	2	2	3	2	2	2	2
CO6	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2

3: High, 2: Medium, 1: Low

B. Sc. (Hons.) Biotechnology

Course code	**: HBTC 401**
Course Name	**: Molecular Biology**
Semester	**: IV**

L	T	P	C
4	4	0	4

Course objectives: Molecular biology has witnessed a paradigm shift after the discovery of double helical structure of DNA. This course on molecular biology aims to teach the fundamental role of DNA molecule as a blueprint of life. The specific objectives of the course are as follows:

1. To familiarize students with the structure and function of biological system at the molecularlevel.
2. To impart knowledge about the key components participating in the replication of geneticmaterial.
3. To teach the processes and pathways which replicate, transcribe and translate DNA.
4. To make students understand the different methods of DNA damage, repair and recombination.
5. To teach the fundamental principles of gene expression regulation.

UNIT I: DNA structure and replication (15 Periods)

DNA as genetic material, Structure of DNA, Types of DNA, Replication of DNA in prokaryotes and eukaryotes: Semiconservative nature of DNA replication, Bi-directional replication, DNA polymerases, The replication complex: Pre-primming proteins, primosome, replisome, Rolling circle replication.

UNIT II: DNA damage, repair and homologous recombination (10 Periods)

DNA damage and repair: causes and types of DNA damage, mechanism of DNA repair: Photoreactivation, base excision repair, nucleotide excision repair, mismatch repair, translesion synthesis, recombinational repair, nonhomologous end joining. Homologous recombination: models and mechanism.

UNIT III: Transcription and RNA processing (17 Periods)

RNA structure and types of RNA, Transcription in prokaryotes: Prokaryotic RNA polymerase, role of sigma factor, promoter, Initiation, elongation and termination of RNA chains Transcription in eukaryotes: Eukaryotic RNA polymerases, transcription factors, promoters, enhancers, mechanism of transcription initiation, promoter clearance and elongation RNA splicing and processing: processing of pre-mRNA: 5' cap formation, polyadenylation, splicing, rRNA and tRNA splicing.

UNIT IV: Regulation of gene expression and translation (18 Periods)

Regulation of gene expression in prokaryotes: Operon concept (inducible and repressible system), Genetic code and its characteristics, Prokaryotic and eukaryotic translation: ribosome structure and assembly, Charging of tRNA, aminoacyl tRNA synthetases, Mechanism of initiation, elongation and termination of polypeptides.

SUGGESTED READING AND TEXT BOOKS

1. Karp, G. (2010). Cell and Molecular Biology: Concepts and Experiments. VI Edition. John Wiley & Sons. Inc.
2. De Robertis, E.D.P. and De Robertis, E.M.F. (2006). Cell and Molecular Biology. VIII Edition. Lippincott Williams and Wilkins, Philadelphia.
3. Becker, W.M., Kleinsmith, L.J., Hardin. J. and Bertoni, G. P. (2009). The World of the Cell. VII Edition. Pearson Benjamin Cummings Publishing, San Francisco.
4. Watson, J. D., Baker T.A., Bell, S. P., Gann, A., Levine, M., and Losick, R., (2008) Molecular Biology of the Gene (VI Edition.). Cold Spring Harbour Lab. Press, Pearson Pub.

Course Outcomes (COs): On completion of this course, the students will be:

CO	Description	Bloom's Taxonomy Level
CO1	**Remember** the different basic concepts of introduction to DNA structure and replication, define the terms and basic concepts of Molecular Biology, DNA damage, repair and homologous recombination, Transcription and RNA processing, Regulation of gene expression and translation.	1 Remembering
CO2	**Understand** and remember the specific and basic concepts of DNA structure and replication, define the terms and basic concepts of Molecular Biology, DNA damage, repair and homologous recombination, Transcription and RNA processing, Regulation of gene expression and translation.	1,2 Remembering, Understanding
CO3	**Applying,** understanding and remembering the detailed processes, essential techniques and features DNA structure and replication, define the terms and basic concepts of Molecular Biology, DNA damage, repair and homologous recombination, Transcription and RNA processing, Regulation of gene expression and translation.	1,2,3 Remembering, Understanding, Demonstrating
CO4	**Analyzing,** applying, remembering and understanding the detailed study related to concepts of DNA structure and replication, define the terms and basic concepts of Molecular Biology, DNA damage, repair and homologous recombination, Transcription and RNA processing, Regulation of gene expression and translation.	1,2,3,4 Remembering, Understanding, Analyzing
CO5	**Evaluating,** analyzing, applying, remembering, and understanding the principle, methods, properties and functions of DNA structure and replication, define the terms and basic concepts of Molecular Biology, DNA damage, repair and homologous recombination, Transcription and RNA processing, Regulation of gene expression and translation.	1, 2,3,4,5 Remembering, Understanding, Analyzing, Evaluating
CO6	**Constructing (Creating),** Evaluating, Analyzing, demonstrating, remembering, and understanding the take part in DNA structure and replication, define the terms and basic concepts of Molecular Biology, DNA damage, repair and homologous recombination, Transcription and RNA processing, Regulation of gene expression and translation.	1,2,3,4,5,6 Remembering, Understanding, Analyzing, Evaluating Creating

Mapping of COs with POs & PSOs

Course Outcomes	Program Outcomes (POs)												Program Specific Outcomes (PSOs)			
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO1	3	3	3	3	3	3	2	2	3	2	2	2	3	2	3	2
CO2	3	2	2	2	2	2	3	3	2	3	3	2	2	2	2	2
CO3	3	3	2	3	3	3	2	2	3	2	2	2	3	2	2	2
CO4	3	2	2	3	2	3	2	2	3	1	3	2	2	2	2	3
CO5	3	2	2	2	2	2	2	2	3	2	2	3	2	2	2	2
CO6	3	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2

3: High, 2: Medium, 1: Low

B. Sc. (Hons.) Biotechnology

Course code	**: HBTL 401**
Course Name	**: Lab Course Based on HBTC 401**
Semester	**: IV**

L	T	P	C
0	0	2	2

Practicals

1. Preparation of solutions for Molecular Biology experiments.
2. Genomic DNA isolation from animal tissue.
3. Genomic DNA isolation from bacterial cells.
4. Isolation of DNA From coconut endosperm.
5. Characterization of DNA by spectrophotometric analysis.
6. Purification of DNA.
7. Melting point determination of DNA.
8. Isolation of Plasmid DNA by alkaline lysis method
9. Agarose gel electrophoresis of genomic DNA & plasmid DNA
10. Preparation of restriction enzyme digests of DNA samples
11. Demonstration of AMES test or reverse mutation for carcinogenicity

B. Sc. (Hons.) Biotechnology

Course code	**: HBTC 402**
Course Name	**: Immunology**
Semester	**: IV**

L	T	P	C
4	4	0	4

Course objectives: The specific objectives of the course are as follows:

1. To familiarize students with the structure and function of the immune system.
2. To impart knowledge about the key components participating in fighting the disease.
3. To make students understand immunodiagnostic methods like RIA and ELISA.
4. To teach students about vaccines and modes of vaccination.

UNIT I (20 Periods)

Immune Response - An overview, components of mammalian immune system, molecular structure of Immuno-globulins or Antibodies, Humoral & Cellular immune responses, Tlymphocytes & immune response (cytotoxic T-cell, helper T-cell, suppressor T-cells), T-cell receptors, genome rearrangements during B-lymphocyte differentiation, Antibody affinity maturation class switching, assembly of T-cell receptor genes by somatic recombination.

UNIT II (15 Periods)

Regulation of immunoglobulin gene expression – Clonal selection theory, allotypes & idiotypes, allelic exclusion, immunologic memory, heavy chain gene transcription, genetic basis of antibody diversity, hypotheses (germ line & somatic mutation), antibody diversity.

UNIT III (13 Periods)

Major Histocompatibility complexes – class I & class II MHC antigens, antigen processing.
Immunity to infection – immunity to different organisms, pathogen defense strategies, avoidance of recognition. Autoimmune diseases, Immunodeficiency-AIDS.

UNIT IV (12 Periods)

Vaccines & Vaccination – adjuvants, cytokines, DNA vaccines, recombinant vaccines, bacterial vaccines, viral vaccines, vaccines to other infectious agents, passive & active immunization. Introduction to immunodiagnostics – RIA, ELISA.

SUGGESTED READING AND TEXT BOOKS

1. Abbas AK, Lichtman AH, Pillai S. (2007). Cellular and Molecular Immunology. 6 th edition Saunders Publication, Philadelphia.
2. Delves P, Martin S, Burton D, Roitt IM. (2006). Roitt's Essential Immunology. 11th edition Wiley-
3. Goldsby **RA, Kindt TJ, Osborne BA. (2007). Kuby's Immunology. 6th edition W.H.** Freeman and
4. Murphy K, Travers P, Walport M. (2008). Janeway's Immunobiology. 7th edition Garland Science Publishers, New York.
5. Peakman M, and Vergani D. (2009). Basic and Clinical Immunology. 2nd edition Churchill Livingstone Publishers, Edinberg.
6. Richard C and Geiffrey S. (2009). Immunology. 6th edition. Wiley Blackwell Publication.

Course Outcomes (COs): On completion of this course, the students will be:

CO	Description	Bloom's Taxonomy Level
CO1	**Remember** the different basic concepts of introduction to Immunology, Immune Response, Immuno-globulins or Antibodies, Regulation of immunoglobulin gene expression, Major Histocompatibility complexes, Immunity to infection, Vaccines & Vaccination and immunodiagnostics – RIA, ELISA.	1 Remembering
CO2	**Understand** and remember the specific and basic concepts of Immunology, Immune Response, Immuno-globulins or Antibodies, Regulation of immunoglobulin gene expression, Major Histocompatibility complexes, Immunity to infection, Vaccines & Vaccination and immunodiagnostics – RIA, ELISA.	1,2 Remembering, Understanding
CO3	**Applying,** understanding and remembering the detailed processes, essential techniques and features of Immunology, Immune Response, Immuno-globulins or Antibodies, Regulation of immunoglobulin gene expression, Major Histocompatibility complexes, Immunity to infection, Vaccines & Vaccination and immunodiagnostics – RIA, ELISA.	1,2,3 Remembering, Understanding, Demonstrating
CO4	**Analyzing,** applying, remembering and understanding the detailed study related to concepts of Immunology, Immune Response, Immuno-globulins or Antibodies, Regulation of immunoglobulin gene expression, Major Histocompatibility complexes, Immunity to infection, Vaccines & Vaccination and immunodiagnostics – RIA, ELISA. Immunity to different organisms.	1,2,3,4 Remembering, Understanding, Analyzing
CO5	**Evaluating,** analyzing, applying, remembering, and understanding the principle, methods, properties and functions of Immunology, Immune Response, Immuno-globulins or Antibodies, Regulation of immunoglobulin gene expression, Major Histocompatibility complexes, Immunity to infection, Vaccines & Vaccination and immunodiagnostics – RIA, ELISA. Immunity to different organisms.	1, 2,3,4,5 Remembering, Understanding, Analyzing, Evaluating
CO6	**Constructing (Creating),** Evaluating, Analyzing, demonstrating, remembering, and understanding the take part in Immunology, Immune Response, Immuno-globulins or Antibodies, Regulation of immunoglobulin gene expression, Major Histocompatibility complexes, Immunity to infection, Vaccines & Vaccination and immunodiagnostics – RIA, ELISA. Immunity to different organisms.	1,2,3,4,5,6 Remembering, Understanding, Analyzing, Evaluating Creating

Mapping of COs with POs & PSOs

Course Outcomes	Program Outcomes (POs)												Program Specific Outcomes (PSOs)			
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO1	2	3	3	2	2	2	2	2	2	2	2	2	3	2	3	2
CO2	2	2	3	3	3	2	3	3	2	3	3	2	2	2	2	2
CO3	2	3	2	3	3	3	2	2	2	2	3	3	3	2	2	2
CO4	3	2	2	3	2	3	2	2	2	1	3	2	2	2	2	3
CO5	3	2	2	2	2	3	3	3	3	2	2	3	2	2	2	2
CO6	3	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2

3: High, 2: Medium, 1: Low

B. Sc. (Hons.) Biotechnology

Course code	**: HBTL 402**
Course Name	**: Lab Course Based on HBTC 402**
Semester	**: IV**

L	T	P	C
0	0	2	2

Practicals

1. Differential leucocytes count
2. Total leucocytes count
3. Total RBC count
4. Haemagglutination assay
5. Haemagglutination inhibition assay
6. Separation of serum from blood
7. Double immunodiffusion test using specific antibody and antigen.
8. ELISA.

B. Sc. (Hons.) Biotechnology

Course code	**: HBTC 403**
Course Name	**: Chemistry- II**
Semester	**: IV**

L	T	P	C
4	4	0	4

Course objective: This course is aimed to introduce the knowledge of biomolecules and their role in metabolic pathways. Also, it deals with the structure and function of enzymes.

UNIT I (10 Periods)

Carbohydrates: Classification of carbohydrates, reducing and non-reducing sugars, General properties of Glucose and Fructose, their open chain structure. Epimers, mutarotation and anomers. Determination of configuration of glucose (Fischer proof). Cyclic structure of glucose. Haworth projections. Cyclic structure of fructose.

UNIT II (12 Periods)

Amino Acids, Peptides and Proteins: Classification of Amino Acids, Zwitterion structure and Isoelectric point. Overview of Primary, Secondary, Tertiary and Quaternary structure of proteins.

UNIT III (20 Periods)

Enzymes and correlation with drug action: Mechanism of enzyme action, factors affecting enzyme action, Coenzymes and cofactors and their role in biological reactions, Specificity of enzyme action (including stereospecificity), Enzyme inhibitors and their importance, phenomenon of inhibition (competitive and noncompetitive inhibition including allosteric inhibition).

UNIT IV (18 Periods)

Components of Nucleic acids: Adenine, guanine, thymine and cytosine (structure only), other components of nucleic acids, Nucleosides and nucleotides (nomenclature), Structure of polynucleotides; Structure of DNA (Watson-Crick model) and RNA (types of RNA), Genetic code, Biological roles of DNA and RNA: Replication, Transcription and Translation.

SUGGESTED READING

1. Morrison, R. T. & Boyd, R. N. Organic Chemistry, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
2. Finar, I. L. Organic Chemistry (Volume 1), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
3. Finar, I. L. Organic Chemistry (Volume 2), Dorling Kindersley (India) Pvt. Ltd. (Pearson
4. **Nelson, D. L. & Cox, M. M. Lehninger's Principles of Biochemistry 7th Ed., W. H.** Freeman.
5. Berg, J. M., Tymoczko, J. L. & Stryer, L. Biochemistry 7th Ed., W. H. Freeman.
6. **Furniss, B.S.; Hannaford, A.J.; Rogers, V.; Smith, P.W.G.; Tatchell, A.R. Vogel's** Textbook of Practical Organic Chemistry, ELBS.

Course Outcomes (COs): On completion of this course, the students will be:

CO	Description	Bloom's Taxonomy Level
CO1	**Remember** the different basic concepts of introduction to Carbohydrates, amino acids, peptides, proteins, Enzymes and correlation with drug action and Components of nucleic acids. Enzyme inhibitors and their importance.	1 Remembering
CO2	**Understand** and remember the specific and basic concepts of Carbohydrates, amino acids, peptides, proteins, Enzymes and correlation with drug action and Components of nucleic acids. Biological roles of DNA and RNA: Replication, Transcription and Translation.	1,2 Remembering, Understanding
CO3	**Applying,** understanding and remembering the detailed processes, essential techniques and features of Carbohydrates, amino acids, peptides, proteins, Enzymes and correlation with drug action and Components of nucleic acids. Biological roles of DNA and RNA: Replication, Transcription and Translation.	1,2,3 Remembering, Understanding, Demonstrating
CO4	**Analyzing,** applying, remembering and understanding the detailed study related to concepts of Carbohydrates, amino acids, peptides, proteins, Enzymes and correlation with drug action and Components of nucleic acids. Biological roles of DNA and RNA: Replication, Transcription and Translation. Enzyme inhibitors and their importance.	1,2,3,4 Remembering, Understanding, Analyzing
CO5	**Evaluating,** analyzing, applying, remembering, and understanding the principle, methods, properties and functions of Carbohydrates, amino acids, peptides, proteins, Enzymes and correlation with drug action and Components of nucleic acids. Biological roles of DNA and RNA: Replication, Transcription and Translation. Enzyme inhibitors and their importance.	1, 2,3,4,5 Remembering, Understanding, Analyzing, Evaluating
CO6	**Constructing (Creating),** Evaluating, Analyzing, demonstrating, remembering, and understanding the take part in Carbohydrates, amino acids, peptides, proteins, Enzymes and correlation with drug action and Components of nucleic acids. Biological roles of DNA and RNA: Replication, Transcription and Translation. Enzyme inhibitors and their importance.	1,2,3,4,5,6 Remembering, Understanding, Analyzing, Evaluating Creating

Mapping of COs with POs & PSOs

Course Outcomes	Program Outcomes (POs)												Program Specific Outcomes (PSOs)			
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO1	3	2	3	2	2	2	2	2	2	2	2	2	3	2	3	2
CO2	2	2	3	3	3	2	3	3	2	3	3	2	2	2	2	2
CO3	3	2	2	3	2	3	2	2	2	2	3	3	3	2	2	2
CO4	3	2	2	3	2	3	2	2	2	1	3	2	2	2	2	3
CO5	3	2	2	2	2	3	3	3	3	2	2	3	2	2	2	2
CO6	2	2	1	1	2	2	2	2	2	1	1	2	2	2	1	1

3: High, 2: Medium, 1: Low

B. Sc. (Hons.) Biotechnology

Course code	**: HBTL 403**
Course Name	**: Lab Course Based on HBTC 403**
Semester	**: IV**

L	T	P	C
0	0	2	2

Practicals

1. Separation of amino acids by paper chromatography
2. To determine the concentration of glycine solution by formylation method.
3. Study of titration curve of glycine
4. Action of salivary amylase on starch
5. Effect of temperature on the action of salivary amylase on starch.
6. To determine the saponification value of an oil/fat.
7. To determine the iodine value of an oil/fat
8. Differentiate between a reducing/nonreducing sugar.
9. Extraction of DNA from onion/ cauliflower
10. To synthesize aspirin by acetylation of salicylic acid and compare it with the ingredient of an aspirin tablet by TLC.

B. Sc. (Hons.) Biotechnology

Course code	**: HBTG 404**
Course Name	**: Biotechnology and Human Welfare**
Semester	**: IV**

L	T	P	C
4	4	0	4

Course Objective: The course introduces students to the fundamentals of biotechnology, current trends and careers in biotechnology, regulatory, and ethical aspects of biotechnology. The knowledge and skills gained in this course will provide students with a broad understanding of biotechnology andits impact on society.

UNIT I (10 Periods)
Industry: protein engineering; enzyme and polysaccharide synthesis, activity and secretion, Alcohol and antibiotic formation.

UNIT II (10 Periods)
Agriculture: N2 fixation: transfer of pest resistance genes to plants; interaction between plants and microbes; qualitative improvement of livestock.

UNIT III (15 Periods)
Environments: e.g. chlorinated and non-chlorinated organ pollutant degradation; degradation of hydrocarbons and agricultural wastes, stress management, development of biodegradable polymers such as PHB.

UNIT IV (12 Periods)
Forensic science: e.g. solving violent crimes such as murder and rape; solving claims of paternity and theft etc. using various methods of DNA finger printing.

UNIT V (13 Periods)
Health: e.g. development of non-toxic therapeutic agents, recombinant live vaccines, gene therapy, diagnostics, monoclonal in *E.coli*, human genome project.

SUGGESTED READING AND TEXT BOOKS

1. Sateesh MK (2010) Bioethics and Biosafety, I. K. International Pvt Ltd.
2. Sree Krishna V (2007) Bioethics and Biosafety in Biotechnology, New age international publishers

Course Outcomes (COs): On completion of this course, the students will be:

CO	Description	Bloom's Taxonomy Level
CO1	**Remember** the different basic concepts of introduction to Industry, protein engineering, enzyme and polysaccharide synthesis, Agriculture, N2 fixation, Environments, Forensic science and health.	1 Remembering
CO2	**Understand** and remember the specific and basic concepts of Industry, protein engineering, enzyme and polysaccharide synthesis, Agriculture, N2 fixation, Environments, Forensic science and health.	1,2 Remembering, Understanding
CO3	**Applying,** understanding and remembering the detailed processes, essential techniques and features of Industry, protein engineering, enzyme and polysaccharide synthesis, Agriculture, N2 fixation, Environments, Forensic science and health.	1,2,3 Remembering, Understanding, Demonstrating
CO4	**Analyzing,** applying, remembering and understanding the detailed study related to concepts of Industry, protein engineering, enzyme and polysaccharide synthesis, Agriculture, N2 fixation, Environments, Forensic science and health.	1,2,3,4 Remembering, Understanding, Analyzing
CO5	**Evaluating,** analyzing, applying, remembering, and understanding the principle, methods, properties and functions of Industry, protein engineering, enzyme and polysaccharide synthesis, Agriculture, N2 fixation, Environments, Forensic science and health.	1, 2,3,4,5 Remembering, Understanding, Analyzing, Evaluating
CO6	**Constructing (Creating),** Evaluating, Analyzing, demonstrating, remembering, and understanding the take part in Industry, protein engineering, enzyme and polysaccharide synthesis, Agriculture, N2 fixation, Environments, Forensic science and health.	1,2,3,4,5,6 Remembering, Understanding, Analyzing, Evaluating Creating

Mapping of COs with POs & PSOs

Course Outcomes	Program Outcomes (POs)												Program Specific Outcomes (PSOs)			
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO1	2	2	3	2	2	2	2	2	2	2	2	2	3	2	3	2
CO2	2	2	3	2	2	2	2	3	2	3	3	2	2	2	2	2
CO3	2	2	2	2	2	3	2	2	2	2	2	2	2	2	2	2
CO4	2	2	2	2	2	2	2	2	2	1	3	2	2	2	2	2
CO5	3	2	2	2	2	2	2	2	3	2	2	2	2	2	2	2
CO6	2	2	1	1	2	2	2	2	2	1	1	2	2	2	1	1

3: High, 2: Medium, 1: Low

B. Sc. (Hons.) Biotechnology

Course code	**: HBTL 404**
Course Name	**: Lab Course Based on HBTG 404**
Semester	**: IV**

L	T	P	C
0	0	2	2

Practicals

1. Perform ethanolic fermentaion using Baker's yeast
2. Study of a plant part infected with a microbe
3. Perform quantitative estimation of residual chlorine in water samples
4. Isolation and analysis of DNA from minimal available biological samples (and demonstrate food adulteration)
5. Case studies on Bioethics
6. Study the interaction of probiotics bacteria with food
7. Demonstration of biofuel production via Virtual Lab
8. Study protein denaturation
9. Study plant diversity of the University campus
10. Demonstration of antibiotic production by video tutorials

B. Sc. (Hons.) Biotechnology

Course code	**: HBTS 405**
Course Name	**: Enzymology**
Semester	**: IV**

L	T	P	C
4	4	0	4

Course objectives: The course aims to impart the knowledge about fundamental principles of enzyme reactions, and applications of enzyme engineering. The specific objectives of the course are:

1. To make students understand the mechanism of enzyme action.
2. To teach students Michaelis-Menten equation for enzyme kinetics.
3. To teach students the regulation of enzyme kinetics
4. To impart knowledge about enzyme engineering and its applications.

UNIT - I (20 Periods)

Isolation, crystallization and purification of enzymes, test of homogeneity of enzyme preparation, methods of enzyme analysis. Enzyme classification (rationale, overview and specific examples) Zymogens and their activation (Proteases and Prothrombin). Enzyme substrate complex: concept of E-S complex, binding sites, active site, specificity, Kinetics of enzyme activity, Michaelis-Menten equation and its derivation.

UNIT – II (15 Periods)

Two substrate reactions (Random, ordered and ping-pong mechanism) Enzyme inhibition types of inhibition, determination of Ki, suicide inhibitor. Mechanism of enzyme action: General mechanistic principle, factors associated with catalytic efficiency: proximity, orientation, distortion of strain, acid-base, nucleophilic and covalent catalysis.

UNIT – III (13 Periods)

Allosteric enzymes with special reference to aspartate transcarbomylase and phosphofructokinase. Qualitative description of concerted and sequential models. Isoenzymes– multiple forms of enzymes with special reference to lactate dehydrogenase. Multienzyme complexes. Ribozymes. Multifunctional enzyme-eg Fatty Acid synthase.

UNIT – IV (12 Periods)

Enzyme technology: Methods for large scale production of enzymes. Immobilized enzyme and their comparison with soluble enzymes, Methods for immobilization of enzymes. Immobilized enzyme reactors. Application of Immobilized and soluble enzyme in health and industry. Application to fundamental studies of biochemistry. Enzyme electrodes.

SUGGESTED READING AND TEXT BOOKS

1. Biochemistry, Lubert Stryer, 6th Edition, WH Freeman, 2006.
2. **Harper's illustrated Biochemistry by Robert K. Murray, David A Bender, Kathleen** M.Botham, Peter J. Kennelly, Victor W. Rodwell, P. Anthony Weil. 28th Edition,McGrawHill, 2009.
3. Biochemistry, Donald Voet and Judith Voet, 2nd Edition, Publisher: John Wiley andSons,1995.
4. Biochemistry by Mary K.Campbell & Shawn O.Farrell, 5th Edition, Cenage Learning,2005.
5. Fundamentals of Enzymology Nicholas Price and Lewis Stevens Oxford University Press 1999

Course Outcomes (COs): On completion of this course, the students will be:

CO	Description	Bloom's Taxonomy Level
CO1	**Remember** the different basic concepts of introduction to isolation, crystallization, purification classification and kinetics of enzymes, Two substrate reactions, Allosteric enzymes and Enzyme technology.	1 Remembering
CO2	**Understand** and remember the specific and basic concepts of isolation, crystallization, purification classification and kinetics of enzymes, Two substrate reactions, Allosteric enzymes and Enzyme technology.	1,2 Remembering, Understanding
CO3	**Applying,** understanding and remembering the detailed processes, essential techniques and features of isolation, crystallization, purification classification and kinetics of enzymes, Two substrate reactions, Allosteric enzymes and Enzyme technology.	1,2,3 Remembering, Understanding, Demonstrating
CO4	**Analyzing,** applying, remembering and understanding the detailed study related to concepts of isolation, crystallization, purification classification and kinetics of enzymes, Two substrate reactions, Allosteric enzymes and Enzyme technology.	1,2,3,4 Remembering, Understanding, Analyzing
CO5	**Evaluating,** analyzing, applying, remembering, and understanding the principle, methods, properties and functions of isolation, crystallization, purification classification and kinetics of enzymes, Two substrate reactions, Allosteric enzymes and Enzyme technology.	1, 2,3,4,5 Remembering, Understanding, Analyzing, Evaluating
CO6	**Constructing (Creating),** Evaluating, Analyzing, demonstrating, remembering, and understanding the take part in isolation, crystallization, purification classification and kinetics of enzymes, Two substrate reactions, Allosteric enzymes and Enzyme technology.	1,2,3,4,5,6 Remembering, Understanding, Analyzing, Evaluating Creating

Mapping of COs with POs & PSOs

Course Outcomes	Program Outcomes (POs)												Program Specific Outcomes (PSOs)			
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO1	3	2	3	2	2	2	2	2	2	2	2	2	3	2	3	2
CO2	3	2	3	3	3	3	2	2	2	3	3	2	3	3	3	2
CO3	3	2	2	2	2	3	2	3	3	3	2	2	3	3	3	2
CO4	2	2	2	2	2	2	2	2	2	1	3	2	2	2	2	2
CO5	3	2	2	2	2	2	2	2	3	2	2	2	2	2	2	2
CO6	2	2	1	1	2	2	2	2	2	1	1	2	2	2	1	1

3: High, 2: Medium, 1: Low

B. Sc. (Hons.) Biotechnology

Course code	**: HBTS 406**
Course Name	**: Drug Designing**
Semester	**: IV**

L	T	P	C
4	4	0	4

Course objectives: The course is designed to give an overview of the process of drug design and development.The specific objectives of the course are as follows:

1. To teach the criteria used for drug development as a process involving target selection and lead discovery.
2. To impart the knowledge about computer aided drug design.
3. To give students an overview of drug delivery system, pre clinical and clinical testing.

UNIT I (12 Periods)

Delivery considerations of biotechnological products: Introduction, Stability profile, Barriers to proteins and peptide delivery, Delivery of protein & peptide drugs, Lymphatic transportation of proteins, Site specific protein modification (protein engineering), Toxicology profile characterization.

UNIT II (12 Periods)

Drug targeting and drug delivery systems: Introduction, Historical perspectives, Drug targeting, Cellular levels events in targeting. Ligands as means of targeting, Blood cell receptors for endogenous compounds, Carrier system for targeting, Vesicular systems for ligand mediated drug targeting, Specialized liposomes for cellular drug targeting.

UNIT III (12 Periods)

Vaccines: Introduction, Multivalent subunit vaccines, Purified macromolecules, Synthetic peptide vaccines, Immuno-adhesions, Recombinant antigen vaccines, Vector vaccines, Anti-idiotype vaccines, Targeted immune stimulants, Miscellaneous approaches, New generation vaccines, Novel vaccine delivery systems.

UNIT IV (12 Periods)

Introduction to drug design cycle: Structure Activity Relationship (SAR), Rational Drug Design, Pharmacophoric patterns, Quantitative Structure-Activity Relationship. (Q SAR) & Hans equation.

UNIT V (12 Periods)

Introduction to molecular modeling: Quantum mechanical and molecular orbital methods, Introduction to semiempirical, molecular mechanics and ab initio techniques. Potential energy surface, Docking and modeling substrate – receptor interactions. Introduction to s/w tools for CADD.

Suggested Reading and Text Books

1. Hill, RG and Rang, HP 2012. Drug Discovery and Development: Technology in Transition. 2nd ed. Churchill Livingstone.
2. Kenakin, TP 2012. Pharmacology in Drug Discovery, 1st ed. Elsevier.
3. Gad, SC 2005. Drug Discovery Handbook, 1st ed. Wiley-Interscience.
4. Stromgaard, K,Krogsgaard-Larsen, P and Madsen, U 2016. Textbook of Drug Design and Discovery, 5th ed. CRC press.

Course Outcomes (COs): On completion of this course, the students will be:

CO	Description	Bloom's Taxonomy Level
CO1	**Remember** the different basic concepts of introduction to delivery considerations of biotechnological products, Drug targeting and drug delivery systems, vaccines, drug design cycle and molecular modeling.	1 Remembering
CO2	**Understand** and remember the specific and basic concepts of delivery considerations of biotechnological products, Drug targeting and drug delivery systems, vaccines, drug design cycle and molecular modeling, Docking and modeling substrate and s/w tools for CADD.	1,2 Remembering, Understanding
CO3	**Applying,** understanding and remembering the detailed processes, essential techniques and features of delivery considerations of biotechnological products, Drug targeting and drug delivery systems, vaccines, drug design cycle and molecular modeling, Docking and modeling substrate and s/w tools for CADD.	1,2,3 Remembering, Understanding, Demonstrating
CO4	**Analyzing,** applying, remembering and understanding the detailed study related to concepts of delivery considerations of biotechnological products, Drug targeting and drug delivery systems, vaccines, drug design cycle and molecular modeling, Docking and modeling substrate and s/w tools for CADD.	1,2,3,4 Remembering, Understanding, Analyzing
CO5	**Evaluating,** analyzing, applying, remembering, and understanding the principle, methods, properties and functions of delivery considerations of biotechnological products, Drug targeting and drug delivery systems, vaccines, drug design cycle and molecular modeling, Docking and modeling substrate and CADD.	1, 2,3,4,5 Remembering, Understanding, Analyzing, Evaluating
CO6	**Constructing (Creating),** Evaluating, Analyzing, demonstrating, remembering, and understanding the take part delivery considerations of biotechnological products, Drug targeting and drug delivery systems, vaccines, drug design cycle and molecular modeling, Docking and modeling substrate and CADD.	1,2,3,4,5,6 Remembering, Understanding, Analyzing, Evaluating Creating

Mapping of COs with POs & PSOs

Course Outcomes	Program Outcomes (POs)												Program Specific Outcomes (PSOs)			
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO1	2	2	3	2	2	2	2	2	3	2	2	2	3	2	3	2
CO2	2	2	2	2	2	2	2	2	3	2	2	2	2	2	2	2
CO3	2	2	2	2	2	2	2	3	3	2	2	2	2	2	2	2
CO4	2	2	2	2	2	2	2	2	2	1	3	2	2	2	2	2
CO5	3	2	2	2	2	2	2	2	3	2	2	2	2	2	2	2
CO6	2	2	1	1	2	2	2	2	2	1	1	2	2	2	1	1

3: High, 2: Medium, 1: Low

B. Sc. (Hons.) Biotechnology

Course code	**: HBTS 407**
Course Name	**: Evolutionary Biology**
Semester	**: IV**

L	T	P	C
4	4	0	4

Course objectives: The objectives of the course are as follows:

1. To make the student understand the population variation.
2. To make the student understand the evolutionary development.
3. To make the student learn the speciation.
4. To impart the knowledge about evolutionary changes.

UNIT I: Variation within populations [16 Hours]
Life's beginnings: chemogeny, RNA world, biogeny, origin of photosynthesis; evolution of eukaryotes mechanisms responsible for the maintenance and loss of genetic polymorphism within populations; Frequency dependent selection; neutral variation; finite populations; mutations. Micro evolutionary changes; inter-population variations; races, Species concept; Isolating mechanisms; modes of speciation-allopatric; sympatric adaptive radiation; macroevolution exemplified by Galapagos finches

UNIT II: Historical review of evolutionary concept [10 Hours]
Lamarckism; Darwinism; Neo-Darwinism; genetic differentiation among populations in time and space: Drift; effects of migration/dispersal; population structure.

UNIT III: Evidences of evolution [12 Hours]
Fossil record: types of fossils; transitional forms, geological time scale; evolution of horse; origin and evolution of the genetic code and protein synthesizing machinery; three domains of life; neutral theory of molecular evolution; molecular clock; evolution of globin gene family.

UNIT IV: Speciation and reproductive isolation [10 Hours]
Divergence mechanisms; evolution of new species; mate choice; role of time and geography; speciation processes), heritable variations and their role in evolution.

SUGGESTED READING AND TEXT BOOKS

1. Ridle, M 2004. Evolution 3rd ed. Blackwell publishing.
2. Hall, BK and Hallgrimson, B 2008. Evolution 4th ed. Jones and Barlett Publishers.
3. Campbell, NA and Reece JB 2011. Biology. 9th ed. Pearson, Benjamin, Cummings.
4. Pevsner, J 2009. Bioinformatics and Functional Genomics. 2nd ed. WileyBlackwell.
5. Campbell, NA and Reece JB 2011. Biology. 9th ed. Pearson, Benjamin, Cummings.

Course Outcomes (COs): On completion of this course, the students will be:

CO	Description	Bloom's Taxonomy Level
CO1	**Remember** the different basic concepts of introduction to Variation within populations, Historical review of evolutionary concept, Evidences of evolution and Speciation and reproductive isolation.	1 Remembering
CO2	**Understand** and remember the specific and basic concepts of Variation within populations, Historical review of evolutionary concept, Evidences of evolution, Speciation and reproductive isolation and heritable variations and their role in evolution.	1,2 Remembering, Understanding
CO3	**Applying,** understanding and remembering the detailed processes, essential techniques and features of Variation within populations, Historical review of evolutionary concept, Evidences of evolution, Speciation and reproductive isolation and heritable variations and their role in evolution. Drift; effects of migration/dispersal; population structure.	1,2,3 Remembering, Understanding, Demonstrating
CO4	**Analyzing,** applying, remembering and understanding the detailed study related to concepts of Variation within populations, Species concept, Historical review of evolutionary concept, Evidences of evolution, Speciation and reproductive isolation and heritable variations and their role in evolution. Drift; effects of migration/dispersal; population structure.	1,2,3,4 Remembering, Understanding, Analyzing
CO5	**Evaluating,** analyzing, applying, remembering, and understanding the principle, methods, properties and functions of Variation within populations, Species concept, Historical review of evolutionary concept, Evidences of evolution, Speciation and reproductive isolation and heritable variations and their role in evolution. Drift; effects of migration/dispersal; population structure.	1, 2,3,4,5 Remembering, Understanding, Analyzing, Evaluating
CO6	**Constructing (Creating),** Evaluating, Analyzing, demonstrating, remembering, and understanding the take part Variation within populations, Species concept, Historical review of evolutionary concept, Evidences of evolution, Speciation and reproductive isolation and heritable variations and their role in evolution. Drift; effects of migration/dispersal; population structure.	1,2,3,4,5,6 Remembering, Understanding, Analyzing, Evaluating Creating

Mapping of COs with POs & PSOs

Course Outcomes	Program Outcomes (POs)												Program Specific Outcomes (PSOs)			
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO1	2	2	3	2	2	2	2	2	3	2	2	2	3	2	3	2
CO2	2	2	2	2	2	2	2	2	3	2	2	2	2	2	2	2
CO3	2	2	2	2	2	2	2	3	3	2	2	2	2	2	2	2
CO4	2	2	2	2	2	2	2	2	2	1	3	2	2	2	2	2
CO5	3	2	2	2	2	2	2	2	3	2	2	2	2	2	2	2
CO6	2	2	1	1	2	2	2	2	2	1	1	2	2	2	1	1

3: High, 2: Medium, 1: Low

B. Sc. (Hons.) Biotechnology

Course code	**: HBTC 501**
Course Name	**: Bioprocess Technology**
Semester	**: V**

L	T	P	C
4	4	0	4

Course objectives: The specific objectives of the course are as follows:

1. To impart the knowledge of cultivation and growth kinetics of microorganisms.
2. To make students understand the basic concept of sterilization and different parts of a bioreactor.
3. To teach the application of bioprocess technology in industries.
4. To make students understand about thermal death kinetics of microorganisms.

UNIT I (10 Periods)

Introduction to bioprocess technology.

Basic principle components of fermentation technology. Types of microbial culture and its growth kinetics– Batch, Fedbatch and Continuous culture.

UNIT II (20 Periods)

Airlift; Cyclone Column; Packed Tower and their application in production processes.

Principles of upstream processing – Media preparation, Inoculation development and sterilization.

UNIT III (15 Periods)

Introduction to oxygen requirement in bioprocess; mass transfer coefficient; factors affecting KLa. Bioprocess measurement and control system with special reference to computer aided process control.

UNIT IV (15 Periods)

Introduction to downstream processing, product recovery and purification. Effluent treatment. Microbial production of ethanol, amylase, lactic acid and Single Cell Proteins.

SUGGESTED READING AND TEXT BOOKS

1. Casida LE. (1991). Industrial Microbiology. 1st edition. Wiley Eastern Limited.
2. Crueger W and Crueger A. (2000). Biotechnology: A textbook of Industrial Microbiology. 2nd edition. Panima Publishing Co. New Delhi.
3. Patel AH. (1996). Industrial Microbiology. 1st edition, Macmillan India Limited.
4. Stanbury PF, Whitaker A and Hall SJ. (2006). Principles of Fermentation Technology. 2nd edition, Elsevier Science Ltd.

Course Outcomes (COs): On completion of this course, the students will be:

CO	Description	Bloom's Taxonomy Level
CO1	**Remember** the different basic concepts of introduction to Introduction to bioprocess technology, Basic principle components of fermentation technology, Principles of upstream processing, oxygen requirement in bioprocess, Bioprocess measurement and Microbial production.	1 Remembering
CO2	**Understand** and remember the specific and basic concepts of bioprocess technology, Basic principle components of fermentation technology, Principles of upstream processing, oxygen requirement in bioprocess, Bioprocess measurement and Microbial production.	1,2 Remembering, Understanding
CO3	**Applying,** understanding and remembering the detailed processes, essential techniques and features of bioprocess technology, Basic principle components of fermentation technology, Principles of upstream processing, oxygen requirement in bioprocess, Bioprocess measurement and Microbial production.	1,2,3 Remembering, Understanding, Demonstrating
CO4	**Analyzing,** applying, remembering and understanding the detailed study related to concepts of bioprocess technology, Basic principle components of fermentation technology, Principles of upstream processing, oxygen requirement in bioprocess, Bioprocess measurement and Microbial production.	1,2,3,4 Remembering, Understanding, Analyzing
CO5	**Evaluating,** analyzing, applying, remembering, and understanding the principle, methods, properties and functions of bioprocess technology, Basic principle components of fermentation technology, Principles of upstream processing, oxygen requirement in bioprocess, Bioprocess measurement and Microbial production.	1, 2,3,4,5 Remembering, Understanding, Analyzing, Evaluating
CO6	**Constructing (Creating),** Evaluating, Analyzing, demonstrating, remembering, and understanding the take part bioprocess technology, Basic principle components of fermentation technology, Principles of upstream processing, oxygen requirement in bioprocess, Bioprocess measurement and Microbial production.	1,2,3,4,5,6 Remembering, Understanding, Analyzing, Evaluating Creating

Mapping of COs with POs & PSOs

Course Outcomes	Program Outcomes (POs)												Program Specific Outcomes (PSOs)			
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO1	3	2	3	2	3	3	3	3	3	2	2	2	3	2	3	2
CO2	3	3	3	2	3	3	3	2	3	2	2	3	3	3	2	2
CO3	2	2	2	2	2	2	2	3	3	2	2	2	2	2	2	2
CO4	2	2	2	2	2	2	2	2	2	1	3	2	2	2	2	2
CO5	3	2	2	2	2	2	2	2	3	2	3	3	3	3	2	2
CO6	2	2	3	3	2	2	2	2	2	3	3	2	2	2	3	3

3: High, 2: Medium, 1: Low

Course code	**: HBTL 501**
Course Name	**: Lab Course Based on HBTC 501**
Semester	**: V**

L	T	P	C
0	0	2	2

Practicals

1. Bacterial growth curve.
2. Estimation of Biomass Production.
3. Determination of the specific growth rate and generation time of a bacterium during submergedfermentation.
4. Estimation of the effect of temperature and pH on the growth of microbes.
5. Estimation of the effect of substrate concentration on the growth of *E.coli.*
6. Estimation of Monod Parameters for microbial growth kinetics.
7. Calculation of thermal death point (TDP) of a microbial sample.
8. Isolation of industrially important microorganisms from natural resource.
9. Screening of microbes for the production of enzymes.
10. Optimization of production and analysis of ethanol.
11. Biological treatment of wastewater originating from an industrial source.

B. Sc. (Hons.) Biotechnology

Course code	**: HBTC 502**
Course Name	**: Recombinant DNA Technology**
Semester	**: V**

L	T	P	C
4	4	0	4

Course objectives: The specific objectives of the course are as follows:

1. To impart knowledge about different components such as vectors, restriction enzymes, ligases, polymerases, alkaline phosphatases used for making recombinant DNA molecule.
2. To make students understand the different techniques such as PCR, transformation, site-directedmutagenesis, etc.
3. To teach the basics of gene transfer technique in plants.
4. To understand Agrobacterium Ti plasmid biology been utilized for making genetically-modifiedplants.

UNIT I (15 Periods)

Molecular tools and applications- restriction enzymes, ligases, polymerases, alkaline phosphatase. Gene Recombination and Gene transfer: Transformation, Episomes, Plasmids and other cloning vectors (Bacteriophage-derived vectors, artificial chromosomes), Microinjection, Electroporation, Ultrasonication, Principle and applications of Polymerase chain reaction (PCR), primer-design, and RT- (Reverse transcription) PCR.

UNIT II (20 Periods)

Restriction and modification system, restriction mapping. Southern and Northern hybridization. Preparation and comparison of Genomic and cDNA library, screening of recombinants, reverse transcription,. Genome mapping, DNA fingerprinting, Applications of Genetic engineering in animals: Production and applications of transgenic mice, role of ES cells in gene targeting in mice, Therapeutic products produced by genetic engineering-blood proteins, human hormones, immune modulators and vaccines (one example each).

UNIT III (10 Periods)

Random and site-directed mutagenesis: Primer extension and PCR based methods of site directed mutagenesis, Random mutagenesis, Gene shuffling, production of chimeric proteins, Protein engineering concepts and examples (any two).

UNIT IV (15 Periods)

Genetic engineering in plants: Use of *Agrobacterium tumefaciens* and A. rhizogenes, Ti plasmids, Strategies for gene transfer to plant cells, Direct DNA transfer to plants, Gene targeting in plants, Use of plant viruses as episomal expression vectors.

SUGGESTED READING AND TEXT BOOKS

1. Brown TA. (2006). Gene Cloning and DNA Analysis. 5th edition. Blackwell Publishing, Oxford, U.K.
2. Clark DP and Pazdernik NJ. (2009). Biotechnology-Applying the Genetic Revolution. Elsevier Academic Press, USA.
3. Glick, B.R., Pasternak, J.J. (2003). Molecular Biotechnology- Principles and Applications of recombinant DNA. ASM Press, Washington
4. Primrose SB and Twyman RM. (2006). Principles of Gene Manipulation and Genomics, 7th edition. Blackwell Publishing, Oxford, U.K.

Course Outcomes (COs): On completion of this course, the students will be:

CO	Description	Bloom's Taxonomy Level
CO1	**Remember** the different basic concepts of introduction to Introduction to molecular tools used in RDT and applications, Restriction and modification system, hybridization techniques, Genetic engineering in animals, Random and site-directed mutagenesis and Genetic engineering in plants.	1 Remembering
CO2	**Understand** and remember the specific and basic concepts of basic principle components of molecular tools used in RDT and applications, Restriction and modification system, hybridization techniques, Genetic engineering in animals, Random and site-directed mutagenesis and Genetic engineering in plants.	1,2 Remembering, Understanding
CO3	**Applying,** understanding and remembering the detailed processes, essential techniques and features of molecular tools used in RDT and applications, Restriction and modification system, hybridization techniques, Genetic engineering in animals, Random and site-directed mutagenesis and Genetic engineering in plants	1,2,3 Remembering, Understanding, Demonstrating
CO4	**Analyzing,** applying, remembering and understanding the detailed study related to concepts of molecular tools used in RDT and applications, Restriction and modification system, hybridization techniques, Genetic engineering in animals, Random and site-directed mutagenesis and Genetic engineering in plants.	1,2,3,4 Remembering, Understanding, Analyzing
CO5	**Evaluating,** analyzing, applying, remembering, and understanding the principle, methods, properties and functions of molecular tools used in RDT and applications, Restriction and modification system, hybridization techniques, Genetic engineering in animals, Random and site-directed mutagenesis and Genetic engineering in plants.	1, 2,3,4,5 Remembering, Understanding, Analyzing, Evaluating
CO6	**Constructing (Creating),** Evaluating, Analyzing, demonstrating, remembering, and understanding the take part in molecular tools used in RDT and applications, Restriction and modification system, hybridization techniques, Genetic engineering in animals, Random and site-directed mutagenesis and Genetic engineering in plants	1,2,3,4,5,6 Remembering, Understanding, Analyzing, Evaluating Creating

Mapping of COs with POs & PSOs

Course Outcomes	Program Outcomes (POs)												Program Specific Outcomes (PSOs)			
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO1	2	2	3	2	2	2	2	2	3	2	2	2	3	2	3	2
CO2	3	2	2	2	3	3	3	2	3	2	2	3	3	3	2	2
CO3	2	2	2	2	2	2	2	3	3	2	2	2	2	2	2	2
CO4	2	2	2	2	2	2	2	2	2	1	3	2	2	2	2	2
CO5	3	2	2	2	2	2	2	2	3	2	2	2	2	2	2	2
CO6	2	2	2	2	2	2	2	2	2	3	3	2	2	2	3	3

3: High, 2: Medium, 1: Low

B. Sc. (Hons.) Biotechnology

Course code	**: HBTL 502**
Course Name	**: Lab Course Based on HBTC 502**
Semester	**: V**

L	T	P	C
0	0	2	2

Practicals

1. Isolation of chromosomal DNA from plant cells
2. Isolation of chromosomal DNA from *E.coli*
3. Plasmid DNA isolation and electrophoresis of DNA from *E. coli*.
4. Restriction digestion of plasmid DNA.
5. Restriction mapping of DNA.
6. Ligation of DNA molecules.
7. Preparation of competent cells.
8. Transformation of competent cells.
9. Designing of primers for polymerase chain reaction (PCR).
10. Perform PCR to amplify a DNA fragment.
11. Isolation of recombinant protein from bacterial cells.

B. Sc. (Hons.) Biotechnology

Course code	**: HBTD 503**
Course Name	**: Animal Diversity- I**
Semester	**: V**

L	T	P	C
4	4	0	4

Course objectives: This course presents an overview of invertebrates, ranging from protozoa to hemichordata. The specific objectives of the course are as follows:

1. To make the student understand the classification invertebrates of animal kingdom.
2. To make the student understand the characteristics of invertebrates.
3. To make the student learn the diversity of protozoa to hemichordata.
4. To impart the knowledge about parasitic adaptation of roundworms.

UNIT I (15 Periods)

a) Outline of classification of Non- Chordates upto subclasses. Coelomata, Acoelomata,Symmetries, Deutrostomes, Protostomes.

b) Protozoa: Locomotion, Reproduction, evolution of Sex, General features of *Paramoecium* and *Plasmodium*. Pathogenic protozoans

c) Porifera: General characters, outline of Classification; skeleton, Canal System

UNIT II (15 Periods)

a) Coelenterata: General Characters, Outline of classifications Polymorphism, Various types of stinging cells; Metagenesis, coral reefs and their formation.

b) Platyhelminthes- General Characters; Outline of classification; Pathogenic flatworms: Parasitic adaptations.

c) Aschelminthes: General features, Outline of classification, Pathogenic roundworms and their vectors in relation to man: Parasite adaptation.

UNIT III (15 Periods)

a) Annelida: - General features, Outline of classification, Coelom: Metameric segmentation,General features of Earthworm, Vermicomposting.

b) Arthropoda: General Features, Outline of Classification; Larval forms of crustacean, Respiration in Arthropoda; Metamorphosis in insects; Social insects; Insect vectors of diseases; Apiculture, Sericulture.

UNIT IV (15 Periods)

a) Mollusca : general features, Outline of classification, Shell Diversity; Torsion ingastropoda.

b) Echinodermata: General features, Outline of Classification Larval forms

c) Hemichordata: Phylogeny: Affinities of *Balanoglossus*

SUGGESTED READING AND TEXT BOOKS

1. Barnes, R.S.K., Calow, P., Olive, P.J.W., Golding, D.W. & J.I., Spicer (2002) TheInvertebrates: A New Synthesis. III Edition. Blackwell Science.
2. Barrington, E.J.W. (1979) Invertebrate Structure and Functions. II Edition. E.L.B.S. and Nelson.
3. Boradale, L.A. and Potts, E.A. (1961) Invertebrates: A Manual for the use of Students. Asia Publishing Home.
4. Bushbaum, R. (1964) Animals without Backbones. University of Chicago Press.
5. Kent, G.C. and Carr R.K. (2000). Comparative Anatomy of the Vertebrates. IX Edition. The McGraw-HillCompanies.

Course Outcomes (COs): On completion of this course, the students will be:

CO	Description	Bloom's Taxonomy Level
CO1	**Remember** the different basic concepts of introduction to Outline of classification of Non- Chordates upto subclasses, Protozoa, Porifera to Arthopoda, Mollusca, Echinodermata and Hemichordata. Apiculture, sericulture.	1 Remembering
CO2	**Understand** and remember the specific and basic concepts of Non- Chordates upto subclasses, Protozoa, Porifera to Arthopoda, Mollusca, Echinodermata and Hemichordata. Apiculture, sericulture.	1,2 Remembering, Understanding
CO3	**Applying,** understanding and remembering the detailed processes, essential techniques for identificatin and features of Non- Chordates upto subclasses, Protozoa, Porifera to Arthopoda, Mollusca, Echinodermata and Hemichordata. Apiculture, sericulture.	1,2,3 Remembering, Understanding, Demonstrating
CO4	**Analyzing,** applying, remembering and understanding the detailed study related to Non- Chordates upto subclasses, Protozoa, Porifera to Arthopoda, Mollusca, Echinodermata and Hemichordata. Apiculture, sericulture.	1,2,3,4 Remembering, Understanding, Analyzing
CO5	**Evaluating,** analyzing, applying, remembering, and understanding the Non- Chordates upto subclasses, Protozoa, Porifera to Arthopoda, Mollusca, Echinodermata and Hemichordata. Apiculture, sericulture.	1, 2,3,4,5 Remembering, Understanding, Analyzing, Evaluating
CO6	**Constructing (Creating),** Evaluating, Analyzing, demonstrating, remembering, and understanding the take part in Non- Chordates upto subclasses, Protozoa, Porifera to Arthopoda, Mollusca, Echinodermata and Hemichordata. Apiculture, sericulture.	1,2,3,4,5,6 Remembering, Understanding, Analyzing, Evaluating Creating

Mapping of COs with POs & PSOs

Course Outcomes	Program Outcomes (POs)												Program Specific Outcomes (PSOs)			
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO1	2	2	2	2	2	2	2	2	2	2	2	2	3	2	2	2
CO2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
CO3	2	2	2	2	2	2	2	3	2	2	2	2	2	2	2	2
CO4	2	2	2	2	2	2	2	2	2	1	3	2	2	2	2	2
CO5	3	2	2	2	2	2	2	2	3	2	2	2	2	2	2	2
CO6	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

3: High, 2: Medium, 1: Low

B. Sc. (Hons.) Biotechnology

Course code	**: HBTL 503**
Course Name	**: Lab Course Based on HBTD 503**
Semester	**: V**

L	T	P	C
0	0	2	2

Practicals

1. Study of protozoa using permanent slides.
2. Identification and classification of porifera: *Euspongia*, *Scypha*.
3. Study of hydra by permanent slides.
4. Identification and classification of platyhelminthes: *Taenia, Fasciola*.
5. Ecological Note – On any of the specimens in Exercise No 1 Models of dissection of Earthworm, Cockroach Earthworm: Digestive, Nervous System, Cockroach: Digestive Reproductive, Nervous System.
6. Study digestive system of earthworm using models.
7. Dissection of salivary glands of cockroach.
8. Glycerin preparation of hastate plate.
9. Permanent preparation of gill lamella.
10. Dissection of *Pila*.

B. Sc. (Hons.) Biotechnology

Course code	**: HBTD 504**
Course Name	**: Animal Biotechnology**
Semester	**: V**

L	T	P	C
4	4	0	4

Course objectives: The course aims to make students gain knowledge in the current trends and techniques in animal biotechnology. The specific objectives of the course are as follows:

1. To develop an understanding about animal cell culture and gene delivery methods in animals.
2. To provide an overview of in-vitro fertilization, embryo transfer methods and other relatedtechniques.
3. To gain knowledge about the stem cells and their various applications
4. To learn about the production of transgenic animal and gene therapy and their applications.

UNIT I (10 Periods)

Gene transfer methods in Animals – Microinjection, Embryonic Stem cell, gene transfer, Retrovirus & Gene transfer.

UNIT II (10 Periods)

Introduction to transgenesis. Transgenic Animals – Mice, Cow, Pig, Sheep, Goat, Bird, Insect. Animal diseases need help of Biotechnology – Foot-and mouth disease, Coccidiosis, Trypanosomiasis, Theileriosis.

UNIT III (20 Periods)

Animal propagation – Artificial insemination, Animal Clones. Conservation Biology – Embryo transfer techniques. Introduction to Stem Cell Technology and its applications.

UNIT IV (20 Periods)

Genetic modification in Medicine - gene therapy, types of gene therapy, vectors in gene therapy, molecular engineering, human genetic engineering, problems & ethics.

SUGGESTED READING AND TEXT BOOKS

1. Brown, T.A. (1998). Molecular biology Labfax II: Gene analysis. II Edition. Academic Press, California,USA.
2. Butler, M. (2004). Animal cell culture and technology: The basics. II Edition. Bios scientific publishers.
3. Glick, B.R. and Pasternak, J.J. (2009). Molecular biotechnology- Principles and applications of recombinant DNA. IV Edition. ASM press, Washington, USA.
4. Griffiths, A.J.F., J.H. Miller, Suzuki, D.T., Lewontin, R.C. and Gelbart, W.M. (2009). An introduction to genetic analysis. IX Edition. Freeman & Co., N.Y., USA.
5. Watson, J.D., Myers, R.M., Caudy, A. and Witkowski, J.K. (2007). Recombinant DNAgenes and genomes- A short course. III Edition. Freeman and Co., N.Y., USA.

Course Outcomes (COs): On completion of this course, the students will be:

CO	Description	Bloom's Taxonomy Level
CO1	**Remember** the different basic concepts of introduction to animal biotechnology, gene transfer methods in animals, transgenesis, animal diseases need help of biotechnology, animal propagation and genetic modification in medicine.	1 Remembering
CO2	**Understand** and remember the specific and basic concepts of animal biotechnology, gene transfer methods in animals, transgenesis, animal diseases need help of biotechnology, animal propagation and genetic modification in medicine..	1,2 Remembering, Understanding
CO3	**Applying,** understanding and remembering the detailed processes, essential techniques for identificatin and features of animal biotechnology, gene transfer methods in animals, transgenesis, animal diseases need help of biotechnology, animal propagation and genetic modification in medicine.	1,2,3 Remembering, Understanding, Demonstrating
CO4	**Analyzing,** applying, remembering and understanding the detailed study related to animal biotechnology, gene transfer methods in animals, transgenesis, animal diseases need help of biotechnology, animal propagation and genetic modification in medicine.	1,2,3,4 Remembering, Understanding, Analyzing
CO5	**Evaluating,** analyzing, applying, remembering, and understanding the animal biotechnology, gene transfer methods in animals, transgenesis, animal diseases need help of biotechnology, animal propagation and genetic	1, 2,3,4,5 Remembering, Understanding, Analyzing, Evaluating
CO6	**Constructing (Creating),** Evaluating, Analyzing, demonstrating, remembering, and understanding the take part in animal biotechnology, gene transfer methods in animals, transgenesis, animal diseases need help of biotechnology, animal propagation and genetic modification in medicine.	1,2,3,4,5,6 Remembering, Understanding, Analyzing, Evaluating Creating

Mapping of COs with POs & PSOs

Course Outcomes	Program Outcomes (POs)												Program Specific Outcomes (PSOs)			
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO1	3	2	2	2	2	2	2	2	2	2	2	2	3	2	2	2
CO2	2	2	3	3	3	3	3	3	2	2	2	2	2	2	2	2
CO3	3	3	3	2	2	2	2	3	2	2	2	2	2	2	2	2
CO4	2	3	3	3	3	3	3	3	3	1	3	2	3	3	3	3
CO5	3	2	2	2	2	2	2	2	3	2	2	2	2	2	2	2
CO6	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2

3: High, 2: Medium, 1: Low

B. Sc. (Hons.) Biotechnology

Course code	**: HBTL 504**
Course Name	**: Lab Course Based on HBTD 504**
Semester	**: V**

L	T	P	C
0	0	2	2

Practicals

1. Sources of contamination and decontamination measures.
2. Preparation of Hanks Balanced salt solution.
3. Preparation of Minimal Essential Growth medium.
4. Isolation of lymphocytes for culturing.
5. Sterilization techniques: Theory and Practical: Glass ware sterilization, Media sterilization, Laboratory sterilization.
6. Preparation of animal cell culture media.
7. Inoculation of cells in animal cell culture media.
8. Trypsinizing and subculturing cells from a monolayer.
9. Perform animal cell counting.
10. Determine the percentage of viable cells by trypan blue exclusion test.
11. MTT cell proliferation assay.
12. Establishment of primary cell culture.
13. Giemsa staining of animal cells.
14. DPPH (2,2 Diphenyl-1-Picryl Hydrazyl) radical scavenging assay.
15. Preservation of animal cells.
15. DNA isolation from animal tissue.
16. Quantification of isolated DNA.
17. Resolving DNA on Agarose Gel.

B. Sc. (Hons.) Biotechnology

Course code	**: HBTD 505a**
Course Name	**: Ecology and Environment Management**
Semester	**: V**

L	T	P	C
4	4	0	4

Course objectives: The specific objectives of the course are as follows:

1. To impart basic knowledge about the environment and its allied problems.
2. To teach students about different types of ecosystem.
3. To make students understand the flow of energy in an ecosystem.
4. To increase awareness amongst students about different environmental challenges.

UNIT-I (12 Periods)

Our Environment: Geological consideration of Atmosphere, Hydrosphere, Lithosphere Scope of Ecology. Development & Evolution of Ecosystem. Principles & Concepts of Ecosystem. Structure of ecosystem. Strata of an ecosystem. Types of ecosystem including habitats. Cybernetics & Homeostasis. Biological control of chemical environment.

UNIT-II (20 Periods)

Energy transfer in an Ecosystem. Food chain, food web, Energy budget, Production & decomposition in a system. Ecological efficiencies, Trophic structure & energy pyramids, Ecological energetic, principles pertaining to limiting factors, Bio-geochemical cycles (N,C,P cycles).

UNIT-III (18 Periods)

Pollution & environmental Health related to Soil, Water, Air, Food, Pesticides, Metals, Solvents, Radiations ,Carcinogen, Poisons. Detection of Environmental pollutant. Indicators & detection systems. Bio-transformation, Plastic, Aromatics, Hazardous wastes Environmental cleanup : Case studies

UNIT-IV (10 Periods)

Environmental biotechnologies, Biotechnologies in protection and preservation of environment. Bioremediation, Waste disposal.

SUGGESTED READING AND TEXT BOOKS

1. Chapman, J.L., Reiss, M.J. 1999. Ecology: Principles and applications (2nd edition) Cambridge University Press.
2. Divan Rosencraz, Environmental laws and policies in India, Oxford Publication.
3. Ghosh, S.K., Singh, R. 2003. Social forestry and forest management. Global Vision Publishing House
4. Joseph, B., Environmental studies, Tata Mc Graw Hill.
5. Michael Allabay, Basics of environmental science, Routledge Press.
6. Miller, G.T. 2002. Sustaining the earth, an integrated approach. (5thedition) Books/Cole, Thompson Learning, Inc.
7. Mohapatra Textbook of environmental biotechnology IK publication.
8. Rana SVS, Environmenta lpollution – health and toxicology, Narosa Publication
9. Sinha, S. 2010. Handbook on Wildlife Law Enforsement in India. TRAFFIC, India.
10. Thakur, I S, Environmental Biotechnology, I K Publication.

Course Outcomes (COs): On completion of this course, the students will be:

CO	Description	Bloom's Taxonomy Level
CO1	**Remember** the different basic concepts of introduction to our environment and ecosystem, energy transfer in an ecosystem, bio-geochemical cycles (N,C,P cycles), pollution & environmental health problems, bio-transformation, environmental biotechnologies, biotechnologies in protection and preservation of environment. Bioremediation, Waste disposal.	1 Remembering
CO2	**Understand** and remember the specific and basic concepts of environment and ecosystem, energy transfer in an ecosystem, bio-geochemical cycles (N,C,P cycles), pollution & environmental health problems, bio-transformation, environmental biotechnologies, biotechnologies in protection and preservation of environment.	1,2 Remembering, Understanding
CO3	**Applying,** understanding and remembering the detailed processes, essential techniques for identificatin and features of environment and ecosystem, energy transfer in an ecosystem, bio-geochemical cycles (N,C,P cycles), pollution & environmental health problems, bio-transformation, environmental biotechnologies, biotechnologies in protection and preservation of environment.	1,2,3 Remembering, Understanding, Demonstrating
CO4	**Analyzing,** applying, remembering and understanding the detailed study related to environment and ecosystem, energy transfer in an ecosystem, bio-geochemical cycles (N,C,P cycles), pollution & environmental health problems, bio-transformation, environmental biotechnologies, biotechnologies in protection and preservation of environment.	1,2,3,4 Remembering, Understanding, Analyzing
CO5	**Evaluating,** analyzing, applying, remembering, and understanding the environment and ecosystem, energy transfer in an ecosystem, bio-geochemical cycles (N,C,P cycles), pollution & environmental health problems, bio-transformation, environmental biotechnologies, biotechnologies in protection and preservation of environment.	1, 2,3,4,5 Remembering, Understanding, Analyzing, Evaluating
CO6	**Constructing (Creating),** Evaluating, Analyzing, demonstrating, remembering, and understanding the take part in environment and ecosystem, energy transfer in an ecosystem, bio-geochemical cycles (N,C,P cycles), pollution & environmental health problems, bio-transformation, environmental biotechnologies, biotechnologies in protection and preservation of environment.	1,2,3,4,5,6 Remembering, Understanding, Analyzing, Evaluating Creating

Mapping of COs with POs & PSOs

Course Outcomes	Program Outcomes (POs)												Program Specific Outcomes (PSOs)			
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO1	2	2	2	2	2	2	2	2	2	2	2	2	3	2	2	2
CO2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
CO3	3	3	3	2	2	2	2	3	2	2	2	2	2	2	2	2
CO4	2	3	3	3	2	2	2	2	2	1	3	2	2	2	2	2
CO5	3	2	2	2	2	2	2	2	3	2	2	2	2	2	2	2
CO6	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2

3: High, 2: Medium, 1: Low

B. Sc. (Hons.) Biotechnology

Course code	**: HBTL 505a**
Course Name	**: Lab Course Based on HBTD 505a**
Semester	**: V**

L	T	P	C
0	0	2	2

Practicals

1. Estimation of the biodiversity of a region.
2. Study the different components of an ecosystem.
3. Analysis of soil types by sieve method and pH method.
4. Determination of population density by quadrat sampling.
5. Study biogas production using plant waste by Spoken Tutorial.
6. Demonstration of Principle of GPS (Global Positioning System).
7. Study of the life table and fecundity table, plotting of the three types of survivorship curves fromthe hypothetical data.
8. Study of the types of soil, their texture by sieve method and rapid tests for – pH, chlorides,nitrates, carbonates and organic carbon.
9. Study any five endangered/ threatened species.
10. Study of bioremediation of contaminated soil.

B. Sc. (Hons.) Biotechnology

Course code	**: HBTD 505b**
Course Name	**: Intellectual Property Rights**
Semester	**: V**

L	T	P	C
4	4	0	4

Course objectives: The course aims to explain students about intellectual property rights and patents.The specific objectives of the course are as follows:

1. To make students aware of types of IPRs and their utility.
2. To make students understand the procedure of filing a patent.
3. To teach students about the bioethical and biosafety practices related to biotechnology.
4. To familiarize students with copyright, trademarks, designs and information technology act.

UNIT I: Introduction to IPR [8 Hours]

Basic understanding of intellectual property rights; utility of IPRs; different types of IPRs; introduction to Indian patent law; world trade organization and its related intellectual property provisions world organizations: WIPO and TRIPS agreement, international treaties and conventions on intellectual property.

UNIT III: Protection of IPRs [8 Hours]

Intellectual/industrial property and its legal protection in research, design and development. Forms of protection of IPRs: Introduction to copyrights and its applicability; fundamental concepts and importance of trademarks and trade secrets; geographical indications; design layout design of integrated circuits.

UNIT III: Patents [8 Hours]

Methods of patenting and general concept of patent; patenting agencies; use of technical information in patent documents; revocation of patent; patenting of biological material like microorganisms, plant and animal, patenting in biotechnology, economic, ethical and depository considerations.

UNIT IV: Copyright [8 Hours]

Nature of Copyright; subject matter of copyright: original literary, dramatic, musical, artistic works; cinematograph films and sound recordings; registration, procedure, term of protection; ownership of copyright; assignment and licence of copyright.

UNIT V: Trademarks [8 Hours]

Concept of Trademarks; different kinds of marks (brand names, logos, signatures, symbols, well known marks, certification marks and service marks); non-registrable trademarks; registration of trademarks; rights of holder and assignment and licensing of marks.

SUGGESTED READINGS AND TEXT BOOKS

1. Pandey, N and Dharni, K 2014. Intellectual Property Rights, 1st ed. PHI Learning Pvt. Ltd.
2. Tomkowicz, R 2011. Intellectual Property Overlaps: Theory, Strategies and Solutions, 1st ed.Routledge.
3. Bouchoux, DE 2013. Intellectual property: The Law of Trademarks, Copyrights, Patents andTrade Secrets, 4th ed. Cenage Learning.

Course Outcomes (COs): On completion of this course, the students will be:

CO	Description	Bloom's Taxonomy Level
CO1	**Remember** the different basic concepts of introduction to IPR, Protection of IPRs, Patents, Copyright, assignment and licence of copyright, trademarks and rights of holder and assignment and licensing of marks.	1 Remembering
CO2	**Understand** and remember the specific and basic concepts of IPR, Protection of IPRs, Patents, Copyright, assignment and licence of copyright, trademarks and rights of holder and assignment and licensing of marks. patenting in biotechnology, economic, ethical and depository considerations.	1,2 Remembering, Understanding
CO3	**Applying,** understanding and remembering the detailed processes and features of IPR, Protection of IPRs, Patents, Copyright, assignment and licence of copyright, trademarks and rights of holder and assignment and licensing of marks. patenting in biotechnology, economic, ethical and depository considerations.	1,2,3 Remembering, Understanding, Demonstrating
CO4	**Analyzing,** applying, remembering and understanding the detailed study related to IPR, Protection of IPRs, Patents, Copyright, assignment and licence of copyright, trademarks and rights of holder and assignment and licensing of marks. patenting in biotechnology, economic, ethical and depository considerations.	1,2,3,4 Remembering, Understanding, Analyzing
CO5	**Evaluating,** analyzing, applying, remembering, and understanding the IPR, Protection of IPRs, Patents, Copyright, assignment and licence of copyright, trademarks and rights of holder and assignment and licensing of marks. patenting in biotechnology, economic, ethical and depository considerations.	1, 2,3,4,5 Remembering, Understanding, Analyzing, Evaluating
CO6	**Constructing (Creating),** Evaluating, Analyzing, demonstrating, remembering, and understanding the take part in IPR, Protection of IPRs, Patents, Copyright, assignment and licence of copyright, trademarks and rights of holder and assignment and licensing of marks. patenting in biotechnology, economic, ethical and depository considerations.	1,2,3,4,5,6 Remembering, Understanding, Analyzing, Evaluating Creating

Mapping of COs with POs & PSOs

Course Outcomes	Program Outcomes (POs)												Program Specific Outcomes (PSOs)			
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO1	3	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
CO2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
CO3	3	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
CO4	2	2	2	3	2	2	2	2	2	1	3	2	2	2	2	2
CO5	3	2	2	2	2	2	2	2	3	2	2	2	2	2	2	2
CO6	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2

3: High, 2: Medium, 1: Low

Course code	**: HBTL 505b**
Course Name	**: Lab Course Based on HBTD 505b**
Semester	**: V**

L	T	P	C
0	0	2	2

Practicals

1. Introduction to IPR with Case Studies
2. Study on mechanism of handling infringement, piracy, and unauthorized use.
3. Case study and provides a pool of information to the general public since all forms of IP are published except in case of trade secrets.
4. Case Studies on Industrial designs relates to features of any shape, configuration, surface pattern, composition of lines and colors applied to an article whether 2-D, e.g., textile, or 3-D, e.g., toothbrush.
5. Brief introduction on trademarks relate to any mark, name, or logo under which trade is conducted for any product or service and by which the manufacturer or the service provider is identified.

B. Sc. (Hons.) Biotechnology

Course code	**: HBTD 506**
Course Name	**: Plant Diversity-I**
Semester	**: V**

L	T	P	C
4	4	0	4

Course objectives: This course presents an overview of lower plants, ranging from algae to pteridophytes. The specific objectives of the course are as follows:

1. To make students understand the organization of plant kingdom.
2. To teach the characteristics of lower plant genera.
3. To make students learn the economic importance of lower plants.
4. To impart the knowledge about diseases caused by plant pathogens.

UNIT I

Algae: (20 Periods)

General character, classification and economic importance. Life histories of algae belonging to various classes:

Chlorophyceae – *Volvox, Oedogonium*

Xantho phyceae –*Vaucheria*

Phaeophyceae – *Ectocarpus*

Rhodophyceae-*Polysiphonia*

UNIT II

Fungi: (20 Periods)

General characters, classification & economic importance. Life histories of Fungi:

Mastigomycontina- *Phytophthora*

Zygomycotina-*Mucor*

Ascomycotina- *Saccharomyces*

Basidomycotina-*Agaricus*

Deutromycotina-*Colletotrichum*

UNIT III

Lichens : (10 Periods)

Classification, general structure, reproduction and economic importance. Plant diseases:

4 of 36 Casual organism, symptoms and control of following plant diseases.

Rust & Smut of Wheat.

White rust of Crucifers.

Late blight of Potato.

Red rot of Sugarcane.

Citrus Canker.

UNIT IV

Bryophytes: (10 Periods)

General characters, classification & economic impotence. Life histories of following:

Marchantia.

Funaria.

SUGGESTED READING AND TEXT BOOKS

1. Agrios, G.N. 1997 Plant Pathology, 4 th edition, Academic Press, U.K.
2. Alexopoulos, C.J., Mims, C.W. and Blackwell, M. 1996 Introductory Mycology, 4 Th edition, John Wiley and Sons (Asia) Singapore.
3. Bold, H.C. & Wayne, M.J. 1996 (2 nd Ed.) Introduction to Algae.
4. Kumar, H.D. 1999. Introductory Phycology. Aff. East-West Press Pvt Ltd., Delhi.
5. Lee, R.E. 2008. Phycology, Fourth Edition, Cambridge University Press, USA.
6. Sambamurty 2008 A Textbook of Bryophytes, Pteridophytes, Gymnosperms and Paleobotany. IK International Publishers.
7. Shaw, A.J. and Goffinet, B. 2000 Bryophyte Biology. Cambridge University Press.

8. Van den Hoek, C.; Mann, D.J. & Jahns, H.M. 1995. Algae: An introduction to Phycology. Cambridge Univ. Press.
9. Vander-Poorteri 2009 Introduction to Bryophytes. COP.
10. Webster, J. and Weber, R. 2007 Introduction to Fungi. 3 Rd edition, Cambridge University Press, Cambridge.
11. Wickens, G.E. 2004 Economic Botany: Principles and Practices, Springer. Kuwer Publishers, Dordrecht, The Netherlands

Course Outcomes (COs): On completion of this course, the students will be:

CO	Description	Bloom's Taxonomy Level
CO1	**Remember** the different basic concepts of introduction to general character, classification and economic importance of plants, fungi, plant diseases and general characters, classification & economic impotence. Life histories of *Marchantia* and *Funaria.*	1 Remembering
CO2	**Understand** and remember the specific and basic concepts of plants, fungi, plant diseases and general characters, classification & economic impotence. Life histories of *Marchantia* and *Funaria.*	1,2 Remembering, Understanding
CO3	**Applying,** understanding and remembering the detailed processes and features of plants, fungi, plant diseases and general characters, classification & economic impotence. Life histories of *Marchantia* and *Funaria.*	1,2,3 Remembering, Understanding, Demonstrating
CO4	**Analyzing,** applying, remembering and understanding the detailed study related to plants, fungi, plant diseases and general characters, classification & economic impotence. Life histories of *Marchantia* and *Funaria.*	1,2,3,4 Remembering, Understanding, Analyzing
CO5	**Evaluating,** analyzing, applying, remembering, and understanding the plants, fungi, plant diseases and general characters, classification & economic impotence. Life histories of *Marchantia* and *Funaria.*	1, 2,3,4,5 Remembering, Understanding, Analyzing, Evaluating
CO6	**Constructing (Creating),** Evaluating, Analyzing, demonstrating, remembering, and understanding the take part plants, fungi, plant diseases and general characters, classification & economic impotence. Life histories of *Marchantia* and *Funaria.*	1,2,3,4,5,6 Remembering, Understanding, Analyzing, Evaluating Creating

Mapping of COs with POs & PSOs

Course Outcomes	Program Outcomes (POs)												Program Specific Outcomes (PSOs)			
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
CO2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
CO3	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
CO4	2	2	2	3	2	2	2	2	2	1	3	2	2	2	2	2
CO5	2	2	2	2	2	2	2	2	3	2	2	2	2	2	2	2
CO6	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2

3: High, 2: Medium, 1: Low

B. Sc. (Hons.) Biotechnology

Course code	**: HBTL 506**
Course Name	**: Lab Course Based on HBTD 506**
Semester	**: V**

L	T	P	C
0	0	2	2

Practicals

1. Collection of algae, fungi, bryophytes and pteridophytes from nearby localities and the campus.
2. Slide preparation of *Volvox* and *Oedogonium* to study their vegetative and reproductivestructures.
3. Preparation of temporary mounts of fungi to study hyphae.
4. Prepare sections of the gills of *Agaricus*.
5. Preparation of temporary mount of *Saccharomyces cerevisiae* (Baker's yeast).
6. Section cutting and lectophenol mount of plant disease materials.
7. Section cutting of lichen to study the anatomy.
8. Study of growth forms of lichens (crustose, foliose and fruticose).
9. Comparative study of thalli of various bryophytes.
10. Section cutting of pteridophyte to study their anatomy and vascular system.

B. Sc. (Hons.) Biotechnology

Course code	**: HBTD 507**
Course Name	**: Plant Biotechnology**
Semester	**: V**

L	T	P	C
4	4	0	4

Course objectives: This course presents an overview of the techniques and underlying theory of plant tissue culture, and plant genetic engineering, and their applications. The specific objectives of the course are as follows:

1. To enable students acquire knowledge of the fundamental principles of plant tissue culture.
2. To learn about different kinds of plant culture techniques.
3. To make students understand the principles of Agrobacterium tumefaciens biology and Ti-plasmid.
4. To impart knowledge about the diverse applications of plant biotechnology and genetically- modified crops.

UNIT I (15 Periods)

Introduction, Cryo and organogenic differentiation, Types of culture: Seed , Embryo, Callus, Organs, Cell and Protoplast culture. Micropopagation Axillary bud proliferation, Meristem and shoot tip culture, cud culture, organogenesis, embryogenesis, advantages and disadvantages of micropropagation.

UNIT- II (20 Periods)

In vitro haploid production: Androgenic methods: Anther culture, Microspore culture andogenesis

Sgnificance and use of haploids, Ploidy level and chromosome doubling, diplodization, Gynogenic

haploids, factors effecting gynogenesis, chromosome elimination

techniques for production of haploids in cereals.

UNIT – III (15 Periods)

Protoplast Isolation and fusion: Methods of protoplast isolation, Protoplast development, Somatic hybridization, identifiation and selection of hybrid cells, Cybrids, Potential of somatic hybridization limitations. Somaclonal variation Nomenclautre, methods, applications basis and disadvantages.

UNIT – IV (10 Periods)

Plant Growth Promoting bacteria. Nitrogen fixation, Nitrogenase, Hydrogenase, Nodulation, Biocontrol of pathogens, Growth promotion by free-living bacteria.

SUGGESTED READING AND TEXT BOOKS

1. Bhojwani, S.S. and Razdan 2004 Plant Tissue Culture and Practice.
2. Brown, T. A. Gene cloning and DNA analysis: An Introduction. Blackwell Publication.
3. Gardner, E.J. Simmonns, M.J. Snustad, D.P. 2008 8th edition Principles of Genetics. Wiley India.
4. Raven, P.H., Johnson, GB., Losos, J.B. and Singer, S.R. 2005 Biology. Tata MC Graw Hill.
5. Reinert, J. and Bajaj, Y.P.S. 1997 Applied and Fundamental Aspects of Plant Cell, Tissue and Organ Culture. Narosa Publishing House.
6. Russell, P.J. 2009 Genetics – A Molecular Approach. 3rdedition. Benjamin Co.
7. Sambrook & Russel. Molecular Cloning: A laboratory manual. (3rd edition)
8. Slater, A., Scott, N.W. & Fowler, M.R. 2008 Plant Biotechnology: The Genetic Manipulation of Plants, Oxford University Press.

Course Outcomes (COs): On completion of this course, the students will be:

CO	Description	Bloom's Taxonomy Level
CO1	**Remember** the different basic concepts of introduction to general character of plant biotechnology, cryo and organogenic differentiation, types of culture, In vitro haploid production, protoplast Isolation and fusion and Plant Growth Promoting bacteria.	1 Remembering
CO2	**Understand** and remember the specific and basic concepts of plant biotechnology, cryo and organogenic differentiation, types of culture, In vitro haploid production, protoplast Isolation and fusion and Plant Growth Promoting bacteria. Somaclonal variation nomenclautre, methods, applications basis and disadvantages.	1,2 Remembering, Understanding
CO3	**Applying,** understanding and remembering the detailed processes and features of plant biotechnology, cryo and organogenic differentiation, types of culture, In vitro haploid production, protoplast Isolation and fusion and Plant Growth Promoting bacteria. Somaclonal variation nomenclautre, methods, applications basis and disadvantages.	1,2,3 Remembering, Understanding, Demonstrating
CO4	**Analyzing,** applying, remembering and understanding the detailed study related to plant biotechnology, cryo and organogenic differentiation, types of culture, In vitro haploid production, protoplast Isolation and fusion and Plant Growth Promoting bacteria. Somaclonal variation nomenclautre, methods, applications basis and disadvantages.	1,2,3,4 Remembering, Understanding, Analyzing
CO5	**Evaluating,** analyzing, applying, remembering, and understanding the plant biotechnology, cryo and organogenic differentiation, types of culture, In vitro haploid production, protoplast Isolation and fusion and Plant Growth Promoting bacteria. Somaclonal variation nomenclautre, methods, applications basis and disadvantages.	1, 2,3,4,5 Remembering, Understanding, Analyzing, Evaluating
CO6	**Constructing (Creating),** Evaluating, Analyzing, demonstrating, remembering, and understanding the take part in plant biotechnology, cryo and organogenic differentiation, types of culture, In vitro haploid production, protoplast Isolation and fusion and Plant Growth Promoting bacteria. Somaclonal variation nomenclautre, methods, applications basis and disadvantages.	1,2,3,4,5,6 Remembering, Understanding, Analyzing, Evaluating Creating

Mapping of COs with POs & PSOs

Course Outcomes	Program Outcomes (POs)												Program Specific Outcomes (PSOs)			
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
CO2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
CO3	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
CO4	2	2	2	3	2	2	2	2	2	1	3	2	2	2	2	2
CO5	2	2	2	2	2	2	2	2	3	2	2	2	2	2	2	2
CO6	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2

3: High, 2: Medium, 1: Low

B. Sc. (Hons.) Biotechnology

Course code	**: HBTL 507**
Course Name	**: Lab Course Based on HBTD 507**
Semester	**: V**

L	T	P	C
0	0	2	2

Practicals

1. Sterilization of glassware, plasticware, and preparation of stock solutions.
2. Preparation of Murashige and Skoog (MS) medium.
3. Sterilization and inoculation of the explant on MS medium.
4. Induction of callus from the explant.
5. Isolation of DNA from plant tissue by CTAB method.
6. Isolation of RNA from plant tissue.
7. Isolation of protein from plant tissue.
8. Isolation of protoplasts by mechanical method.
9. Perform seed viability test by tetrazolium chloride test.
10. Isolation of plant embryos and their *in vitro* culture.

B. Sc. (Hons.) Biotechnology

Course code	**: HBTD 508a**
Course Name	**: Bioinformatics**
Semester	**: V**

L	T	P	C
4	4	0	4

Course objectives: The aim of the course is to introduce students to the basic tenets of bioinformatics. The course provides a strong foundation for developing skills in using biological sequence databases, and tools for biological sequence analysis. The specific objectives of the course are as follows:

1. To teach students about biological sequence data storage.
2. To make students understand about various bioinformatics tools used for DNA, RNA and proteinsequence analysis.
3. To impart knowledge about biological sequence alignment.
4. To teach the fundamental principles of molecular phylogeny.

UNIT I (10 Periods)

History of Bioinformatics. The notion of Homology. Sequence Information Sources, EMBL, GENBANK, Entrez, Unigene, Understanding the structure of each source and using it on the web.

UNIT II (20 Periods)

Protein Information Sources, PDB, SWISSPROT, TREMBL, Understanding the structure of each source and using it on the web. Introduction of Data Generating Techniques and Bioinformatics problem posed by them- Restriction Digestion, Chromatograms, Blots, PCR, Microarrays, Mass Spectrometry.

UNIT III (20 Periods)

Sequence and Phylogeny analysis, Detecting Open Reading Frames, Outline of sequence Assembly, Mutation/Substitution Matrices, Pairwise Alignments, Introduction to BLAST, using it on the web, Interpreting results, Multiple Sequence Alignment, Phylogenetic Analysis.

UNIT IV (10 Periods)

Searching Databases: SRS, Entrez, Sequence Similarity Searches-BLAST, FASTA, Data Submission. Genome Annotation: Pattern and repeat finding, Gene identification tools.

SUGGESTED READING

1. Ghosh Z. and Bibekanand M. (2008) Bioinformatics: Principles and Applications. Oxford University Press.
2. Pevsner J. (2009) Bioinformatics and Functional Genomics. II Edition. Wiley-Blackwell.
3. Campbell A. M., Heyer L. J. (2006) Discovering Genomics, Proteomics and Bioinformatics. II Edition. Benjamin Cummings.

Course Outcomes (COs): On completion of this course, the students will be:

CO	Description	Bloom's Taxonomy Level
CO1	**Remember** the different basic concepts of introduction to general character of Bioinformatics, history of Bioinformatics, Sequence Information Sources, Protein Information Sources, techniques for data identifications, Sequence and Phylogeny analysis, Searching Databases and genome annotation.	1 Remembering
CO2	**Understand** and remember the specific and basic concepts of Bioinformatics, history of Bioinformatics, Sequence Information Sources, Protein Information Sources, techniques for data identifications, Sequence and Phylogeny analysis, Searching Databases and genome annotation.	1,2 Remembering, Understanding
CO3	**Applying,** understanding and remembering the detailed processes and features of Bioinformatics, history of Bioinformatics, Sequence Information Sources, Protein Information Sources, techniques for data identifications, Sequence and Phylogeny analysis, Searching Databases and genome annotation.	1,2,3 Remembering, Understanding, Demonstrating
CO4	**Analyzing,** applying, remembering and understanding the detailed study related to Bioinformatics, history of Bioinformatics, Sequence Information Sources, Protein Information Sources, techniques for data identifications, Sequence and Phylogeny analysis, Searching Databases and genome annotation.	1,2,3,4 Remembering, Understanding, Analyzing
CO5	**Evaluating,** analyzing, applying, remembering, and understanding the Bioinformatics, history of Bioinformatics, Sequence Information Sources, Protein Information Sources, techniques for data identifications, Sequence and Phylogeny analysis, Searching Databases and genome annotation.	1, 2,3,4,5 Remembering, Understanding, Analyzing, Evaluating
CO6	**Constructing (Creating),** Evaluating, Analyzing, demonstrating, remembering, and understanding the take part in Bioinformatics, history of Bioinformatics, Sequence Information Sources, Protein Information Sources, techniques for data identifications, Sequence and Phylogeny analysis, Searching Databases and genome annotation.	1,2,3,4,5,6 Remembering, Understanding, Analyzing, Evaluating Creating

Mapping of COs with POs & PSOs

Course Outcomes	Program Outcomes (POs)												Program Specific Outcomes (PSOs)			
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO1	3	2	2	2	2	2	2	3	3	3	3	3	3	3	2	2
CO2	3	3	3	3	3	3	3	2	2	2	2	2	2	2	2	2
CO3	3	3	3	3	3	3	3	2	2	2	3	3	3	3	3	3
CO4	2	2	2	3	2	2	2	2	2	1	3	2	2	2	2	2
CO5	2	2	3	3	2	2	3	3	3	2	2	2	2	2	2	2
CO6	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3

3: High, 2: Medium, 1: Low

B. Sc. (Hons.) Biotechnology

Course code	**: HBTL 508a**
Course Name	**: Lab Course Based on HBTD 508a**
Semester	**: V**

L	T	P	C
0	0	2	2

Practicals

1. Sequence information resource
2. Understanding and use of various web resources: EMBL, Genbank, Entrez, Unigene, Protein information resource (PIR)
3. Retrieval of nucleotide and protein sequence of a gene from NCBI.
4. Use of BLAST for searching a gene sequence.
5. Understanding and using: PDB, Swissprot, TREMBL
6. Finding ORF in a given DNA sequence.
7. Protein 3D structure visualization using RasMol.
8. Retrieval of structural data of a protein from PDB database.
9. Finding motif information of a protein using Prosite.
10. Multiple sequence alignment using Clustal omega.
11. Protein sequence analysis using PeptideCutter.
12. Perform virtual cloning using Benchling.

B. Sc. (Hons.) Biotechnology

Course code	**: HBTD 508b**
Course Name	**: Advance Forensic Science**
Semester	**: V**

L	T	P	C
4	4	0	4

Course objectives: This is an introductory course on forensic sciences withthe following objectives:

5. To familiarize students with the fundamentalprinciples of forensic sciences.
6. To impart knowledge about the injuries and deaths and how they are assessed.
7. To make students understand the process of documentation of crime scenes.
8. To impart the knowledge about the importance of cyber security in forensic sciences.

UNIT I: Principles of forensic sciences and Forensic biology (14 Hours)

Introduction and principles of forensic science; forensic science laboratory and its organization; tools and techniques in forensic science; branches of forensic science; causes of crime; role of *modus operandi* in criminal investigation. Nature and importance of biological evidence; significance of hair, semen and blood as biological evidences; types and identification of microbial organisms of forensic significance;identification of wood, leaves, pollens, diatoms and insects as forensic evidence.

UNIT II: Injuries and deaths (10 Hours)

Classification of injuries and their medico-legal aspects; method of assessing various types of deaths;general and individual characteristics of handwriting; examination and comparison of handwritings and analysis of ink from various samples.

UNIT III: Exposives and ballistics (12 Hours)

Classification of firearms and explosives; introduction to internal, external and terminal ballistics;chemical evidence for explosives; process of documentation of crime scene by photography, sketching and field notes.

UNIT IV: Fingerprints, DNA fingerprinting and toxicology (12 Hours)

Fundamental principles of fingerprinting; classification of fingerprints; development of fingerprints as science for identification; principle of DNA fingerprinting; application of DNA profiling in forensics; role of the toxicologist; significance of toxicological findings in forensics.

SUGGESTED READING AND TEXT BOOKS

1. Bhasin, MK and Nath, S 2002.Role of Forensic Science in the New Millennium, University ofDelhi, Delhi.
2. James, SH and Nordby, JJ 2005. Forensic Science: An Introduction to Scientific andInvestigative Techniques, 2nd ed. CRC Press, Boca Raton.
3. Nanda, BB and Tiwari, RK 2001. Forensic Science in India: A Vision for the Twenty FirstCentury, Select Publishers, New Delhi.
4. Eckert, WG editor 1997.Introduction to Forensic Sciences, 2nd ed. CRC Press, Boca Raton.
5. Tilstone, WJ, Hastrup, ML and Hald, C 2012. Fisher's Techniques of Crime Scene Investigation,1st International ed. CRC Press, Boca Raton.

Course Outcomes (COs): On completion of this course, the students will be:

CO	Description	Bloom's Taxonomy Level
CO1	**Remember** the different basic concepts of introduction to general character of principles of forensic science; forensic science laboratory and its organization, Classification of injuries and their medico-legal aspects, Exposives and ballistics, process of documentation of crime scene by photography, sketching and field notes and Fingerprints, DNA fingerprinting and toxicology.	1 Remembering
CO2	**Understand** and remember the specific and basic concepts of forensic science; forensic science laboratory and its organization, Classification of injuries and their medico-legal aspects, Exposives and ballistics, process of documentation of crime scene by photography, sketching and field notes and Fingerprints, DNA fingerprinting and toxicology.	1,2 Remembering, Understanding
CO3	**Applying,** understanding and remembering the detailed processes and features of forensic science; forensic science laboratory and its organization, Classification of injuries and their medico-legal aspects, Exposives and ballistics, process of documentation of crime scene by photography, sketching and field notes and Fingerprints, DNA fingerprinting and toxicology.	1,2,3 Remembering, Understanding, Demonstrating
CO4	**Analyzing,** applying, remembering and understanding the detailed study related to forensic science; forensic science laboratory and its organization, Classification of injuries and their medico-legal aspects, Exposives and ballistics, process of documentation of crime scene by photography, sketching and field notes and Fingerprints, DNA fingerprinting and toxicology.	1,2,3,4 Remembering, Understanding, Analyzing
CO5	**Evaluating,** analyzing, applying, remembering, and understanding the forensic science; forensic science laboratory and its organization, Classification of injuries and their medico-legal aspects, Exposives and ballistics, process of documentation of crime scene by photography, sketching and field notes and Fingerprints, DNA fingerprinting and toxicology.	1, 2,3,4,5 Remembering, Understanding, Analyzing, Evaluating
CO6	**Constructing (Creating),** Evaluating, Analyzing, demonstrating, remembering, and understanding the take part in forensic science; forensic science laboratory and its organization, Classification of injuries and their medico-legal aspects, Exposives and ballistics, process of documentation of crime scene by photography, sketching and field notes and Fingerprints, DNA fingerprinting and toxicology.	1,2,3,4,5,6 Remembering, Understanding, Analyzing, Evaluating Creating

Mapping of COs with POs & PSOs

Course Outcomes	Program Outcomes (POs)												Program Specific Outcomes (PSOs)			
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO1	2	2	2	2	2	2	2	3	3	3	3	3	3	3	2	2
CO2	3	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
CO3	2	2	2	2	2	2	2	2	2	2	3	3	3	3	3	3
CO4	2	2	2	3	2	2	2	2	2	1	3	2	2	2	2	2
CO5	2	2	3	3	2	2	3	3	3	2	2	2	2	2	2	2
CO6	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2

3: High, 2: Medium, 1: Low

B. Sc. (Hons.) Biotechnology

Course code	**: HBTL 508b**
Course Name	**: Lab Course Based on HBTD 508b**
Semester	**: V**

L	T	P	C
0	0	2	2

Practicals

1. Study of Crime Scene Investigation: Safeguarding, Searching, Recognition, Documentation, Collection, Packaging, and Preservation of Physical Evidence
2. Study of Trace Evidence Collection and Sorting.
3. Study of Examination of Human Hair.
4. Study of Examination of Trace Quantities of Synthetic Fibers.
5. Case Studies

B. Sc. (Hons.) Biotechnology

Course code	**: HBTC 601**
Course Name	**: Bio-Analytical Tools**
Semester	**: VI**

L	T	P	C
4	4	0	4

Course objectives: The broad objective of the course is to make students aware about the importance and significance of the diverse tools and techniques used to study and understand the biologicalworld. The specific objectives of the course are as follows:

1. To introduce the basic principle, types and application of microscopy.
2. To study concepts applications and types of centrifugation.
3. To acquaint students with chromatography and spectroscopy techniques.
4. To makes students understand the techniques of electrophoresis and blotting.

UNIT I (10 Periods)

Simple microscopy, phase contrast microscopy, florescence and electron microscopy (TEM and SEM), pH meter, absorption and emission spectroscopy.

UNIT II (15 Periods)

Principle and law of absorption fluorimetry, colorimetry, spectrophotometry (visible, UV, infrared), centrifugation, cell fractionation techniques, isolation of sub-cellular organelles and particles.

UNIT III (15 Periods)

Introduction to the principle of chromatography. Paper chromatography, thin layer chromatography, column chromatography: silica and gel filtration, affinity and ion exchange chromatography, gas chromatography, HPLC.

UNIT IV (20 Periods)

Introduction to electrophoresis. Starch-gel, polyacrylamide gel (native and SDS-PAGE), agarose-gel electrophoresis, pulse field gel electrophoresis, immuno- electrophoresis, isoelectric focusing, Western blotting. Introduction to Biosensors and Nanotechnology and their applications**.**

SUGGESTED READING AND TEXT BOOKS

1. Karp, G. 2010. Cell and Molecular Biology: Concepts and Experiments. 6th Edition. John Wiley& Sons. Inc.
2. De Robertis, E.D.P. and De Robertis, E.M.F. 2006. Cell and Molecular Biology. 8th edition. Lippincott Williams and Wilkins, Philadelphia.
3. Cooper, G.M. and Hausman, R.E. 2009. The Cell: A Molecular Approach. 5th edition. ASM Press & Sunderland, Washington, D.C.; Sinauer Associates, MA.
4. Becker, W.M., Kleinsmith, L.J., Hardin. J. and Bertoni, G. P. 2009 The World of the Cell.7th edition. Pearson Benjamin Cummings Publishing, San Francisco.

Course Outcomes (COs): On completion of this course, the students will be:

CO	Description	Bloom's Taxonomy Level
CO1	**Remember** the different basic concepts of introduction to general character of bio-analytical, Simple microscopy, Principle and law of techniques, Introduction to the principle of chromatography, electrophoresis, blotting techniques and Biosensors and Nanotechnology and their applications**.**	1 Remembering
CO2	**Understand** and remember the specific and basic concepts of Biosensors and Nanotechnology and their applications**,** bio-analytical, Simple microscopy, Principle and law of techniques, Introduction to the principle of chromatography, electrophoresis, blotting techniques and cell fractionation techniques.	1,2 Remembering, Understanding
CO3	**Applying,** understanding and remembering the detailed processes and features of bio-analytical, Simple microscopy, Principle and law of techniques, Introduction to the principle of chromatography, electrophoresis, blotting techniques, Biosensors and Nanotechnology and their applications and cell fractionation techniques.	1,2,3 Remembering, Understanding, Demonstrating
CO4	**Analyzing,** applying, remembering and understanding the detailed study related to bio-analytical tools, Simple microscopy, Principle and law of techniques, Introduction to the principle of chromatography, electrophoresis, blotting techniques, Biosensors and Nanotechnology and their applications and cell fractionation techniques.	1,2,3,4 Remembering, Understanding, Analyzing
CO5	**Evaluating,** analyzing, applying, remembering, and understanding the bio-analytical tools, Simple microscopy, Principle and law of techniques, Introduction to the principle of chromatography, electrophoresis, blotting techniques, Biosensors and Nanotechnology and their applications and cell fractionation techniques.	1, 2,3,4,5 Remembering, Understanding, Analyzing, Evaluating
CO6	**Constructing (Creating),** Evaluating, Analyzing, demonstrating, remembering, and understanding the take part in bio-analytical tools, Simple microscopy, Principle and law of techniques, Introduction to the principle of chromatography, electrophoresis, blotting techniques, Biosensors and Nanotechnology and their applications and cell fractionation techniques.	1,2,3,4,5,6 Remembering, Understanding, Analyzing, Evaluating Creating

Mapping of COs with POs & PSOs

Course Outcomes	Program Outcomes (POs)												Program Specific Outcomes (PSOs)			
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO1	2	2	2	2	2	2	2	3	3	3	3	3	3	3	2	2
CO2	3	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
CO3	2	2	2	2	2	2	2	2	2	2	3	3	3	3	3	3
CO4	2	2	2	3	2	2	2	2	2	1	3	2	2	2	2	2
CO5	2	2	3	3	2	2	3	3	3	2	2	2	2	2	2	2
CO6	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2

3: High, 2: Medium, 1: Low

B. Sc. (Hons.) Biotechnology

Course code	**: HBTL 601**
Course Name	**: Lab Course Based on HBTC 601**
Semester	**: VI**

L	T	P	C
0	0	2	2

1. Centrifugation principle and separation of precipitate by centrifugation.
2. Native gel electrophoresis of proteins.
3. Separation of protein sample by SDS-polyacrylamide gel electrophoresis.
4. Separation of amino acids by paper chromatography.
5. Verification of Beer's law and determine the molar extinction coefficient of NADH.
6. Brightfield microscopy of the onion membrane cells.
7. Identification of lipids in a given sample by TLC.
8. Study of DNA blotting.
9. Demonstration of preparation of the sub-cellular fractions of rat liver cells.
10. Study the applications of spectroscopy.

B. Sc. (Hons.) Biotechnology

Course code	**: HBTC 602**
Course Name	**: Genomics & Proteomics**
Semester	**: VI**

L	T	P	C
4	4	0	4

Course objectives: The broad objective of the course is to make students aware about the importance of the modern methods of genome and proteome analysis and the significance of these on the changing paradigm in genetics, medicine and agriculture. The specific objectives of the course are as follows:

1. To introduce the basic concepts of genomics and next generation sequencing.
2. To acquaint students with various genome databases and their applications.
3. To make students aware about the applications of genomics in various industries.
4. To makes students understand the techniques of proteome analysis diverse applications andbenefits of genome and proteome analysis.

UNIT I (15 Periods)

Introduction to Genomics, DNA sequencing methods – manual & automated: Maxam & Gilbert and Sangers method. Pyrosequencing, Genome Sequencing: Shotgun & Hierarchical (clone contig) methods, Computer tools for sequencing projects: Genome sequence assembly software.

UNIT II (10 Periods)

Managing and Distributing Genome Data: Web based servers and softwares for genome analysis: ENSEMBL, VISTA, UCSC Genome Browser, NCBI genome. Selected Model Organisms' Genomes and Databases.

UNIT III (20 Periods)

Introduction to protein structure, Chemical properties of proteins. Physical interactions that determine the property of proteins. Short-range interactions, electrostatic forces, van der waal interactions, hydrogen bonds, Hydrophobic interactions. Determination of sizes (Sedimentation analysis, gel filtration, SDS-PAGE); Native PAGE, Determination of covalent structures – Edman degradation.

UNIT IV (15 Periods)

Introduction to Proteomics, Analysis of proteomes. 2D-PAGE. Sample preparation, solubilization, reduction, resolution. Reproducibility of 2D-PAGE. Mass spectrometry based methods for protein identification. *De novo* sequencing using mass spectrometric data.

SUGGESTED READING AND TEXT BOOKS

1. Genes IX by Benjamin Lewin, Johns and Bartlett Publisher, 2006.
2. Modern Biotechnology, 2nd Edition, S.B. Primrose, Blackwell Publishing, 1987.
3. Molecular Biotechnology: Principles and Applications of Recombinant DNA, 4th Edition, B.R.
4. Molecular Cloning: A Laboratory Manual (3rd Edition) Sambrook and Russell Vol. I to III, 1989.
5. Principles of Gene Manipulation 6th Edition, S.B.Primrose, R.M.Twyman and R.W. Old. Blackwell Science, 2001.
6. Snustad, D.P., Simmons, M.J. (2009). Principles of Genetics. V Edition. John Wiley and Sons Inc.
7. Klug, W.S., Cummings, M.R., Spencer, C.A. (2009). Concepts of Genetics. IX Edition. Benjamin Cummings.
8. Russell, P. J. (2009). *i*Genetics- A Molecular Approach. III Edition. Benjamin Cummings.
9. Glick, B.R., Pasternak, J.J. (2003). Molecular Biotechnology- Principles and Applications of recombinant DNA. ASM Press, Washington.
10. Pevsner, J. (2009). Bioinformatics and Functional Genomics. II Edition. John Wiley & Sons.

Course Outcomes (COs): On completion of this course, the students will be:

CO	Description	Bloom's Taxonomy Level
CO1	**Remember** the different basic concepts of introduction to general character of genomics and proteonomics, Computer tools for sequencing projects, Managing and Distributing Genome Data, protein structure, interactions, Determination of sizes (Sedimentation analysis), Analysis of proteomes and genome and protein sequencing.	1 Remembering
CO2	**Understand** and remember the specific and basic concepts of genomics and proteonomics, Computer tools for sequencing projects, Managing and Distributing Genome Data, protein structure, interactions, Determination of sizes (Sedimentation analysis), Analysis of proteomes and genome and protein sequencing.	1,2 Remembering, Understanding
CO3	**Applying,** understanding and remembering the detailed processes and features of Mass spectrometry based methods for protein identification, Computer tools for sequencing projects, Managing and Distributing Genome Data, protein structure, interactions, Determination of sizes (Sedimentation analysis), Analysis of proteomes and genome and protein sequencing.	1,2,3 Remembering, Understanding, Demonstrating
CO4	**Analyzing,** applying, remembering and understanding the detailed study related to genomics and proteonomics, Computer tools for sequencing projects, Managing and Distributing Genome Data, protein structure, interactions, Determination of sizes (Sedimentation analysis), Analysis of proteomes and genome and protein sequencing.	1,2,3,4 Remembering, Understanding, Analyzing
CO5	**Evaluating,** analyzing, applying, remembering, and understanding the genomics and proteonomics, Computer tools for sequencing projects, Managing and Distributing Genome Data, protein structure, interactions, Determination of sizes (Sedimentation analysis), Analysis of proteomes and genome and protein sequencing.	1, 2,3,4,5 Remembering, Understanding, Analyzing, Evaluating
CO6	**Constructing (Creating),** Evaluating, Analyzing, demonstrating, remembering, and understanding the take part in genomics and proteonomics, Computer tools for sequencing projects, Managing and Distributing Genome Data, protein structure, interactions, Determination of sizes (Sedimentation analysis), Analysis of proteomes and genome and protein sequencing.	1,2,3,4,5,6 Remembering, Understanding, Analyzing, Evaluating Creating

Mapping of COs with POs & PSOs

Course Outcomes	Program Outcomes (POs)												Program Specific Outcomes (PSOs)			
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO1	3	2	2	3	3	3	2	3	3	3	3	3	3	3	2	2
CO2	3	3	2	2	2	2	2	3	3	3	3	2	3	3	3	3
CO3	2	3	2	2	3	3	3	2	2	2	3	3	3	3	3	3
CO4	2	3	2	3	2	2	3	3	3	1	3	2	2	2	2	2
CO5	2	3	3	3	2	2	3	3	3	2	2	3	3	3	3	2
CO6	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2

3: High, 2: Medium, 1: Low

B. Sc. (Hons.) Biotechnology

Course code	**: HBTL 602**
Course Name	**: Lab Course Based on HBTC 602**
Semester	**: VI**

L	T	P	C
0	0	2	2

1. Identification of unknown sequence by BLAST and its functional annotation.
2. SNP analysis using SNP database of NCBI.
3. Comparison of genomes of two organisms using SynMap of CoGe.
4. Demonstration of microarray applications and analysis of microarray data.
5. Computation of pI and molecular weight of a protein using ExPASy ProtParam tool.
6. Demonstration of 2D PAGE and data analysis.
7. Generation of protein interaction networks using STRING software.
8. Subcellular protein localization study using CELLO tool.
9. Protein motif identification using MEME software.
10. Conserved domain analysis using NCBI batch-CD research.

B. Sc. (Hons.) Biotechnology

Course code	**: HBTD 603**
Course Name	**: Animal Diversity-II**
Semester	**: VI**

L	T	P	C
4	4	0	4

Course objectives: The objectives of the course are as follows:

1. To make the student understand the classification and characteristics of Proto-chordates and theOrigin of Chordates
2. To make the student understand the characteristics and classifications of Pisces and Ambhibia
3. To make the student learn the diversity of different classes of Reptilia and Aves and Mammalia
4. To impart the knowledge about the Comparative anatomy of vertebrates.

UNIT I: Proto-chordates, Pisces and Ambhibia (15 Periods)

Proto-chordates: Outline of classification, General features and important characters of *Herdmania, Branchiostoma.* Origin of Chordates. Pisces: Migration in Pisces, Outline of classification. Amphibia: Classification, Origin, Parental care, Paedogenesis

UNIT II: Reptilia, Aves and Mammalia (15 Periods)

Reptelia: Classification, Origin
Aves: Classification, Origin, flight- adaptations, migration.
Mammalia: Classification, Origin, dentition

UNIT III: Comparative anatomy of vertebrates I (15 Periods)

Comparative anatomy of various systems of vertebrates: Integumentary, digestive, respiratory systems.

UNIT IV: Comparative anatomy of vertebrates II (15 Periods)

Comparative Anatomy of vertebrates – Heart, Aortic arches, Kidney & urinogenital system, Brain, Eye, Ear. Autonomic Nervous system in Mammals.

SUGGESTED READING AND TEXT BOOKS

1. **Hall B.K. and Hallgrimsson B. (2008). Strickberger's Evolution. IV Edition. Jones and** Bartlett Publishers Inc.
2. Kardong, K.V. (2005) Vertebrates Comparative Anatomy, Function and evolution. IV Edition. McGraw-Hill Higher Education.
3. Kent, G.C. and Carr R.K. (2000). Comparative Anatomy of the Vertebrates. IX Edition. The McGraw-Hill Companies.
4. Weichert, C.K. (1970). Anatomy of Chordate. McGraw Hill.
5. Young, J.Z. (2004). The life of vertebrates. III Edition. Oxford university press.

Course Outcomes (COs): On completion of this course, the students will be:

CO	Description	Bloom's Taxonomy Level
CO1	**Remember** the different basic concepts of introduction to general character of Proto-chordates, Pisces and Ambhibia, Reptilia, Aves and Mammalia, Comparative anatomy of vertebrates, Comparative anatomy of vertebrates.	1 Remembering
CO2	**Understand** and remember the specific and basic concepts of Proto-chordates, Pisces and Ambhibia, Reptilia, Aves and Mammalia, Comparative anatomy of vertebrates, Comparative anatomy of vertebrates, Autonomic Nervous system in Mammals and Outline of classification.	1,2 Remembering, Understanding
CO3	**Applying,** understanding and remembering the detailed processes and features of Proto-chordates, Pisces and Ambhibia, Reptilia, Aves and Mammalia, Comparative anatomy of vertebrates, Comparative anatomy of vertebrates, Autonomic Nervous system in Mammals and Outline of classification.	1,2,3 Remembering, Understanding, Demonstrating
CO4	**Analyzing,** applying, remembering and understanding the detailed study related to Proto-chordates, Pisces and Ambhibia, Reptilia, Aves and Mammalia, Comparative anatomy of vertebrates, Comparative anatomy of vertebrates, Autonomic Nervous system in Mammals and Outline of classification.	1,2,3,4 Remembering, Understanding, Analyzing
CO5	**Evaluating,** analyzing, applying, remembering, and understanding the Proto-chordates, Pisces and Ambhibia, Reptilia, Aves and Mammalia, Comparative anatomy of vertebrates, Comparative anatomy of vertebrates, Autonomic Nervous system in Mammals and Outline of classification.	1, 2,3,4,5 Remembering, Understanding, Analyzing, Evaluating
CO6	**Constructing (Creating),** Evaluating, Analyzing, demonstrating, remembering, and understanding the take part in Proto-chordates, Pisces and Ambhibia, Reptilia, Aves and Mammalia, Comparative anatomy of vertebrates, Comparative anatomy of vertebrates, Autonomic Nervous system in Mammals and Outline of classification.	1,2,3,4,5,6 Remembering, Understanding, Analyzing, Evaluating Creating

Mapping of COs with POs & PSOs

Course Outcomes	Program Outcomes (POs)												Program Specific Outcomes (PSOs)			
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO1	3	2	2	3	3	3	2	3	3	3	3	3	3	3	2	2
CO2	3	3	2	2	2	2	2	2	3	2	3	2	3	3	3	3
CO3	3	3	2	2	3	3	3	2	3	2	3	3	3	3	3	3
CO4	2	3	2	3	2	2	2	2	3	1	3	2	2	2	2	2
CO5	2	2	2	2	2	2	3	3	3	2	2	3	3	3	3	2
CO6	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2

3: High, 2: Medium, 1: Low

B. Sc. (Hons.) Biotechnology

Course code	**: HBTL 603**
Course Name	**: Lab Course Based on HBTD 603**
Semester	**: VI**

L	T	P	C
0	0	2	2

Practicals

1. Identification and classification upto order of the Proto-chordata: Salpa, Doliolum,
2. Herdmania, Branchiostoma.
3. Classification and identification upto order of the Cyclostomata: Myxine, Petromyzon.
4. Virtual dissection of frog (Rana tigrina).
5. Identification and classification upto order of the Reptiles: Hemidactylus, Calotes and Draco.
6. Classification upto order of the Aves: Columba, Alcedo and Passer.
7. Identification and classification upto order of the Mammalia: Ornithorhynchu and Macropus.
8. Slides of mammalian histology of liver, lung, intestine, kidney, ovary and testes.
9. Preparation of slides of spicules of Herdmania and tadpole of Frog.
10. Preparation of mount of tadpole larva of frog.
11. Identification of endoskeletons of frog and rabbit.

B. Sc. (Hons.) Biotechnology

Course code	**: HBTD 604**
Course Name	**: Microbial Physiology**
Semester	**: VI**

L	T	P	C
4	4	0	4

Course objectives: The specific objectives of the course are as follows:

1. To make students understand the classification of microbes.
2. To teach students about the transport of metabolites in microbes.
3. To teach students about the effects of the environmental factors on microbial growth andmetabolism.
4. To impart knowledge about nitrogen fixation by microbes.

UNIT I (12 Periods)

Nutritional classification of microorganisms based on carbon, energy and electron sources, Metabolite Transport, Diffusion: Passive and facilitated, Primary active and secondary active transport, Group translocation (phosphotransferase system), symport, antiport and uniport, electrogenic and electro neutral transport, transport of Iron.

UNIT II (13 Periods)

Microbial Growth. Definition of growth, balanced and unbalanced growth, growth curve, the mathematics of growth-generation time, specific growth rate, batch and continuous culture, synchronous growth, diauxie growth curve. Measurement of microbial growth. Measurement of cell numbers, cell mass and metabolic activity

UNIT III (15 Periods)

Effect of the environment on microbial growth

Temperature- temperature ranges for microbial growth, classification based on temperature ranges and adaptations, pH-classification based on pH ranges and adaptations, solutes and water activity, oxygen concentration, radiation and pressure. Chemolithotrophic metabolism,

Physiological groups of aerobic and anaerobic chemolithotrophs. Hydrogenoxidizing bacteria and methanogens.

UNIT IV (20 Periods)

Phototrophic metabolism. Historical account of photosynthesis, diversity of phototrophic bacteria, anoxygenic and oxygenic photosynthesis, photosynthetic pigments: action and absorption spectrum, type, structure and location, physiology of bacterial photosynthesis: light reactions, cyclic and non-cyclic photophosphorylation. Carbon dioxide fixation, Calvin cycle and reductive TCA cycle.

SUGGESTED READING AND TEXT BOOKS

1. Gottschalk G. (1986). Bacterial Metabolism. 2nd edition. Springer Verlag.
2. Madigan MT, Martinko JM and Parker J. (2003). Brock Biology of Microorganisms.10th edition. Pearson/ Benjamin Cummings.
3. Moat AG and Foster JW. (2002). Microbial Physiology. 4th edition. John Wiley & Sons.
4. Reddy SR and Reddy SM. (2005). Microbial Physiology. Scientific Publishers India.
5. Stanier RY, Ingrahm JI, Wheelis ML and Painter PR. (1987). General Microbiology. 5th edition, McMillan Press.
6. Willey JM, Sherwood LM, and Woolverton CJ. (2008). Prescott, Harley and Klein's Microbiology. 7th edition. McGraw Hill Higher Education.

Course Outcomes (COs): On completion of this course, the students will be:

CO	Description	Bloom's Taxonomy Level
CO1	**Remember** the different basic concepts of introduction to general character of microbial physiology, Nutritional classification of microorganisms, metabolism transport through membrane, Microbial Growth and effect of environmental factors of microbial growth and microbial physiology.	1 Remembering
CO2	**Understand** and remember the specific and basic concepts of measurement of cell numbers, cell mass and metabolic activity, Nutritional classification of microorganisms, metabolism transport through membrane, Microbial Growth and effect of environmental factors of microbial growth and microbial physiology.	1,2 Remembering, Understanding
CO3	**Applying,** understanding and remembering the detailed processes and features of measurement of cell numbers, cell mass and metabolic activity, Nutritional classification of microorganisms, metabolism transport through membrane, Microbial Growth and effect of environmental factors of microbial growth and microbial physiology.	1,2,3 Remembering, Understanding, Demonstrating
CO4	**Analyzing,** applying, remembering and understanding the detailed study related to measurement of cell numbers, cell mass and metabolic activity, Nutritional classification of microorganisms, metabolism transport through membrane, Microbial Growth and effect of environmental factors of microbial growth and microbial physiology.	1,2,3,4 Remembering, Understanding, Analyzing
CO5	**Evaluating,** analyzing, applying, remembering, and understanding the measurement of cell numbers, cell mass and metabolic activity, Nutritional classification of microorganisms, metabolism transport through membrane, Microbial Growth and effect of environmental factors of microbial growth and microbial physiology.	1, 2,3,4,5 Remembering, Understanding, Analyzing, Evaluating
CO6	**Constructing (Creating),** Evaluating, Analyzing, demonstrating, remembering, and understanding the take part in measurement of cell numbers, cell mass and metabolic activity, Nutritional classification of microorganisms, metabolism transport through membrane, Microbial Growth and effect of environmental factors of microbial growth and microbial physiology.	1,2,3,4,5,6 Remembering, Understanding, Analyzing, Evaluating Creating

Mapping of COs with POs & PSOs

Course Outcomes	Program Outcomes (POs)												Program Specific Outcomes (PSOs)			
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO1	3	2	2	3	3	3	2	3	3	3	3	3	3	3	2	2
CO2	3	3	3	3	3	3	3	3	3	2	3	2	3	3	3	3
CO3	2	3	2	2	3	3	3	2	3	2	3	3	3	3	3	3
CO4	2	3	2	3	2	2	2	2	3	1	3	2	2	2	2	2
CO5	3	3	3	2	2	2	3	3	3	2	2	3	3	3	3	2
CO6	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

3: High, 2: Medium, 1: Low

B. Sc. (Hons.) Biotechnology

Course code	**: HBTL 604**
Course Name	**: Lab Course Based on HBTD 604**
Semester	**: VI**

L	T	P	C
0	0	2	2

1. Introduction to microbiological laboratory safety rules and laboratory instructions.
2. Calculation of specific growth rate and generation time in bacteria.
3. Determination of the effect of pH on bacterial growth.
4. Determination of the effect of temperature on the growth of *Aspergillus niger* by dry weightmethod.
5. To study and plot the growth curve of *Aspergillus niger* by radial growth measurements.
6. Demonstration of lactic acid fermentation.
7. Demonstration of the thermal death time and decimal reduction time of *E. coli.*
8. Effect of inhibitors on growth of bacteria.
9. Effect of carbon source on microbes growth.
10. Biofilm analysis.

B. Sc. (Hons.) Biotechnology

Course code	**: HBTD 605**
Course Name	**: Biostatistics**
Semester	**: VI**

L	T	P	C
4	4	0	4

Course objectives: This is an introductory course on statistics. The specific objectives of the courseare as follows:

1. To teach students the basic principles of statistics, data types and collection of data.
2. To make students understand the various methods of data presentation and measures of centraltendency.
3. To make students understand the basic concepts of probability and Probability distribution
4. Understand the testing of the hypothesis and learn its applications.

UNIT I (12 Periods)

Types of Data, Collection of data; Primary & Secondary data, Classification and Graphical representation of Statistical data. Measures of central tendency and Dispersion. Measures of Skewness and Kurtosis.

UNIT II (18 Periods)

Probability classical & axiomatic definition of probability, Theorems on total and compound Probability), Elementary ideas of Binomial, Poisson and Normal distributions.

UNIT III (18 Periods)

Methods of sampling, confidence level, critical region, testing of hypothesis and standard error, large sample test and small sample test. Problems on test of significance, t-test, chi-square test for goodness of fit and analysis of variance (ANOVA)

UNIT IV (12 Periods)

Correlation and Regression. Emphasis on examples from Biological Sciences.

SUGGESTED READING

1. Le CT (2003) Introductory biostatistics. 1st edition, John Wiley, USA
2. Glaser AN (2001) High YieldTM Biostatistics. Lippincott Williams and Wilkins, USA
3. Edmondson A and Druce D (1996) Advanced Biology Statistics, Oxford University Press.
4. Danial W (2004) Biostatistics : A foundation for Analysis in Health Sciences, John Wiley and Sons Inc.

Course Outcomes (COs): On completion of this course, the students will be:

CO	Description	Bloom's Taxonomy Level
CO1	**Remember** the different basic concepts of introduction to general character and concepts of biostatistics, Types of Data, Measures biostatical analysis, Probability classical & axiomatic definition of probability, distributions, sampling, analysis of variance, Correlation and Regression. Emphasis on examples from Biological Sciences.	1 Remembering
CO2	**Understand** and remember the specific and basic concepts of measurement of biostatistics, Types of Data, Measures biostatical analysis, Probability classical & axiomatic definition of probability, distributions, sampling, analysis of variance, Correlation and Regression. Emphasis on examples from Biological Sciences.	1,2 Remembering, Understanding
CO3	**Applying,** understanding and remembering the detailed processes and features of biostatical analysis, Types of Data, Measures biostatical analysis, Probability classical & axiomatic definition of probability, distributions, sampling, analysis of variance, Correlation and Regression. Emphasis on examples from Biological Sciences.	1,2,3 Remembering, Understanding, Demonstrating
CO4	**Analyzing,** applying, remembering and understanding the detailed study related to measurement of biostatical analysis, Types of Data, Measures biostatical analysis, Probability classical & axiomatic definition of probability, distributions, sampling, analysis of variance, Correlation and Regression. Emphasis on examples from Biological Sciences.	1,2,3,4 Remembering, Understanding, Analyzing
CO5	**Evaluating,** analyzing, applying, remembering, and understanding the measurement of biostatical analysis, Types of Data, Measures biostatical analysis, Probability classical & axiomatic definition of probability, distributions, sampling, analysis of variance, Correlation and Regression. Emphasis on examples from Biological Sciences.	1, 2,3,4,5 Remembering, Understanding, Analyzing, Evaluating
CO6	**Constructing (Creating),** Evaluating, Analyzing, demonstrating, remembering, and understanding the take part in biostatical analysis, Types of Data, Measures biostatical analysis, Probability classical & axiomatic definition of probability, distributions, sampling, analysis of variance, Correlation and Regression. Emphasis on examples from Biological Sciences.	1,2,3,4,5,6 Remembering, Understanding, Analyzing, Evaluating Creating

Mapping of COs with POs & PSOs

Course Outcomes	Program Outcomes (POs)												Program Specific Outcomes (PSOs)			
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO1	2	2	2	3	3	3	2	3	3	3	3	3	3	3	2	2
CO2	3	3	3	3	2	2	2	2	2	2	3	2	3	3	3	3
CO3	2	3	2	2	3	3	3	2	3	2	2	2	2	2	2	3
CO4	2	3	2	3	2	2	2	2	3	1	3	2	2	2	2	2
CO5	2	2	2	2	2	2	3	3	3	2	2	3	3	3	3	2
CO6	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3

3: High, 2: Medium, 1: Low

Course code	**: HBTL 605**
Course Name	**: Lab Course Based on HBTD 605**
Semester	**: VI**

L	T	P	C
0	0	2	2

Practicals

1. Based on graphical Representation.
2. Based on measures of Central Tendency & Dispersion.
3. Based on Distributions Binomial Poisson Normal.
4. Based on t, f, z and Chi-square.

B. Sc. (Hons.) Biotechnology

Course code	**: HBTD 606**
Course Name	**: Plant Diversity-II**
Semester	**: VI**

L	T	P	C
4	4	0	4

Course objectives: The objectives of the course are as follows:

1. To make students understand the general features and clasiification of pteridophytes.
2. To impart knowledge about the features of gymnosperms and process of fossil formation.
3. To make students learn about general characters of angiosperms.
4. To remember the origin, evolution of flowering plants and their economic importance.

UNIT I: (10 Periods)

Pteridophytes

General characters of pteridophytes, affinities with bryophytes & gymnosperms, classification, economic importance, study of life histories of fossil Pteridophytes – *Rhynia.*

UNIT II: (20Periods)

Pteridophytes: Type studies

Life histories of *Selaginella*- (Heterospory and seed habit), *Equisetum*, *Pteris*, *Lycopodium.*

UNIT III: (20 Periods)

Gymnosperms

General characters, classification, geological time scale, theories of fossil formation, types of fossils, fossil gymnosperms- *Williamsonia* & *Glossopteris*, telome and stele concept.

UNIT IV: (10 Periods)

Gymnosperms: Type studies

Life histories of *Cycas & Pinus*, economic importance of gymnosperms.

SUGGESTED READING AND TEXT BOOKS

1. Bhatnager, S.P. and Moitra, A. 1996 Gymnosperms. New Age International (P) Ltd. Publishers,New Delhi.
2. Parihar, N.S. 1996. The Biology and Morphology of Pteridophytes. Central Book Depot, Allahabad.
3. Sambamurty 2008 A Textbook of Bryophytes, Pteridophytes, Gymnosperms and Paleobotany. IK International Publishers.
4. Wickens, G.E. 2004 Economic Botany: Principles and Practices, Springer. Kuwer Publishers, Dordrecht, The Netherlands

Course Outcomes (COs): On completion of this course, the students will be:

CO	Description	Bloom's Taxonomy Level
CO1	**Remember** the different basic concepts and introduction to general character of Pteridophytes, types of Pteridophytes, Gymnosperms, types of Gymnosperms, economic importance of gymnosperms and pteridophytes.	1 Remembering
CO2	**Understand** and remember the specific and basic concepts of Pteridophytes, types of Pteridophytes, Gymnosperms, types of Gymnosperms, economic importance of gymnosperms and pteridophytes.	1,2 Remembering, Understanding
CO3	**Applying,** understanding and remembering the detailed processes and features of Pteridophytes, types of Pteridophytes, Gymnosperms, types of Gymnosperms, economic importance of gymnosperms and pteridophytes.	1,2,3 Remembering, Understanding, Demonstrating
CO4	**Analyzing,** applying, remembering and understanding the detailed study related to Pteridophytes, types of Pteridophytes, Gymnosperms, types of Gymnosperms, economic importance of gymnosperms and pteridophytes.	1,2,3,4 Remembering, Understanding, Analyzing
CO5	**Evaluating,** analyzing, applying, remembering, and understanding the Pteridophytes, types of Pteridophytes, Gymnosperms, types of Gymnosperms, economic importance of gymnosperms and pteridophytes.	1, 2,3,4,5 Remembering, Understanding, Analyzing, Evaluating
CO6	**Constructing (Creating),** Evaluating, Analyzing, demonstrating, remembering, and understanding the take part in Pteridophytes, types of Pteridophytes, Gymnosperms, types of Gymnosperms, economic importance of gymnosperms and pteridophytes.	1,2,3,4,5,6 Remembering, Understanding, Analyzing, Evaluating Creating

Mapping of COs with POs & PSOs

Course Outcomes	Program Outcomes (POs)												Program Specific Outcomes (PSOs)			
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO1	2	2	2	3	3	3	2	3	3	3	3	3	3	3	2	2
CO2	2	2	2	2	2	2	2	2	2	2	3	2	2	2	2	2
CO3	2	3	2	2	2	2	2	2	3	2	2	2	2	2	2	3
CO4	2	3	2	3	2	2	2	2	3	1	3	2	2	2	2	2
CO5	2	2	2	2	2	2	3	3	3	2	2	2	2	2	2	2
CO6	2	2	2	2	2	2	2	2	3	2	2	2	2	2	2	2

3: High, 2: Medium, 1: Low

B. Sc. (Hons.) Biotechnology

Course code	**: HBTL 606**
Course Name	**: Lab Course Based on HBTD 606**
Semester	**: VI**

L	T	P	C
0	0	2	2

1. Collection of plants pteridophytes, gymnosperms and angiosperms.
2. Sectioning to study anatomy of vegetative and reproductive parts of *Selaginella.*
3. Sectioning to study anatomy of vegetative and reproductive parts of *Equisetum.*
4. Study anatomy of vegetative and reproductive parts of *Pteris.*
5. Examination of morphology and anatomy of vegetative and reproductive parts of *Cycas.*
6. Section cutting of *Pinus* needle.
7. Examination of morphology and anatomy of vegetative and reproductive parts of *Ephedra.*
8. Study morphology and anatomy of vegetative and reproductive parts of angiospermic flower.
9. Permanent slide of LS and TS of monocot root.
10. Permanent slide of LS and TS of dicot root.

B. Sc. (Hons.) Biotechnology

Course code	**: HBTD 607**
Course Name	**: Medical Microbiology**
Semester	**: VI**

L	T	P	C
4	4	0	4

Course objectives: The objective of this course is:

1. To introduce basic principles and application relevance of microbiological diseases
2. To gain the knowledge about the bacterial agents responsible for infectious diseases.
3. To understand the pathology of the viruses and fungal diseases.
4. To gain the knowledge about laboratory diagnosis

UNIT I (18 Periods)

Introduction: Normal microflora of human body, nosocomial infections, carriers, septic shock, septicemia, pathogenicity, virulence factors, toxins, biosafety levels.
Morphology, pathogenesis, symptoms, laboratory diagnosis, preventive measures and chemotherapy of gram positive bacteria: *S.aureus, S.pyogenes, B.anthracis, C.perferinges, C.tetani, C.botulinum, C.diphtheriae M.tuberculosis, M. leprae.*

UNIT II (15 Periods)

Morphology, pathogeneis, symptoms, laboratory diagnosis, preventive measures and chemotherapy caused by gram negative bacteria: *E.coli, N. gonorrhoea, N. meningitidis, P. aeruginosa, S. typhi, S. dysenteriae, Y. pestis, B. abortus, H. influenzae, V. cholerae, M. pneumoniae, T. pallidum M. pneumoniae, Rickettsiaceae, Chlamydiae.*

UNIT III (12 Periods)

Diseases caused by viruses- Picornavirus, Orthomyxoviruses, Paramyxoviruses, Rhabdoviruses, Reoviruses, Pox virus, Herpes virus, Papova virus, Retro viruses (including HIV/AIDS) and Hepatitis viruses.

UNIT IV (15 Periods)

Fungal and Protozoan infections. Dermatophytoses (*Trichophyton, Microsporun and Epidermophyton*) Subcutaneous infection (*Sporothrix, Cryptococcus*), systemic infection (*Histoplasma, Coccidoides)* and opportunistic fungal infections (*Candidiasis, Aspergillosis*), Gastrointestinal infections (Amoebiasis, Giardiasis), Blood-borne infections (Leishmaniasis, Malaria)

SUGGESTED READINGS

1. Brooks GF, Carroll KC, Butel JS and Morse SA. (2007). Ja**wetz, Melnick and Adelberg's** Medical Microbiology. 24th edition. McGraw Hill Publication.
2. **Goering R, Dockrell H, Zuckerman M and Wakelin D. (2007). Mims' Medical Microbiology.** 4th edition. Elsevier. .
3. Willey JM, Sherwood LM, and Woolverton CJ. **(2008). Prescott, Harley and Klein's** Microbiology. 7th edition. McGraw Hill Higher Education.

Course Outcomes (COs): On completion of this course, the students will be:

CO	Description	Bloom's Taxonomy Level
CO1	**Remember** the basic concepts of general character of medical microbiology, Normal microflora of human body, nosocomial infections, carriers, septic shock, septicemia, pathogenicity, virulence factors, toxins, biosafety levels, Morphology, pathogeneis, symptoms, laboratory diagnosis, Diseases caused by viruses, Fungal and Protozoan infections.	1 Remembering
CO2	**Understand** and remember the specific and basic concepts of Normal microflora of human body, nosocomial infections, carriers, septic shock, septicemia, pathogenicity, virulence factors, toxins, biosafety levels, Morphology, pathogeneis, symptoms, laboratory diagnosis, Diseases caused by viruses, Fungal and Protozoan infections.	1,2 Remembering, Understanding
CO3	**Applying,** understanding and remembering the detailed processes and features of Normal microflora of human body, nosocomial infections, carriers, septic shock, septicemia, pathogenicity, virulence factors, toxins, biosafety levels, Morphology, pathogeneis, symptoms, laboratory diagnosis, Diseases caused by viruses, Fungal and Protozoan infections.	1,2,3 Remembering, Understanding, Demonstrating
CO4	**Analyzing,** applying, remembering and understanding the detailed study related to Normal microflora of human body, nosocomial infections, carriers, septic shock, septicemia, pathogenicity, virulence factors, toxins, biosafety levels, Morphology, pathogeneis, symptoms, laboratory diagnosis, Diseases caused by viruses, Fungal and Protozoan infections.	1,2,3,4 Remembering, Understanding, Analyzing
CO5	**Evaluating,** analyzing, applying, remembering, and understanding the Normal microflora of human body, nosocomial infections, carriers, septic shock, septicemia, pathogenicity, virulence factors, toxins, biosafety levels, Morphology, pathogeneis, symptoms, laboratory diagnosis, Diseases caused by viruses, Fungal and Protozoan infections.	1, 2,3,4,5 Remembering, Understanding, Analyzing, Evaluating
CO6	**Constructing (Creating),** Evaluating, Analyzing, demonstrating, remembering, and understanding the take part in Normal microflora of human body, nosocomial infections, carriers, septic shock, septicemia, pathogenicity, virulence factors, toxins, biosafety levels, Morphology, pathogeneis, symptoms, laboratory diagnosis, Diseases caused by viruses, Fungal and Protozoan infections.	1,2,3,4,5,6 Remembering, Understanding, Analyzing, Evaluating Creating

Mapping of COs with POs & PSOs

Course Outcomes	Program Outcomes (POs)												Program Specific Outcomes (PSOs)			
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO1	2	2	2	3	3	3	2	3	3	3	3	3	3	3	2	2
CO2	2	2	2	2	2	2	2	2	2	2	3	2	2	2	2	2
CO3	2	3	3	3	3	3	2	2	3	2	3	3	3	3	2	3
CO4	2	3	2	3	3	3	3	3	3	1	3	2	2	2	2	2
CO5	3	3	3	3	2	2	3	3	3	3	3	3	3	2	2	2
CO6	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3

3: High, 2: Medium, 1: Low

Course code	**: HBTL 607**
Course Name	**: Lab Course Based on HBTD 607**
Semester	**: VI**

L	T	P	C
0	0	2	2

1. Demonstration of safety and GLP in medical microbiology laboratory.
2. Identification of Gram-negative pathogenic bacteria (based on cultural, morphological andbiochemical characteristics.
3. Growth curve of pathogenic bacteria.
4. Identification of Gram-positive pathogenic bacteria (based on cultural, morphological andbiochemical characteristics.
5. To perform antibacterial testing by Kirby-Bauer method.
6. To prepare temporary mounts of *Aspergillus* and *Candida*.
7. Evaluating the growth potential of pathogenic bacteria in water.
8. Capsule staining and spore staining of pathogenic bacteria.
9. Culture of bacteria from the buccal swab.
10. Antifungal testing for *Aspergillus sp*.

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Course code	**: HBTD 608**
Course Name	**: Environmental Biotechnology**
Semester	**: VI**

L	T	P	C
4	4	0	4

Course objectives: The course is aimed to introduce basics of environmental biotechnology and focuses on the utilization of different biotechnological methods to protect environment. The course is designed to meet the following specific objectives:

1. To impart the basic knowledge about environmental biotechnology.
2. To make students understand the concepts and applications of biofuels and bioremediation.
3. To make the student understand the process of formation of biofertilizers and leran its applications.
4. To give students an overview of various applications of biotechnology in pollution control and biotransformation of pollutants.

UNIT I (18 Periods)

Conventional fuels and their environmental impact – Firewood, Plant, Animal, Water, Coal and Gas. Modern fuels and their environmental impact – Methanogenic bacteria, Biogas, Microbial hydrogen Production, Conversion of sugar to alcohol Gasohol

UNIT II (20 Periods)

Bioremediation of soil & water contaminated with oil spills, heavy metals and detergents. Phyto-remediation. Degradation of pesticides and other toxic chemicals by micro-organisms. Treatment of municipal waste and Industrial effluents.

UNIT III (12 Periods)

Bio-fertilizers. Role of symbiotic and asymbiotic nitrogen fixing bacteria in the enrichment of soil. Algal and fungal biofertilizers VAM)

UNIT IV (10 Periods)

Bioleaching. Environmental significance of genetically modified microbes, plants and animals.

SUGGESTED READING

1. Environmental Science, S.C. Santra
2. Environmental Biotechnology, Pradipta Kumar Mohapatra
3. Environmental Biotechnology – Concepts and Applications, Hans-Joachim Jordening and Jesef Winter
4. Waste Water Engineering, Metcalf and Eddy, Tata McGraw hill
5. Agricultural Biotechnology, S.S. Purohit
6. Environmental Microbiology: Methods and Protocols, Alicia L. Ragout De Spencer, John F.T. Spencer
7. Introduction to Environmental Biotechnology, Milton Wainwright
8. Principles of Environmental Engineering, Gilbert Masters
9. Wastewater Engineering – Metcalf & Eddy

Course Outcomes (COs): On completion of this course, the students will be:

CO	Description	Bloom's Taxonomy Level
CO1	**Remember** the basic concepts of general character of environmental biotechnology, conventionala and modern fuels and their environmental impact, bioremediation, phytoremediation, biodegradation, Bio-fertilizers and Bioleaching. Environmental significance of genetically modified microbes, plants and animals.	1 Remembering
CO2	**Understand** and remember the specific and basic concepts and applications environmental biotechnology, conventionala and modern fuels and their environmental impact, bioremediation, phytoremediation, biodegradation, Bio-fertilizers and Bioleaching.	1,2 Remembering, Understanding
CO3	**Applying,** understanding and remembering the detailed processes and features of Environmental significance of genetically modified microbes, plants and animals, environmental biotechnology, conventionala and modern fuels and their environmental impact, bioremediation, phytoremediation, biodegradation, Bio-fertilizers and Bioleaching.	1,2,3 Remembering, Understanding, Demonstrating
CO4	**Analyzing,** applying, remembering and understanding the detailed study related to environmental biotechnology, conventionala and modern fuels and their environmental impact, bioremediation, phytoremediation, biodegradation, Bio-fertilizers and Bioleaching, Environmental significance of genetically modified microbes, plants and animals	1,2,3,4 Remembering, Understanding, Analyzing
CO5	**Evaluating,** analyzing, applying, remembering, and understanding the environmental biotechnology, conventionala and modern fuels and their environmental impact, bioremediation, phytoremediation, biodegradation, Bio-fertilizers and Bioleaching, Environmental significance of genetically modified microbes, plants and animals.	1, 2,3,4,5 Remembering, Understanding, Analyzing, Evaluating
CO6	**Constructing (Creating),** Evaluating, Analyzing, demonstrating, remembering, and understanding the take part in environmental biotechnology, conventionala and modern fuels and their environmental impact, bioremediation, phytoremediation, biodegradation, Bio-fertilizers and Bioleaching, Environmental significance of genetically modified microbes, plants and animals	1,2,3,4,5,6 Remembering, Understanding, Analyzing, Evaluating Creating

Mapping of COs with POs & PSOs

Course Outcomes	Program Outcomes (POs)												Program Specific Outcomes (PSOs)			
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO1	2	2	2	2	2	2	2	3	2	2	2	2	2	3	2	2
CO2	2	2	2	2	2	2	2	2	3	2	3	2	2	2	2	2
CO3	2	2	2	2	2	2	2	2	3	2	3	2	2	2	2	3
CO4	2	3	2	3	3	2	2	2	2	1	3	2	2	2	2	2
CO5	2	2	2	2	2	2	2	2	2	2	2	3	3	2	2	2
CO6	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2

3: High, 2: Medium, 1: Low

B. Sc. (Hons.) Biotechnology

Course code	**: HBTL 608**
Course Name	**: Lab Course Based on HBTD 608**
Semester	**: VI**

L	T	P	C
0	0	2	2

Practicals

1. Calculation of Total Dissolved Solids (TDS) of water sample.
2. Calculation of Total Suspended Solids (TSS) and Total Dissolved Solids (TDS) of water sample.
3. Calculation of Total Solids (TS) of water sample.
4. Calculation of BOD of water sample.
5. Calculation of COD of water sample.
6. Bacterial Examination of Water by MPN Method.