BANASTHALI VIDYAPITH

Bachelor of Science (Biotechnology)

Curriculum Structure

First Semester Examination, December, 2020
Second Semester Examination, April/May, 2021
Third Semester Examination, December, 2021
Fourth Semester Examination, April/May, 2022
Fifth Semester Examination, December, 2022
Sixth Semester Examination, April/May, 2023

BANASTHALI VIDYAPITH
P.O. BANASTHALI VIDYAPITH
(Rajasthan)-304022

July, 2020

47

No. F. 9-6/81-U.3

Government of India
Ministry of Education and Culture
(Department of Education)

New Delhi, the 25th October, 1983

N O T I F I C A T I O N

In exercise of the powers conferred by Section 3 of the University Grants Commission Act, 1956 (3 of 1956) the Central Government, on the advice of the Commission, hereby declare that Banasthali Vidyapith, P. O. Banasthali Vidyapith, (Rajasthan) shall be deemed to be a University for the purpose of the aforesaid Act.

Sd/-
(M. R. Kolhatkar)
Joint Secretary of the Government of India

N O T I C E

Changes in Bye-laws/Syllabi and Books may from time to time be made by amendment or remaking, and a Candidate shall, except in so far as the Vidyapith determines otherwise, comply with any change that applies to years she has not completed at the time of change.

Programme Educational Objectives

The B.Sc. Biotechnology programme aims at holistic development of the students through the innovative and unique Five fold Educational ideology of Banasthali Vidyapith. This programme broadly includes core subjects of biotechnology, botany, zoology and chemistry. The courses in the programme aim to provide a basic and advanced understanding of the different disciplines of each core subject by means of a lecture series and laboratory work. The program has identified necessary competencies in the respective areas for which all essential theoretical, practical and field based skills will be provided.

The main objectives of the B. Sc. Biotechnology programme are to:

- provide an introduction to the basic concepts of biotechnology and its recent advances
- gain in-depth knowledge of different areas of biotechnology such as biochemistry, immunology, bioinformatics, molecular biology, cell biology, environmental biology, cell and tissue culture techniques, genetic engineering etc.
- develop logical thinking, analytical and independent learning skills
- create awareness amongst students towards the importance of multidisciplinary approach for problem solving skills in biotechnology
- provide broad exposure to various societal, ethical and commercial issues in the various aspects of biotechnology
- raise sensitivity to professional ethical codes of conduct, social values and respect for all
- train the students for an academic and professional fields of biotechnology
- develop an ability to work in collaboration with expertise of different subjects in industries and research
- imbibe and inculcate the basic foundation of biotechnology among students so that they can excel in esteemed academic institutes, various public and private sector organizations with professional competence, technical knowledge and analytical skills

Programme Outcomes

PO1: Biotechnology knowledge: This course provides necessary theoretical and practical experience in all divisions of biotechnology to pursue a professional career in this field.

PO2: Planning ability: Demonstrate effective planning abilities including time management, resource management and organizational skills. Develop and implement plans and organize work to meet deadlines.

PO3: Problem analysis: Utilize subject and practical knowledge to think analytically, design experiments, handle scientific instruments, drawing logical inferences from the scientific experiments while solving problems for the betterment of society.

PO4: Modern tool usage: Utilize gained knowledge to apply appropriate methods, resources and related computational tools with an understanding of their limitations.

PO5: Leadership skills: Develop students with sound concepts in biotechnology who can excel as leaders both in academics and industries. Develop enterpreunership skills to explore the market potential of products and processes, creating business plans and raising money from venture capitalists.

PO6: Professional identity: Understand, analyse and communicate the value of their professional roles in society (e.g. biotechnologist, researchers, educators, managers, employers, employees).

PO7: Hands-on training: Laboratory experiments will provide hands-on training on experimenting with biomolecules and thereby develop a research aptitude for various allied fields of biotechnology.

PO8: Bioethics: Imbibe ethical, moral and social values in personal and social life leading to highly cultured and civilized personality.

PO9: Communication: Develop various communication skills such as reading, listening, speaking, writing and make effective presentations, which will help them in expressing their ideas and views clearly and effectively.

PO10: Environment and sustainability: Utilize the acquired knowledge to maintain the environmental friendly philosophy with sustainability of various environmental resources. Also to create awareness amongst others to keep the environment safe and clean.

PO11: Life-long learning: Develop trained human resources in biotechnology to promote quality education and to initiate lifelong learning process for productive career.

Curriculum Structure
Bachelor of Science (Biotechnology)

Semester - I

Course	Code	Course Name	L	T	P	C*
BVF 011/ BVF014		General English / सामान्य हिन्दी	2	0	0	2
		Core Foundation Course – I	2	0	0	2
Zoology						
ZOO	105	Biosystematics and Evolution	6	0	0	6
ZOO	105L	Biosystematics and Evolution Lab	0	0	4	2
Biotechnology						
BT	102	Cell and Molecular Biology- I	6	0	0	6
BT	104L	Cell and Molecular Biology - I Lab	0	0	4	2
Chemistry						
CHEM	102	Inorganic Chemistry –I	6	0	0	6
CHEM	102 L	Inorganic Chemistry –I Lab	0	0	4	2
		Semester Total:	**22**	**0**	**12**	**28**

Semester - II

Course	Code	Course Name	L	T	P	C*
BVF014/ BVF011		सामान्य हिन्दी/General English	2	0	0	2
		Core Foundation Course – II	2	0	0	2
Biotechnology						
BT	103	Biostatistics, Bioinformatics and Instrumentation	6	0	0	6
BT	103L	Biostatistics, Bioinformatics and Instrumentation Lab	0	0	4	2
Botany						
BOT	103	Introduction to Genetics and Genetic Engineering	6	0	0	6
BOT	103L	Introduction to Genetics and Genetic Engineering Lab	0	0	4	2
Chemistry						
CHEM	103	Organic Chemistry – I	6	0	0	6
CHEM	103L	Organic Chemistry – I Lab	0	0	4	2
		Semester Total:	**22**	**0**	**12**	**28**

Semester - III

Course	Code	Course Name	L	T	P	C *
		Core Foundation Course –III	2	0	0	2
		Elective Foundation Course-I	2	0	0	2
Zoology						
BT	212	Biochemistry	6	0	0	6
BT	212L	Biochemistry lab	0	0	4	2
Biotechnology						
BT	213	Environmental Biotechnology	6	0	0	6
BT	213L	Environmental Biotechnology Lab	0	0	4	2
Chemistry						
CHEM	202	Physical Chemistry – I	6	0	0	6
CHEM	202L	Physical Chemistry – I Lab	0	0	4	2
		Semester Total:	**22**	**0**	**12**	**28**

Semester - IV

Course	Code	Course Name	L	T	P	C *
		Core Foundation Course – IV	2	0	0	2
		Elective Foundation Course – II	2	0	0	2
Biotechnology						
BT	211	Animal and Plant Biotechnology	6	0	0	6
BT	211L	Animal and Plant Biotechnology Lab	0	0	4	2
BT	214	Industrial Biotechnology	6	0	0	6
BT	214L	Industrial Biotechnology Lab	0	0	4	2
Chemistry						
CHEM	201	Inorganic Chemistry – II	6	0	0	6
CHEM	201L	Inorganic Chemistry – II Lab	0	0	4	2
		Semester Total:	**22**	**0**	**12**	**28**

Semester - V

Course Code	Course Name	L	T	P	C*
	Vocational Course – I	2	0	0	2
	Core Foundation Course - V/	2	0	0	2
	Elective Foundation Course-III				
Biotechnology	**Elective**				
	Discipline Elective-I	6	0	0	6
	Discipline Elective -I Lab	0	0	4	2
	Discipline Elective -II	6	0	0	6
	Discipline Elective -II Lab	0	0	4	2
Chemistry					
	Discipline Elective – V	6	0	0	6
	Discipline Elective – V Lab	0	0	4	2
	Semester Total:	**22**	**0**	**12**	**28**

Semester - VI

Course Code	Course Name	L	T	P	C*
	Vocational Course – II	2	0	0	2
	Elective Foundation Course-III/	2	0	0	2
	Core Foundation Course - V				
Biotechnology	**Elective**				
	Discipline Elective-III	6	0	0	6
	Discipline Elective -III Lab	0	0	4	2
	Discipline Elective -IV	6	0	0	6
	Discipline Elective -IV Lab	0	0	4	2
Chemistry					
	Discipline Elective – VI	6	0	0	6
	Discipline Elective – VI Lab	0	0	4	2
	Semester Total:	**22**	**0**	**12**	**28**

List of Discipline Elective- I, II, III, IV (Biotechnology)

Course Code	Course Name	L	T	P	C*
BT 320	Microbiology and Immunology	6	0	0	6
BT 320 L	Microbiology and Immunology Lab	0	0	4	2
BT 317	Advances in Biotechnology	6	0	0	6
BT 317L	Advances in Biotechnology Lab	0	0	4	2
BT 318	Genomics and Proteomics	6	0	0	6
BT 318L	Genomics and Proteomics Lab	0	0	4	2
BT 319	Medical Biotechnology	6	0	0	6
BT 319L	Medical Biotechnology Lab	0	0	4	2
BOT 306	Angiosperms: Morphology, Anatomy and Embryology	6	0	0	6
BOT 306L	Angiosperms: Morphology, Anatomy and Embryology Lab	0	0	4	2
BOT 309	Plant Physiology	6	0	0	6
BOT 309L	Plant Physiology Lab	0	0	4	2
BOT 308	Plant Pathology	6	0	0	6
BOT 308L	Plant Pathology Lab	0	0	4	2
BOT 307	Economic Botany and Ethnobotany	6	0	0	6
BOT 307L	Economic Botany and Ethnobotany Lab	0	0	4	2
BOT 305	Horticulture	6	0	0	6
BOT 305L	Horticulture Lab	0	0	4	2
ZOO 306	Animal Physiology	6	0	0	6
ZOO 301L	Animal Physiology Lab	0	0	4	2
ZOO 307	Developmental Biology	6	0	0	6
ZOO 307L	Developmental Biology Lab	0	0	4	2
ZOO 309	Economic and Applied Zoology	6	0	0	6
ZOO 309L	Economic and Applied Zoology Lab	0	0	4	2
ZOO 308	Ecology and Biodiversity	6	0	0	6
ZOO 308L	Ecology and Biodiversity Lab	0	0	4	2

List of Discipline Elective- V and VI (Chemistry)

Course Code	Course Name	L	T	P	C*
CHEM 302	Organic Chemistry - II	6	0	0	6
CHEM 302L	Organic Chemistry - II Lab	0	0	4	2
CHEM 305	Molecular Modeling and Drug Design	6	0	0	6
CHEM 305L	Molecular Modeling and Drug Design Lab	0	0	4	2
CHEM 303	Physical Chemistry - II	6	0	0	6
CHEM 303L	Physical Chemistry - II Lab	0	0	4	2
CHEM 304	Analytical Methods in Chemistry	6	0	0	6
CHEM 304L	Analytical Methods in Chemistry Lab	0	0	4	2

List of Core Foundation Courses

Course	Code	Course Name	L	T	P	C*
BVF	002	Environment Studies	2	0	0	2
BVF	013	Indian Cultural Heritage	2	0	0	2
BVF	017	Selected Writings of Great Authors - I	2	0	0	2
BVF	020	Women in Indian Society	2	0	0	2
BVF	015	Parenthood and Family Relation	2	0	0	2

List of Elective Foundation Courses

Course	Code	Course Name	L	T	P	C*
BVF	010	Design Thinking	2	0	0	2
BVF	012	Human Body and Health	2	0	0	2
BVF	016	Science of Happiness	2	0	0	2
BVF	019	Universal Human Values	2	0	0	2
BVF	018	Selected Writings of Great Authors - II	2	0	0	2

List of Vocational Course

Course Code		Course Name	L	T	P	C*
VOC	011L	Basic Dress Making	0	0	4	2
VOC	005L	Dress Designing	0	0	4	2
VOC	014	Entrepreneurship - I	2	0	0	2
VOC	015	Entrepreneurship - II	2	0	0	2
VOC	020	Radio Production - I	2	0	0	2
VOC	021	Radio Production - II	2	0	0	2
VOC	022	Web Designing and Internet Technology-I	1	0	0	1
VOC	022 L	Web Designing and Internet Technology-I Lab	0	0	2	1
VOC	023	Web Designing and Internet Technology-II	1	0	0	1
VOC	023 L	Web Designing and Internet Technology-II Lab	0	0	2	1
VOC	009	Library Science - I	1	0	0	1
VOC	009 L	Library Science - I Lab	0	0	2	1
VOC	010	Library Science - II	1	0	0	1
VOC	010 L	Library Science - II Lab	0	0	2	1
VOC	018	Photography - I	0	0	4	2
VOC	019	Photography - II	0	0	4	2
VOC	016	Introduction to Artificial Intelligence-I	2	0	0	2
VOC	017	Introduction to Artificial Intelligence-II	2	0	0	2
VOC	012	Computer Assisted Learning and Teaching	1	0	0	1
VOC	012 L	Computer Assisted Learning and Teaching - Lab	0	0	2	1
VOC	013	Emerging Technologies for Learning and Teaching	2	0	0	2

***L - Lecture hrs/week ; T - Tutorial hrs/week;**

P - Project/Practical/Lab/All other non-classroom academic activities, etc. hrs/week; C- Credit Points of the Course

1. Student can opt for at most 2 additional Open (Generic) audit/credit Elective from other disciplines opting at most 1 per semester from Semesters III onwards with prior permission of respective heads and time table permiting.

2. Every Student shall also opt for:
   Five Fold Education: Physical Education I, Physical Education II,
   Five Fold Education: Aesthetic Education I, Aesthetic Education II,
   Five Fold Education: Practical Education I, Practical Education II
   one each semester

Note: Syllabus of Foundation and Vocational courses are available in separate booklet, "Curriculum Structure and Syllabus Foundation and Vocational Courses"

Five Fold Activities

Aesthetic Education I/II		Physical Education I/II	
BVFF 101	Classical Dance (Bharatnatyam)	BVFF 201	Aerobics
BVFF 102	Classical Dance (Kathak)	BVFF 202	Archery
BVFF 103	Classical Dance (Manipuri)	BVFF 203	Athletics
BVFF 104	Creative Art	BVFF 204	Badminton
BVFF 105	Folk Dance	BVFF 205	Basketball
BVFF 106	Music-Instrumental (Guitar)	BVFF 206	Cricket
BVFF 107	Music-Instrumental (Orchestra)	BVFF 207	Equestrian
BVFF 108	Music-Instrumental (Sarod)	BVFF 208	Flying - Flight Radio Telephone Operator's Licence (Restricted)
BVFF 109	Music-Instrumental (Sitar)	BVFF 209	Flying - Student Pilot's Licence
BVFF 110	Music-Instrumental (Tabla)	BVFF 229	Aeromodelling
BVFF 111	Music-Instrumental (Violin)	BVFF 210	Football
BVFF 112	Music-Vocal	BVFF 211	Gymnastics
BVFF 113	Theatre	BVFF 212	Handball
Practical Education I/II		BVFF 213	Hockey
BVFF 301	Banasthali Sewa Dal	BVFF 214	Judo
BVFF 302	Extension Programs for Women Empowerment	BVFF 215	Kabaddi
BVFF 303	FM Radio	BVFF 216	Karate - Do
BVFF 304	Informal Education	BVFF 217	Kho-Kho
BVFF 305	National Service Scheme	BVFF 218	Net Ball
BVFF 306	National Cadet Corps	BVFF 219	Rope Mallakhamb
		BVFF 220	Shooting
		BVFF 221	Soft Ball
		BVFF 222	Swimming
		BVFF 223	Table Tennis
		BVFF 224	Tennis
		BVFF 225	Throwball
		BVFF 226	Volleyball
		BVFF 227	Weight Training
		BVFF 228	Yoga

Every Student shall also opt for:
Five Fold Education: Physical Education I, Physical Education II,
Five Fold Education: Aesthetic Education I, Aesthetic Education II,
Five Fold Education: Practical Education I, Practical Education II
one each semester

Evaluation Scheme and Grading System

Continuous Assessment (CA) (Max. Marks)					End-Semester Assessment (ESA) (Max. Marks)	Grand Total (Max. Marks)
Assignment		Periodical Test		Total (CA)		
I	II	I	II			
10	10	10	10	40	60	100

In all theory, laboratory and other non classroom activities (project, dissertation, seminar, etc.), the Continuous and End-semester assessment will be of 40 and 60 marks respectively. However, for Reading Elective, only End semester exam of 100 marks will be held. Wherever desired, the detailed breakup of continuous assessment marks (40), for project, practical, dissertation, seminar, etc shall be announced by respective departments in respective student handouts.

Based on the cumulative performance in the continuous and end-semester assessments, the grade obtained by the student in each course shall be awarded. The classification of grades is as under:

Letter Grade	Grade Point	Narration
O	10	Outstanding
A+	9	Excellent
A	8	Very Good
B+	7	Good
B	6	Above Average
C+	5	Average
C	4	Below Average
D	3	Marginal
E	2	Exposed
NC	0	Not Cleared

Based on the obtained grades, the Semester Grade Point Average shall be computed as under:

$$SGPA = \frac{CC_1 * GP_1 + CC_2 * GP_2 + CC_3 * GP_3 + ---- + CC_n * GP_n}{CC_1 + CC_2 + CC_3 + ---- + CC_n} = \frac{\sum_{i=1}^{n} CC_i * GP_i}{\sum_{i=1}^{n} CC_i}$$

Where n is the number of courses (with letter grading) registered in the semester, CC_i are the course credits attached to the i^{th} course with letter grading and GP_i is the letter grade point obtained in the i^{th} course. The courses which are given Non-Letter Grades are not considered in the calculation of SGPA.

The Cumulative Grade Point Average (CGPA) at the end of each semester shall be computed as under:

$$CGPA = \frac{CC_1 * GP_1 + CC_2 * GP_2 + CC_3 * GP_3 + ---- + CC_n * GP_n}{CC_1 + CC_2 + CC_3 + ---- + CC_n} = \frac{\sum_{i=1}^{n} CC_i * GP_i}{\sum_{i=1}^{n} CC_i}$$

Where n is the number of all the courses (with letter grading) that a student has taken up to the previous semester.

Student shall be required to maintain a minimum of 4.00 CGPA at the end of each semester. If a student's CGPA remains below 4.00 in two consecutive semesters, then the student will be placed under probation and the case will be referred to Academic Performance Review Committee (APRC) which will decide the course load of the student for successive semester till the student comes out of the probationary clause.

To clear a course of a degree program, a student should obtain letter grade C and above. However, D/E grade in two/one of the courses throughout the UG/PG degree program respectively shall be deemed to have cleared the respective course(s). The excess of two/one D/E course(s) in UG/PG degree program shall become the backlog course(s) and the student will be required to repeat and clear them in successive semester(s) by obtaining grade C or above.

After successfully clearing all the courses of the degree program, the student shall be awarded division as per following table.

Division	CGPA
Distinction	7.50 and above
First Division	6.00 to 7.49
Second Division	5.00 to 5.99
Pass	4.00 to 4.99

CGPA to % Conversion Formula: % of Marks Obtained = CGPA * 10

———

First Semester

ZOOLOGY

ZOO 105 Biosystematics and Evolution

	L	T	P	C
Max. Marks : 100				
(CA: 40 + ESA: 60)	**6**	**0**	**0**	**6**

Learning Outcomes:

After successful completion of the course, students should be able to:

- gain fundamental knowledge of the origin of life and its evolution
- describe basic concepts of systematics and classification of plants and animals
- gain knowledge about the fossils and the distribution of organisms in different geological time scale

Unit-1

- Origin of life on earth.
- Introduction to evolutionary theories: Lamarckism, Darwinism and Neo Darwinism, Theory of mutation, Modern synthetic theory of evolution.
- Role of variations, adaptive colouration and mimicry, speciation (sympatric and allopatric) and isolation in the process of evolution.
- Centres of origins.

Unit-2

- Basic concept of systematics: Terminology, definition, and significance.
- Botanical classification: International code of Botanical nomenclature, principles of nomenclature, kinds of classification (Natural- Bentham and Hooker and Phylogenetic- Engler and Prantl).
- Zoological classification: International code of zoological nomenclature, principles of nomenclature, kinds of classification (phenetic and cladistic), Linnaean hierarchy.

Unit-3

Plant Kingdom

- General characteristics and systematic position of Cryptogams and Phanerogams.

- **Algae** (Chlorophyta, Xanthophyta, Phaeophyta and Rhodophyta). Life cycle of *Chlamydomonos.*
- **Bryophytes** (Hepaticopsida, Anthocerotopsida and Bryopsida). Life cycle of *Riccia.*
- **Pteridophytes** (Psilophyta, Lycophyta, Sphenophyta and Filicophyta). Life cycle of *Lycopodium.*
- **Gymnosperms**-Life cycle of Gymnosperms (*Thuja*).
- **Angiosperms**- Life cycle of Angiosperms (*Asters*).

Unit-4

Animal Kingdom

- General characters and systematic position (excluding extinct forms) of the following upto classes: Lower non-chordates (protozoa, porifera, coelenterata, platyhelminthes and nematods). Higher non-chordates (annelida, arthropoda, mollusca and echinodermata).
- General characters and classification upto sub –classes of hemichordates and protochordates (urochordates, cephalochordates).
- Chordates: General characters and classification of the following upto sub-classes cyclostomes, fishes, amphibians, reptiles, birds and mammals.

Unit-5

- Fossils: Formation of fossils, kinds of fossils, significance of the study of fossils.
- Geological time scale and the distribution of organisms in time and space.
- Evolution of humans.

Suggested Books:

- Alam, A. (2015). *Text book of Bryophyta*. New Delhi: I K International Publishers.
- Alexopoulus, C. (1979). *Introductory Mycology*. New York: John Wiley Sons.
- Arora, M.P., and Arora, H. (2013). *A Textbook of Organic Evolution*. New Delhi: Himalaya Publishing House.
- Bhatia, K. (1975). *A Treatise on Algae*. New Delhi: S. Chand and Company.
- Biswas, C., and Johri, B.M. (2010). *Gymnosperm*. Springer-Verlag Berlin and Heidelberg GmbH and Co. KG

- Chaki, K.K., Kundu, G., and Sarkar, S. (2016). *Introduction to General Zoology* Vol-II. Kolkata: New Central Book Agency.
- Chamberlian, C.J. (1919). *Morphology of Gymnosperms*. Allahabad: Central Book Depot.
- Dubey, H.C. (2011). *Introduction to Fungi*. India: Vikas Publishing House.
- Dutta, S.C. (1967). *Introduction to Gymnosperms*. Asia Publishing House.
- Ganguli, H.C., Das, K.S., and Dutta C. (2011). *College Botany* Vol. I. India: New Central Book Agency.
- Ghoshe, K.C., and Manna, B. (2012). *Fundamentals of Zoology*. Kolkata: New Central Book Agency.
- Kapoor, V.C. (2018). *Theory and Practice of Animal Taxonomy and Biodiversity* (8th ed.). New Delhi: CBS Publishers and Distributors.
- Kotpal, R.L. (2014). *Modern Textbook of Zoology: Invertebrates* (11th ed.). Meerut: Rastogi Publications.
- Kotpal, R.L. (2018). *Modern Text book of Zoology: Vertebrates* (4th ed.). Meerut: Rastogi Publications.
- Kumar, H.D. (1999). *Introductory Phycology*. New Delhi: Affiliated East-West.
- Mayr, E., and Ashlock, P.D. (1991). *Principles of Systematic Zoology* (2nd ed.). New Delhi: McGraw-Hill College.
- Nigam, H.C. (2013). *Biology of Non-Chordates.* New Delhi: Vishal Publishing Co.
- Pandey, B.P. (2018). *A Text Book of Botany: Angiosperms Taxonomy, Anatomy and embryology*. New Delhi: S Chand and Company Ltd.
- Parihar, N.S. (1956). *Bryophyta Pteridophyta*. Allahabad: Central Book Depot.
- Prasad, S.N., and Kashyap, V. (2012). *A text book of Invertebrate Zoology* (14th ed.). New Delhi: New Age International (P) Limited.
- Rashid, A. (1999). *An Introduction to Pteridophyta*. New Delhi: Vikas publications.
- Rastogi, V.B. (2016). *Organic Evolution* (1st ed.). Medtech.
- Saxena, S. (2000). *A text book of Botany* (Vol. I and II). Agra: Ratan Prakash Mandir.
- Sharma, O.P., and Gupta, R.C. (2010). *Text Book of Fungi.* IBH. New Delhi, India: Vedams eBooks (P) Ltd.

- Sporne, K.R. (1966). *Morphology of Pteridophytes*. London: Hutchinson University Library.
- Vashistha, B.R., and Sinha, A.K. (2010). *Botany for Degree Students-Algae*. New Delhi: S. Chand Publication.
- Vashistha, B.R., and Sinha, A.K. (2016). *Botany for Degree Students-Fungi*. New Delhi: S. Chand Publication.
- Vashistha, B.R., Sinha, A.K., and Kumar, A. (1987). *Botany for Degree classes- Gymnosperms*. New Delhi: S. Chand Publication.
- Vashistha, B.R., Sinha, A.K., and Kumar, A. (2010). *Botany for Degree Students-Bryophyta*. New Delhi: S. Chand Publication.
- Vashisthai, B.R., and Vashistha, P.C. (1987). *Botany for Degree Students Pteridophyta*. New Delhi: S. Chand Publication.
- Webster, J., and Weber, R. (2007) *Introduction to Fungi*. New York: Cambridge University Press.

Suggested e-Resources:

- **Bryophytes: General account, classification and structure**
  http://nsdl.niscair.res.in/jspui/bitstream/123456789/150/1/BRYOPHYTES%20.pdf
- **Gymnosperms**
  http://www-plb.ucdavis.edu/courses/bis/1c/text/Chapter24nf.pdf
- **Pteridophytes**
  http://nsdl.niscair.res.in/jspui/bitstream/123456789/556/1/PTERIDOPHYTES%20april609%20-%20formatted.pdf
- **Taxonomy and classification**
  http://www.austincc.edu/sziser/Biol%201413/LectureNotes/lnexamI/taxonomyClassification.pdf
  http://www.iaszoology.com/zoological-nomenclature/
- **Evolution**
  http://www.iaszoology.com/category/evolution/
- **Origin of life**
  https://nptel.ac.in/courses/122103039/10

ZOO 105L Biosystematics and Evolution Lab

Max. Marks : 100	**L**	**T**	**P**	**C**
(CA: 40 + ESA: 60)	**0**	**0**	**4**	**2**

Learning Outcomes:

After successful completion of the course, students should be able to:

- identify selected algae, fungi, bryophytes, pteridophytes, gymnosperms and angiosperms
- identify selected non chordates and chordates based on external features
- prepare slides of selected invertebrates and develop an understanding of internal features

1. Morphotaxonomical study and preparation of permanent slides of

- *Chlamydomonos* sp.
- *Riccia* sp.
- *Lycopodium* sp.
- *Thuja* sp.
- *Verbesina encelioides*

2. Study of museum specimens

- Porifera: *Sycon*, *Hyalonema*, and *Euspongia*.
- Coelenterata: *Porpita, Velella, Gorgonia, Pennatula, Alcyonium,* and *Adamsia*.
- Platyhelminthes: *Fasciola,* and *Echinococcus*.
- Nemathelminthes: *Dracunculus* and *Enterobius.*
- Annelida: *Pheretima, Aphrodite, Terebella,* and *Pontobdella.*
- Arthropoda: *Lepus*, *Sacculina,* Crab, Hermit crab, *Melanopus*, Queen-termite, *Limulus* and *Peripatus.*
- Mollusca: *Chiton, Aplysia, Dentalium, Mytilus, Teredo, Sepia,* and *Loligo.*
- Echinodermata: *Asterias, Holothuria, Echinus,* and *Clypeaster.*
- Protochordata: *Ascidia,* and *Botryllus.*
- Cyclostomata: *Petromyzon.*
- Pisces: *Torpedo, Labeo,* and *Hippocampus.*
- Amphibia: *Ichthyophis, Salamandra,* and *Pipa.*
- Reptilia: Turtle, *Chaemeleon, Calotes,* and *Python.*
- Aves: *Archaeopteryx,* and *Passer.*

- Mammalia: *Funambulus,* and *Hedgehog.*

3. **Study the evidences of evolution (Analogy and homology) through charts/ models.**
4. **Survey of pond water**
5. **Preparation of permanents slides of**
   - *Euglena*
   - *Hydra*
   - *Cyclops*
   - *Mysis*
   - *Daphnia*

Suggested Books:

- Bendre, A., and Kumar, A. (2009). *A Textbook of Practical Botany- I.* Meerut: Rastogi Publications.
- Lal, S.S. (2015). *Practical Zoology: Invertebrates* (11th ed.). Meerut: Rastogi Publication.
- Lal, S.S. (2015). *Practical Zoology: Vertebrates* (11th ed.). Meerut: Rastogi Publication.
- Verma, P.S. (2010). *A Manual of Practical Zoology: Invertebrates* (11th ed.). New Delhi: S Chand Publishing.

BIOTECHNOLOGY

BT 102 Cell and Molecular Biology - I

Max. Marks : 100	**L**	**T**	**P**	**C**
(CA: 40 + ESA: 60)	**6**	**0**	**0**	**6**

Learning Outcomes::

After successful completion of the course, students should be able to:

- gain knowledge in the ultra structural information of cell besides the detailed views of the cell interior
- understand the complex molecular mechanisms occurring in the cell and regulation of gene expression
- describe types, structural organization and packaging of chromosomes

Unit 1

- General introduction to the science of biotechnology, cell biology, molecular biology and their scope.
- Structural and functional organization of prokaryotic and eukaryotic cell, difference between prokaryotic and eukaryotic cell.
- Molecular structure of cell wall and plasma membrane of eukaryotic cell.
- Ultrastructural organization of cilia, flagella and basal bodies.
- Basic idea of different types of cell junctions.

Unit 2

- Transport across cell membrane: Passive transport (simple and facilitated diffusion) and active transport (primary and secondary).
- An elementary idea of autocrine, paracrine and endocrine signaling.
- Basic concept of receptors (GPCR, receptor tyrosine kinase and intracellular receptors) that mediate the response to extra cellular signals.
- Basic concept of signal transduction (adenylate cyclase pathway and inositol lipid pathway).
- Cell division, cell cycle and its regulation.

Unit 3

- A study of ultrastructural organization and functions of eukaryotic cell organelles:
    - Mitochondria.
    - Chloroplast.
    - Endoplasmic reticulum.
    - Golgi complex.
    - Lysosomes.

- Peroxisomes.

Unit 4

- Ultrastructural organization of nucleus and nucleolus.
- Structural organization of chromosomes including lampbrush and polytene chromosomes. DNA packaging into chromosomes.
- Types of chromosomes based on number and position of centromere. Karyotype.
- Molecular structure and types of DNA, denaturation and renaturation, Tm value, basic idea of Cot curves.
- Molecular structure and types of RNA.
- DNA replication in prokaryotes and eukaryotes.

Unit 5

- Mechanism of transcription in prokaryotes.
- Mechanism of transcription in eukaryotes, RNA processing.
- Genetic code.
- Mechanism of translation in prokaryotes and eukaryotes.
- Regulation of gene expression in prokaryotes: Lac and Trp operons.

Suggested Books:

- De Robertis, E.D.P., De Robertis, E.M.F. (1987). *Cell and Molecular Biology* (8th ed.). USA: Lea and Febiger.
- Gupta, P.K. (2005). *Cell and Molecular Biology*. Meerut: Rastogi Publications.
- Hardin, J., Bertoni, G.P. (2016). *Becker's World of the Cell* (9th ed.). USA: Pearson education.
- Klug, W.S., Cummings, M.R., Spencer, C.A., Palladino, M.A., Killian, D. (2018). *Concepts of Genetics* (12th ed.). USA: Pearson.

- Krebs, J.E., Goldstein, E.S., Kilpatrick, S.T. (2012). *Lewin's Genes XI* (11th ed.). USA: Jones and Bartlett Publishers.
- Lodish, H., Berk, A. Kaiser, C.A., Krieger, M. Scott, M.P. (2007). *Molecular Cell Biology* (6th ed.). USA: W H Freeman.
- Malacinski, G.M. (2015). *Freifelders Essentials of Molecular Biology* (4th ed.). USA: Jones and Bartlett.
- Paul, A. (2011). *Textbook of Cell and Molecular Biology*. Kolkata: Books and Allied Ltd.
- Powar, C.B. (2014). *Essentials of Cytology*. Mumbai: Himalaya Publishing House.
- Rastogi, V.B. (2010). *Fundamental of Molecular Biology*. New Delhi: ANE Books.
- Rastogi, V.B. (2016). *Introductory Cytology – Knrn*. Meerut: Kedar Nath Ram Nath Publishers.
- Singh, B.D. (2015). *Biotechnology*. New Delhi: Kalyani Publishers.
- Tamarin, R.H. (2004). *Principles of Genetics* (7th ed.). USA: McGraw-Hill Higher Education.
- Verma, P.S., Agarwal, V.K. (2004). *Cell Biology, Genetics, Molecular Biology, Evolution and Ecology*. New Delhi: S. Chand Publisher.
- Weaver, R.F. (2011). *Molecular Biology* (5th ed.). USA: McGraw-Hill Education.

Suggested e-Resources:

- **Cell organelles**

  https://www.khanacademy.org/test-prep/mcat/cells/eukaryotic-cells/a/organelles-article

  https://www.ncbi.nlm.nih.gov/books/NBK21743/

- **DNA packaging**

  https://www.nature.com/scitable/topicpage/dna-packaging-nucleosomes-and-chromatin-310

- **Replication, transcription, translation**

  https://www.atdbio.com/content/14/Transcription-Translation-and-Replication

- **Signal transduction pathway**

  https://www.ncbi.nlm.nih.gov/books/NBK9870/

- **Cell biology**

  https://nptel.ac.in/courses/102103012/6

- **Cell biology and organelles**

  https://www.nicholls.edu/biol-ds/biol155/Lectures/Cell%20Biology.pdf

- **Molecular cell biology**

  https://nptel.ac.in/courses/102106025/

  https://nptel.ac.in/courses/122103039/22

BT 104L Cell and Molecular Biology – I Lab

Max. Marks : 100	**L**	**T**	**P**	**C**
(CA: 40 + ESA: 60)	**0**	**0**	**4**	**2**

Learning Outcomes::

After successful completion of the course, students should be able to:

- understand the structure of cells and its organelles with the help of permanent slides
- gain hands-on training for operating microscope for cell analysis
- use relevant tools and techniques for the analysis of chromosomes, and cell size determination using micrometry

1. Organization and working of optical microscope: Dissecting and compound microscopes.
2. To examine the phenomenon of cell permeability using hypotonic, isotonic and hypertonic solutions.

3. Microscopic study of giant chromosomes (Polytene and Lampbrush) with the help of permanent slides.
4. To study the prokaryotic (bacterial) and eukaryotic cells (plant and animal) with the help of microscope.
5. To study the cell organelles (mitochondria, nucleus, and chloroplast) with the help of permanent slide.
6. To observe the different stages of mitosis and meiosis using permanent slides.
7. Preparation of temporary stained squash of onion root tip to study various stages of mitosis.
8. Squash preparation of onion bud/grasshopper testis and study of the various stages of meiosis.
9. Calibration of microscope followed by determination of cell size using stage and ocular micrometer.
10. To determine the λ_{max} for given DNA sample.
11. Double staining of *Calotropis* sp. stem, and leaf material.

Suggested Books:

- Ghose, K., and Manna, B. (2016). *Practical Zoology* (4th ed.). Kolkata: New Central Book Agency.
- Lal, S.S. (2016). *A Textbook of Practical Zoology* Vol-III (2nd ed.). Meerut: Rastogi Publication.

CHEMISTRY

CHEM 102 Inorganic Chemistry-I

Max. Marks : 100	**L**	**T**	**P**	**C**
(CA: 40 + ESA: 60)	**6**	**0**	**0**	**6**

Learning Outcomes:

On completion of course, the students will be able to:

- derive Schrodinger wave equation and quantum numbers, predict shapes of orbital from probability curves and apply Slater's rule for calculating Z_{eff}.
- explain periodic properties like atomic and ionic radii, ionization energy, electron affinity and electronegativity.
- demonstrate bonding theories including valence bond theory, valence shell electron pair repulsion and molecular orbital theory and its applications.
- determine ionic structure of solids with the help of radius ratio values for coordination numbers 3, 4 and 6 and have brief knowledge of metallic bond.
- acquire knowledge of characteristic properties of 3d series elements and it's comparison with 4d and 5d series.
- apply the Werner's coordination theory and its experimental verification; to solve numerical problems based on effective atomic number concept.

Unit 1 Atomic Structure:

Schrodinger wave equation, significance of Ψ and Ψ^2, quantum numbers, radial and angular wave function and probability distribution curves, shapes of *s, p, d* orbitals. Aufbau and Pauli principles, Hund's multiplicity rule, exchange energy, pairing energy, symmetrical distribution of charge, extra stability of half-filled and completely-field orbitals, electronic configurations of elements up to atomic No. 71, effective nuclear charge, shielding effect, Slater's rules for evaluation of shielding constant.

Periodic Properties:

Atomic and ionic radii, ionization energy, electron affinity and electronegativity-definition, methods of determination or evaluation, trends in periodic table and application in predicting and explaining the chemical behavior

Unit 2 Chemical Bonding:

Covalent bond: resonance, valence bond theory and its limitations, directional characteristics of covalent bond, various types of hybridization and shapes of simple inorganic molecules and ions, valence shell electron pair repulsion (VSEPR) theory with reference to BF_3, BF_4^-, NH_3, H_2O, H_3O^+, PCl_5, SF_4, CIF_3, I_3^-, SF_6, IF_7, ICI_2^-, and $POCl_3$; MO theory, simple LCAO theory; sigma and pi molecular orbitals; homonuclear and heteronuclear (CO and NO) diatomic molecules and their ions, multicenter bonding in electron deficient molecules, bond strength and bond energy, percentage ionic character from dipole moment and electronegativity difference.

Ionic Solids:

Ionic structure, radius ratio effect and coordination number, calculation of limiting radius ratio values for CN 3, 4 and 6; limitations of radius ratio rule, lattice defects, semi-conductors, lattice energy (excluding mathematical derivation), Born-Haber cycle, solvation energy and solubility of ionic solids, polarizing power and polarisability of ions, Fajan's rule, metallic bond: free electron, valence bond and band theories; weak interactions: hydrogen bonding, Van der Waals interactions.

Unit 3 s-Block Elements:

Comparative study, diagonal relationship, salient features of hydrides, solvation and complexation tendencies and an introduction to alkalides and electrides, alkyls and aryls of *s*-block elements

p-Block Elements:

Comparative study (including diagonal realtionship) of groups 13 to17 elements, compounds like hydrides, oxides, oxyacids and halides of groups 13 to 16, hydrides of boron-diboranes and higher boranes, borazine, borohydride; fullerenes, carbides, flourocarbons, silicates (structural principle), tetrasulphur tetranitride, basic properties of halogens, interhalogens and polyhalides

Chemistry of Noble Gases:

Chemical properties of noble gases, chemistry of xenon, structure and bonding in xenon compounds.

Unit 4 Chemistry of Elements of First Transition Series:

Characteristic properties of *d*-block elements, properties of elements of the first transition series, their binary compounds and complexes illustrating relative stability of their oxidation states, coordination number and geometry.

Chemistry of Elements of Second and Third Transition Series:

General characteristics, comparative treatment with their 3*d*-analogues with respect to ionic radii, oxidation states, magnetic behaviour, spectral properties and stereochemistry.

Unit 5 Valence Bond Theory:

Introduction, Werner's coordination theory and its experimental verification, effective atomic number concept, chelates, nomenclature of coordination compounds, isomerism in coordination compounds, valence bond theory of transition metal complexes, limitations of VBT.

Oxidation and Reduction:

Use of redox potential data, analysis of redox cycle, redox stability in water, Frost, Latimer and Pourbaix diagrams, principles involved in the extraction of the elements.

Acids and Bases:

Arrhenius, Lewis, Bronsted-Lowry, Lux-Flood and solvent system concepts of acids and bases.

Recommended Books:

1. Lee, J. D. (1998). *Concise Inorganic Chemistry* (5th ed.). United Kingdom: Wiley/Oxford Publications.

2. Puri, B. R., Sharma, L. R. and. Kalia, K. C. (2017). *Principles of Inorganic Chemistry* (33rd ed.). India: Vishal Publications.

3. Cotton, F. A., and Wilkinson, G. (1994). *Basic Inorganic Chemistry* (3rd ed.). United Kingdom: John Wiley Publications**.**

4. Bhagchandani, P. (2017)**.** *Inorganic Chemistry*. India: Sahitya Bhawan Publications.

5. Malik, W. U., Tuli, G. D., and Madan, R. D. (2010). *Selected Topics in Inorganic Chemistry*. (Revised ed.).India: S. Chand Publications**.**

Suggested e-Sources

1. National Programme on Technology Enhanced Learning

   https://nptel.ac.in

2. Online Chemistry Courses

   https://www.edx.org/learn/chemistry

3. Free Online Education SWAYAM

   https://swayam.gov.in

CHEM 102L Inorganic Chemistry-I Lab

Max. Marks : 100	**L**	**T**	**P**	**C**
(CA: 40 + ESA: 60)	**0**	**0**	**4**	**2**

Learning Outcomes:

On completion of course, the students will be able to:

- understand the principles of working with laboratory equipments and ability to properly use them during chemistry experiments.
- prepare standard solution of various secondary standard salts.
- process purification of impure compounds by crystallization.
- calibrate lab equipments like pipettes and burettes.
- analyze, separate and identify inorganic ions from various groups.

1. **Semi-micro Analysis**: Anion and cation analysis, separation and identification of ions from groups Zero, I, II, III, IV, V and VI.
2. **Calibration**: fractional weights, pipettes and burettes, preparation of standard solutions (0.1 M to 0.001 M).

3. **Volumetric Analysis**

(a) Determination of acetic acid in commercial vinegar using NaOH.

(b) Determination of alkali content in antacid tablet using HCl.

(c) Estimation of calcium content in chalk as calcium oxalate by permanganometry.

(d) Estimation of copper using thiosulphate.

Recommended Books:

1. Gurdeep, R. (2016*), Advanced Practical Inorganic Chemistry*, revised Ed., Krishna Prakashan publication.

2. Svehla, G. (2010), Vogel's *Qualitative Inorganic Analysis*, 7th Edition, Prentice Hall.

3. Gurtu, J. N. and Gurtu , A (2011), *Physical Chemistry Vol – I,* Pragati Prakashan publication.

Suggested e-Sources

1. National Programme on Technology Enhanced Learning

   https://nptel.ac.in

2. Online Chemistry Courses

   https://www.edx.org/learn/chemistry

3. Free Online Education SWAYAM

   https://swayam.gov.in

Second Semester

BIOTECHNOLOGY

BT 103 Biostatistics, Bioinformatics and Instrumentation

Max. Marks : 100	**L**	**T**	**P**	**C**
(CA: 40 + ESA: 60)	**6**	**0**	**0**	**6**

Learning Outcomes:

After successful completion of the course, students should be able to:

- gain fundamental knowledge of biostatistics including sampling, data collection, measures of central tendency and dispersion
- gain introductory knowledge of bioinformatics including biological databases, protein structure prediction and phylogenetic analysis
- understand the working principle and applications of various analytical instruments to explore biological activities

Unit 1

- Introduction to biostatistics and its scope.
- Sampling techniques.
- Collection of data, frequency distribution, tabulation, graphical representation of data by histogram, frequency polygon, frequency curve and cumulative frequency curve.
- Measures of central tendency: Mean, median, mode.
- Measures of dispersion: Mean deviation, standard deviation and variance.

Unit 2

- Correlation and regression analysis.
- Law of probability, Basic concept and calculation.
- Introduction to computers; hardware and software.

- Data representation.
- Data representation: Number systems; binary, octal, decimal and hexadecimal.
- Computer programming; Basic concept of Algorithm and flowchart.

Unit 3

- Introduction and scope of bioinformatics.
- Introduction to biological database.
- Databases at NCBI; nucleotide, gene protein, MMDB, Pubmed and Bookshelf.
- Introduction to sequence alignment; dot plot method.
- Concept of phylogenetics tree; sequence analysis based phylogenetics.

Unit 4

- Introduction to protein secondary structure prediction; Chou-Fasman method.
- A brief introduction to computational drug design.
- Working principle and applications of:
  - Colorimeter and spectrophotometer (UV-VIS) and fluorimetry.
  - Microscopy (compound, phase contrast and electron).

Unit 5

- Working principle and applications of:
  - Centrifuge.
  - Chromatography: Paper, TLC, brief idea about different types of columns.
  - Electrophoresis: Agarose gel and PAGE (native and SDS).

Suggested Books:

- Attwood, T. (2007). *Introduction to Bioinformatics*. USA: Pearson Education.
- Barker, K. (2004). *At the Helm: A Laboratory Navigator*. New Delhi: I K International Publishing House.
- Bhuyan, K.C. (2017). *Advanced Biostatistics*. Kolkata: New Central Book Agency.
- Chatwal, G.R., Anand, S. (2011). *Instrumental Methods of Chemical Analysis*. Mumbai: Himalaya Publishing House.
- Datta, A.K. (2014). *Basic Biostatistics and Application*. Kolkata: New Central Book Agency.
- Freifelder, D.M. (1983). *Physical Biochemistry: Applications to Biochemistry and Molecular Biology*. USA: W. H. Freeman.
- Gupta, S.P. (2018). *Statistical Methods* (45th ed.). New Delhi: Sultan Chand and Sons.
- Pandey, M. (2015*). Biostatistics: Basic and Advanced*. New Delhi: MV Learning.
- Rana, S.V.S. (2012). *Biotechniques: Theory and Practice* (3rd ed.). Meerut: Rastogi Publications.
- Rao, P.H., and Janardhan, K. (2014). *Fundamentals of Biostatistics*. New Delhi: I. K. International Publishing House.
- Rastogi, S.C., Mendiratta, N., and Rastogi, P. (2018). *Bioinformatics: Concepts, Skills and Applications* (2nd ed.). New Delhi: CBS Publishers and Distributors.
- Sharma, B.K. (2011). *Instrumental Methods of Chemical Analysis*. Mumbai: Meerut: Goel Publishing House.
- Sharma, V., Munjal, A., and Shanker, A. (2008). *A Text Book of Bioinformatics*. Meerut: Rastogi Publications.
- Sinha, P.K., and Sinha, P. (2004). *Computer Fundamentals* (6th ed.). New Delhi: BPB Publications.

- Walker, J,M., and Wilson, K. (2000). *Practical Biochemistry Principles and Techniques* (5th ed.). New Delhi: Cambridge University Press.

Suggested e-Resources:

- **Analytical techniques**

  https://nptel.ac.in/courses/102107028/

  http://www.tulane.edu/~wiser/methods/notes.pdf

- **Basic bioinformatics**

  https://courses.cs.ut.ee/MTAT.03.242/2017_fall/uploads/Main/Basics_of_Bioinformatics.pdf

- **Analytical techniques and bioinformatics**

  https://nptel.ac.in/courses/102103044/38

- **Biostatistics**

  https://nptel.ac.in/courses/102106051/

  https://nptel.ac.in/courses/102101056/

- **Measures of central tendency**

  https://www.tutorialspoint.com/statistics/arithmetic_mean.htm

BT 103L Biostatistics, Bioinformatics and Instrumentation Lab

Max. Marks : 100	**L**	**T**	**P**	**C**
(CA: 40 + ESA: 60)	**0**	**0**	**4**	**2**

Learning Outcomes:

After successful completion of the course, students should be able to:

- use bioinformatics tools and techniques for separating the obtained biological data, sequence analysis, molecular visualization and make valid inferences in various disciplines of science and technology

- apply effective planning abilities to ensure different safety measures in laboratory, handling and care of instruments
- learn the preparation of buffers and solutions of varied concentrations

1. Demonstration including working principle and applications of the following instruments:
    i. pH meter
    ii. Balance
    iii. Centrifuge
    iv. Autoclave
    v. Different types of microscopes
    vi. Incubator and oven
    vii. Shaker
    viii. Spectrophotometer/Colorimeter
    ix. Server
2. Statistical problems (exercise on mean, mode, median, standard deviation, standard error).
3. Bioinformatics exercise:
    - Dot plot; palindrome and repeat sequence identification.
    - Visualization of biomolecular structures; PyMol.
4. To understand the concept of molarity and normality followed by preparation of solutions of different molarity and normality.
5. To understand the concept of buffer followed by preparations of few buffers e.g. Tris (alkaline range), acetate and citrate (acidic range).
6. To determine the pH of five aliquots of the given soil sample and plot a graph of the same.
7. Separation of cell organelles using sucrose density gradient.

8. Separation of amino acids by paper chromatography and thin layer chromatography.

9. Demonstration of SDS-PAGE for separation of proteins.

10. To prepare standard curve of protein by Bradford method.

Suggested Books:

- Boya, R.F. (2006). *Modern Experimental Biochemistry* (3rd ed.). Noida: Pearson Education.
- Ghose, K., and Manna, B. (2016). *Practical Zoology* (4th ed.). Kolkata: New Central Book Agency.
- Lal, S.S. (2016). *A Textbook of Practical Zoology* Vol-III (2nd ed.). Meerut: Rastogi Publication.
- Sharma, S., and Sharma, R. (2016). *Practical Manual of Biochemistry* (2nd ed.). New Delhi: Medtech.

BOTANY

BOT 103 Introduction to Genetics and Genetic Engineering

Max. Marks : 100	**L**	**T**	**P**	**C**
(CA: 40 + ESA: 60)	**6**	**0**	**0**	**6**

Learning Outcomes:

After successful completion of the course, students should be able to:

- gain in-depth knowledge about principles of genetics, its approaches and methodology at the molecular, cellular, organismal and population levels
- gain knowledge of various tools and techniques in recombinant DNA technology
- translate learned concepts in genetic engineering to their own research

Unit 1

- Mendel's experiments: Laws of inheritance.
- Deviation from Mendel's laws, multiple alleles.

- Extra chromosomal inheritance.
- Linkage and crossing over.
- Sex determination, dosage compensation, barr body and sex linked inheritance.

Unit 2

- Chromosomal aberrations- Structural and numerical.
- Gene mutations: Types, significance; brief idea about mutagens.
- Eugenics, genetic counseling and pedigree analysis.
- Population genetics: Hardy Weinberg law.

Unit 3

- Introduction of genetic engineering and an overview of steps involved in gene cloning.
- Restriction endonucleases, Dam and Dcm methylases, demethylases, ligases, S1 nucleases, DNA polymerases, reverse transcriptase, terminal transferase, polynucleotide kinase, and alkaline phosphatases.
- Linkers, adaptors, blunt end ligation, homopolymer tailing.
- Isolation of DNA from bacterial, plant and animal cells.
- Cloning vectors: Plasmids, phages (M13 and λ), cosmids, phagemids, shuttle vectors, BAC, and YAC.

Unit 4

- Screening and selection of recombinant clones in prokaryotes.
- Expression of cloned genes in prokaryotes (*E. coli*) using pET vector as an example.
- Genomic library: Construction and screening.
- cDNA synthesis and cDNA library.

Unit 5

- *Agrobacterium tumefaciens:* Ti plasmid, mechanism of T-DNA transfer in plant cells. Brief idea of using Ti plasimd as an experimental gene vector.
- Brief idea of gene cloning and expression of cloned gene in insect cells (Baculovirus).
- Gene transfer methods: Electroporation, liposome, microinjection, microprojectile, and calcium phosphate precipitation.

- Molecular markers: RFLP, RAPD, AFLP, and SNP.

Suggested Books:

- Borem, A., Santos, F.R., and Bowen, D.E. (2003). *Understanding Biotechnology* (1st d.). USA: Prentice Hall.
- Brown, T. (2011). *Introduction to Genetics –A molecular approach* (1st ed.). USA: Garland Science.
- Brown, T.A. (2010). *Gene Cloning and DNA Analysis: An Introduction* (6th ed.). USA: Wiley-Blackwell.
- Gardner, E.J., Simmons, M.J., and Snustad, D.P. (2005). *Principles of Genetics* (8th ed.). New Jersey, USA: John Wiley and Sons Ltd.
- Glick, B.R., and Patten, C.L. (2017). *Molecular Biotechnology: Principles and Applications of Recombinant DNA* (5th ed.). USA: American Society for Microbiology Press.
- Griffiths, A.J.F., Miller, J.H., Suzuki, D.T., Lewonith, R.C. and Gelbert, W.M. (2000). *An Introduction to Genetic Ananlysis* (7th ed.). New York, U.S.: W. H. Freeman.
- Gupta, P.K. (2009). *Genetics.* Meerut: Rastogi Publications.
- Gupta, P.K. (2010). Plant biotechnology. Meerut: Rastogi Publications.
- Hartl, D.L. and Jones, E.W. (1997). *Genetics: Analysis of Genes and Genome* (9th ed.). Canada: Jones and Barlett Publishers.
- Hartwell, L., Hood., Goldberg, M., Reynolds, A.E., and Silver, L. (2010). *Genetics: From Genes to Genomes* (4th ed.). New York: McGraw-Hill Education.
- Klug, W.S., Cummings, M.R., Spencer, C.A., Palladino, M.A., Killian, D. (2018). *Concepts of Genetics* (12th ed.). USA: Pearson Education.
- Krebs, J.E., Goldstein, E.S., and Kilpatrick, S.T. (2012). *Lewin's Genes XI* (11th ed.). USA: Jones and Bartlett Publishers.
- Maloy, S.R., Cronan, J.E., and Friefelder, D. (1994). *Microbial Genetics* (2nd ed.). USA: Jones and Bartlett.
- Primrose, S.B., and Twyman, R. (2006). *Principles of Gene Manipulation and Genomics* (7th ed.) UK: Oxford University Press.
- Rastogi, V.B. (2018). *Genetics* (4th ed.). Medtech.
- Singh, B.D. (2015). Biotechnology. New Delhi: Kalyani Publishers.
- Singh, B.D. (2014). *Fundamentals of Genetics* (332nd ed.). New Delhi: Kalyani Publishers.

- Strickberger, M.W. (1995). Genetics (3rd ed.). New Delhi: Prentice Hall India Learning Private Limited.
- Tamarin, R.H. (2004). *Principles of Genetics* (7th ed.). USA: McGraw-Hill Higher Education.
- Watson, J.D., Tania, A.B., and Stephen, P.B. (2017). *Molecular Biology of the Gene* (7th ed.). USA: Pearson Education.
- Winnacker, E.L. (1987). *From Genes to Clones: Introduction to Gene Technology*. Germany: Wiley VCH.

Suggested e-Resources:

- **Mendelian genetics and deviation**

  https://www.khanacademy.org/science/biology/classical-genetics/variations-on-mendelian-genetics/a/multiple-alleles-incomplete-dominance-and-codominance

  http://download.nos.org/srsec314newE/PDFBIO.EL21.pdf

- **Genetics**

  https://www.britannica.com/science/genetics

- **Recombinant-DNA-technology**

  https://www.britannica.com/science/recombinant-DNA-technology

  https://nptel.ac.in/courses/102103013/4

  http://www.agbioworld.org/biotech-info/topics/dev-world/policies4.html

- **Principles and processes of recombinant-DNA-technology**

  https://www.toppr.com/guides/biology/biotechnology-principles-and-process/processes-of-recombinant-dna-technology/

- **Vectors used in genetic engineering**

  http://www.biologydiscussion.com/genetic-engineering/vectors-used-in-genetic-engineering-biotechnology/61382

  https://sci-hub.tw/10.1038/nbt0483-175

BOT 103L Introduction to Genetics and Genetic Engineering Lab

Max. Marks : 100	**L**	**T**	**P**	**C**
(CA: 40 + ESA: 60)	**0**	**0**	**4**	**2**

Learning Outcomes:

After successful completion of the course, students will be able to:

- develop skills and understanding about different techniques used in genetics and genetic engineering
- critically analyze and interpret data generated from each practical
- develop knowledge about genetic problems such as genetic mapping, test cross etc

1. Problems of genetics based on Mendel's laws, gene interaction multiple alleles, sex linked inheritence and pedigree analysis.
2. Human genetics: Tongue rolling, widow's peak, ear lobes, and little finger.
3. Preparation of permanent slide to show the presence of barr body in human female blood cells/buccal epithelium cells.
4. Isolation of genomic DNA from *E.coli*.
5. Determination of purity of DNA.
6. Analysis of isolated DNA by Agarose gel electrophoresis.
7. Estimation of DNA by DPA method.
8. To determine the melting curve and base composition of DNA.
9. Estimation of RNA by Orcinol method.

Suggested Books:

- Purohit, S.D. (2007). *Molecular Biology and Biotechnology: A Practical Manual.* Udaipur: Apex Publishing House.
- Vats, S. (2015). *A Laboratory Textbook of Biochemistry, Molecular biology and Microbiology.* GRIN Verlag.

CHEMISTRY

CHEM 103 Organic Chemistry-I

Max. Marks : 100	**L**	**T**	**P**	**C**
(CA: 40 + ESA: 60)	**6**	**0**	**0**	**6**

Learning Outcomes:

On completion of course, the students will be able to:

- explain the organic reactions and their mechanisms.
- explain the stereochemistry of the organic compounds including their optical activity, conformations and configurations.
- explain physical and chemical properties of the hydrocarbons, alcohols, carbonyl compounds and carboxylic acids.
- understand the basics of chemistry of aromatic compounds.

Unit 1 Organic Reactions and their Mechanisms:

Nature of fission of covalent bonds, notations of bond fission, types of reagents, types of organic reactions and energy considerations.

Reactive intermediates:

Carbocation, carbanion, free radical, carbene and nitrene.

Organomatellic Compound:

Structure, synthesis and applications of Grignard reagent.

Unit 2 Setereochemistry of Organic Compounds:

Concept of isomerism, types of isomerism.

Geometrical Isomerism: *cis*- and *trans*- isomerism, E and Z system of nomenclature, determination of configuration of geometrical isomers, geometrical isomerism in oximes and alicyclic compounds.

Optical Isomerism: elements of symmetry, molecular chirality, stereogenic centre, optical activity, chiral and achiral molecules with two stereogenic centres- enantiomers, diastereoisomers, threo and erythro diastereoisomers, meso compounds; relative and absolute configuration,

sequence rules, D and L and R and S systems of nomenclature; inversion, retention and racemization; resolution of enantiomers.

Confomational Isomerism: projection formulae (Fischer, sawhorse, Newman and flying wedge formulae), interconversion of projection formulae, difference between configuration and conformation, conformational analysis of ethane and n-butane, conformations of cyclohexane, axial and equatorial bonds, conformation of monosubstituted cyclohexane derivatives.

Unit 3 Alkanes and Cycloalkanes:

(a) Alkanes: Nomenclature, isomerism, methods of preparation (with special reference to Wurtz reaction, Corey-House reaction, Kolbe reaction and decarboxylation of carboxylic acids), physical properties, mechanism of free radical halogenation of alkanes, reactivity and selectivity.

(b) Cycloalkanes: Nomenclature, methods of preparation, chemical reactions, Baeyer's strain theory and its limitation, cyclopropane- Banana Bond.

Alkenes:

Nomenclature, isomerism, relative stabilities, methods of preparation: dehydration of alcohols, dehydrohalogenation of alkyl halides, dehalogenation of vic-dihalides, pyrolysis of quarternary ammonium hydroxides; physical properties, chemical reactions: catalytic hydrogenation, addition of hydrogen halides, hydroboration-oxidation, oxymercuration-reduction, epoxidation, ozonolysis, hydration, hydroxylation with $KMnO_4$, substitution reactions at the allylic and vinylic positions, polymerization; regioselectivity in alcohol dehydration, Saytzeff and Hofmann rules for elimination; industrial applications of ethylene and propene.

Dienes:

Classification, structure of allene and butadiene, chemical reactions:- electrophilic and free radical addition, polymerization, Diels-Alder reaction.

Alkynes:

Nomenclature, isomerism, structure and bonding in alkynes, methods of preparation, physical properties, chemical reactions-addition of hydrogen, mechanism of electrophilic and nucleophilic addition, acidity of alkynes, hydroboration-oxidation, metal-ammonia reductions, oxidation and polymerization**.**

Unit 4 Aromaticity:

Nomenclature of benzene derivatives, aromatic nucleus, side chain, aryl group, structure of benzene: Kekule structure, MO diagram; aromaticity: Huckel rule, aromatic, anti-aromatic and non-aromatic compounds.

Aromatic Electrophilic Substitution Reactions: General mechanism, role of σ-and π-complexes, mechanism of nitration, halogenation, sulphonation, and Friedel-Crafts reaction; activating and deactivating substituents, *ortho*/*para* ratio, orientation and methods of determination of the orientation.

Alky Halides and Aryl Halides:

Alkyl Halides: Nomenclature, classification and methods of preparation, chemical reactions: nucleophilic substitution and elimination reactions.

Aryl Halides: Nomenclature, classification, methods of preparation, chemical reactions: nucleophilic aromatic substitution reactions, low reactivity of vinyl and aryl halides, and high reactivity of allyl and benzyl halides; DDT and BHC.

Alcohols and Phenols:

Alcohols: Nomenclature and classification, dihydric alcohols: methods of preparation, physical properties, chemical reactions of vicinal glycols: acidic nature, reaction with phosphorous halides, reaction with HCl, esterification, oxidative cleavage [$Pb(OAc)_4$ and HIO_4] and pinacol-pinacolone rearrangement; trihydric alcohols: methods of preparation, physical properties, chemical reactions of glycerol.

Phenols: Nomenclature, classification, structure and bonding, preparation of phenols, physical properties, chemical reactions: acidic character, comparative acidic strengths of alcohols and phenols, resonance stabilization of phenoxide ion, electrophilic aromatic substitution, acylation and carboxylation, Fries rearrangement, Claisen rearrangement, Gatterman synthesis, Lederer-Manasse reaction and Reimer-Tiemann reaction.

Unit 5 Aldehydes and Ketones:

Aldehydes and Ketones:

Nomenclature, structure of the carbonyl group, synthesis of aldehydes and ketones with particular reference to synthesis of aldehydes and ketones using acid chlorides and 1, 3-dithianes, synthesis of ketones from nitrile and carboxylic acids; physical properties; mechanism of nucleophilic additions to carbonyl group with particular emphasis on aldol, Perkin, Cannizzaro and Knoevenagel condensations; reactions with ammonia and its derivatives; Wittig reaction, Mannich reaction, Clemmenson reduction and Wolf-Kishner reduction; oxidation of aldehydes (reactions with Tollen's reagents, Fehling's solution and Benedict's solution) and ketones (Baeyer-Villiger oxidation).

Carboxylic Acids:

Nomenclature, structure and bonding, preparation, physical properties, effects of substituents on acid strength, chemical reactions of carboxylic acids: salt formation, formation of acid derivatives, reduction, reaction with Grignard reagent, decrboxylation and halogenation (Hell-Volhard-Zelinsky reaction).

Recommended Books:

1. Clayden, J., Greeves, N., Warren, S., and Wothers, P., (2001). *Organic Chemistry.* (2nd ed.).Oxford University Press.
2. Sykes, P. (1986). *A guide book to mechanism in organic chemistry* (6th ed.). Pearson.
3. Ingold, C. K. (1970). *Structure and mechanism in organic chemistry*. Cornell University Press.
4. Morrison, R.T., Boyd, R.N. (2002). *Organic chemistry* (6th ed.). PrentlceHall: Englewood Cliffs, NJ.

5. Nasipuri, D. (1994). *Stereochemistry of organic compounds.* (2nd ed.). New Age International

6. Singh, M.S. (2005). *Advanced organic chemistry-reactions and mechanisms*. Pearson Education (Singapore) Pvt. Ltd.

7. Wade, L.G., Singh, M.S. (2008). *Organic chemistry*. Pearson Education, Dorling Kindersley Pvt. Ltd.

8. Singh, M.S. (2014). *Reactive intermediates in organic chemistry-structure, mechanism and reactions*. Wiley, VCH, and Weinheim.

9. Eliel E. L., Wilen S. H., Manden L. N. (2005). *Stereochemistry of Carbon compounds*. Wiley and sons.

Suggested e-Sources

1. National Programme on Technology Enhanced Learning

   https://nptel.ac.in

2. Online Chemistry Courses

   https://www.edx.org/learn/chemistry

3. Free Online Education SWAYAM

   https://swayam.gov.in

CHEM 103L Organic Chemistry -I Lab

Max. Marks : 100	**L**	**T**	**P**	**C**
(CA: 40 + ESA: 60)	**0**	**0**	**4**	**2**

Laboratory Techniques:

- To calibrate the thermometer using naphthalene (80-82°C), acetanilide (113.5-114ºC), urea (132.5-133ºC), water (100ºC) as reference materials.
- To Determine the boiling point of ethanol, cyclohexane, toluene, benzene.
- To determine the mixed melting point of Urea-cinnamic acid mixture of various compositions (1:4, 1:1, 4:1).

Distillation

- Simple distillation of ethanol-water mixture using water condenser.
- Distillation of nitrobenzene and aniline using air condenser.

Crystallization

- Concept of introduction of crystallization
- Phthalic acid from hot water (using fluted filter paper and steamless funnel)
- Acetanilide from boiling water
- Naphthalene from ethanol
- Benzoic acid from water

Decolorisation and Crystallization using Charcoal

- Decolorisation of brown sugar (sucrose) with animal charcoal using gravity filtration.
- Crystallization and decolorisation of impure naphthalene.

Sublimation (Simple and Vacuum)

Qualitative Analysis:

- **Part-I** Detection of extra elements (N, S and halogens) and functional groups (carboxylic, alcoholic, phenolic, carbonyl, ester, carbohydrate, amine, amide and nitro) in simple organic compounds
- **Part-II** Identification of an organic compound through the functional group analysis, determination of melting points and preparation of suitable derivatives.

Stereochemical Study of Organic Compounds via Models:

- R and S configuration of optical isomers.
- E and Z configuration of geometrical isomers.
- Conformational analysis of cyclohexanes and substituted cyclohexanes.

Paper Chromatography: Ascending and Circular:

- Determination of R_f values and identification of organic compounds.
- Separation of monosaccharides (a mixture of D-galactose and D-fructose) using n-butanol, acetone and water in 4:5:1 ratio, and spray reagent (aniline hydrogen phthalate).

Recommended Books:

1. Leonard, J., Lygo, B., Procter, G. (2013). *Advanced Practical Organic Chemistry* (3rd ed.). CRC Press, Taylor and Francis Group.
2. Furniss, B.S., Hannaford, A.J., Smith, P.W.G., Tatchell, A.R. (1989). *Practical Organic Chemistry* (5th ed.). New York, John Wiley and Sons, Inc.

Suggested e-Sources

1. National Programme on Technology Enhanced Learning

   https://nptel.ac.in
2. Online Chemistry Courses

   https://www.edx.org/learn/chemistry
3. Free Online Education SWAYAM

   https://swayam.gov.in

Third Semester

Zoology

BT 212 Biochemistry

Max. Marks : 100	L	T	P	C
(CA: 40 + ESA: 60)	6	0	0	6

Learning Outcomes:

After successful completion of the course, students should be able to:

- gain fundamental knowledge of structure and function of biomolecules, metabolic pathways and the regulation of biochemical processes
- gain knowledge of basic energy metabolism of cells and identify some of common reaction mechanisms in biochemical processes
- describe structure, functions, kinetics, regulation and the mechanisms of action of enzymes

Unit-1

- Structure and colligative properties of water.
- pH, pKa, acids, bases, and buffers. Ionic product of water, Henderson-Hasselbalch equation.
- Carbohydrates: Classification, structure, properties and functions.
- Lipids: Classification, structure, properties and functions.

Unit-2

- Amino acids and proteins-Classification, structure, properties and functions.
- Various levels of structural organization of proteins.
- Bioenergetics: Energy and its forms, principles of thermodynamics.
- Energy rich biomolecules: ATP, NADP and other phosphorylated compounds.

Unit-3

- Glycolysis, citric acid cycle and pentose phosphate pathway. Shuttle mechanisms (malate-aspartate and glycerol-phosphate), glycogenolysis and glycogenesis; gluconeogenesis.

- Mechanism of ATP synthesis: Oxidative phosphorylation, chemiosmotic hypothesis, Photophosphorylation.
- Fat Metabolism: Mechanism of synthesis and break down of fats (Palmitic acid), Fate of Acetyl CoA.

Unit-4

- Protein metabolism: Biosynthesis of amino acids (tryptophan). Oxidative deamination, transamination and decarboxylation of amino acids, fate of glucogenic and ketogenic amino acids.
- Metabolism of purine and pyrimidines.
- Classification, nomenclature and general properties of enzymes.

Unit-5

- Introduction to mechanism of enzyme action (lock and key hypothesis, induced fit hypothesis).
- Kinetics of enzyme catalyzed reaction (Michaelis-Menten law), double reciprocal plot.
- Enzyme inhibition: competitive, non- competitive and uncompetitive.
- Coenzymes: Classification, structure and functions.

Suggested Books:

- Berg, J.M., Stryer, L., Tymoczko, J.L. and Gatto, G.J. (2015). *Biochemistry* (8th ed.). New York, USA: WH Freeman.
- Conn, E.E., Stumpf, P.K., and Bruening, G. (2006). *Outlines of Biochemistry* (5th ed.). New Jersey: Wiley-Blackwell.
- Copeland, R.A. (2008). *Enzymes: A Practical Introduction to Structure, Mechanism and Data Analysis* (2nd ed.). India: Wiley-VCH.
- Gupta, S.N. (2015). *Biochemistry* (2nd ed.). Meerut: Rastogi Publication.
- Jain, J.L., Jain, S., and Jain, N. (2016). *Fundamentals of Biochemistry* (7th ed.). New Delhi: S Chand.
- Mathews, C.K., Van Holde, K.E., Appling, D.R., and Anthony-Cahill, S.J. (2012). *Biochemistry* (4th ed.). London, UK: Pearson Education.
- Nelson, D.L., and Cox, M.M. (2017). *Lehninger Principles of Biochemistry* (7th ed.). USA: W H Freeman and Co.
- Palmer, T. (2001). *Enzymes: Biochemistry, Biotechnology, Clinical Chemistry* (5th ed.). Cambridge: Horwood Publishing Ltd.

- Rodwell, V., Bender, D., Kennelly, P., and Weil, P.A. (2015). *Harpers Illustrated Biochemistry* (30th ed.). New York, USA: McGraw-Hill Education / Medical.
- Satyanarayana, U., and Chakrapani, U. (2017). *Essentials of Biochemistry* (end ed.). Kolkata: Booka and Allied Ltd.
- Voet, D., and Voet, J.G. (2010). *Biochemistry* (4th ed.). New York, USA: John Wiley and Sons Inc.
- Zubay, G., Parson, W.W., and Vance, D.E. (1995). *Principles of Biochemistry*. USA: Brown (William C.) Co.

Suggested e-Resources:

- **Enzymology**
  https://nptel.ac.in/courses/102102033/14
- **Biomolecules**
  http://www.biologie.ens.fr/~mthomas/L3/intro_biologie/2-sucres-lipides-acides-nucleiques.pdf
- **ETC**
  https://www.khanacademy.org/science/biology/cellular-respiration-and-fermentation/oxidative-phosphorylation/a/oxidative-phosphorylation-etc
  http://courses.chem.indiana.edu/c483/documents/lecture23.pdf
- **Biochemistry**
  https://nptel.ac.in/courses/102105034/3

BT 212L Biochemistry Lab

Max. Marks : 100	**L**	**T**	**P**	**C**
(CA: 40 + ESA: 60)	**0**	**0**	**4**	**2**

Learning Outcomes:

After successful completion of the course, students should be able to:

- apply various tools and techniques to understand different biochemical processes of experimentation and hypothesis testing
- identify and distinguish the carbohydrates, proteins and lipids based on specific biochemical tests
- apply the gained knowledge to develop enterpreunership skills in both academics and industries

1. To find out the λ_{max} of protein (BSA).

2. Qualitative analysis of carbohydrates (reducing and non-reducing): Molisch's test, Benedict's test, Fehling's test, Barfoed's test, Seliwanoff's test, and acidic hydrolysis test for sucrose.
3. Qualitative test for proteins: Biuret test, Ninhydrin test, Xanthoproteic test, Million's test, Sakaguchi test, and Fohl's test.
4. Qualitative analysis of lipids: Solubility test, Grease spot test, Emulsification test, Saponification test, Unsaturation test, Acrolein test, and Salkowski test.
5. Determination of iodine number.
6. Determination of the acid value of lipid.
7. Determination of saponification value of fats and oil.
8. Titration curve of glycine (determination of isoelectric point).
9. To prepare a standard curve of ammonium sulfate.
10. Preparation of enzyme (Urease) extract from horse gram seeds.
11. Determination of urease activity using standard curve of ammonium sulfate.
12. To check time linearity of urease catalyzed reaction.
13. To check protein linearity of urease catalyzed reaction.
14. Preparation and precipitation of casein from buffalo milk.

Suggested Books:

- Deb, A.C. (2013). *Comprehensible Viva and Practical Biochemistry* (2nd ed.). Kolkata: New Central Book Agency.
- Kumar, A., Grg, S., and Garg, N. (2017). *Biochemical Tests: Principles and Protocols*. New Delhi: Viva Books.
- Rao, B.S., and Deshpande, V. (2012). *Experimental Biochemistry*. New Delhi: I.K. International Publisher.
- Sadasivam, S., and Manickam, A. (1996). *Biochemical Methods* (2nd ed.). New Delhi: New Age International Publishers.
- Saxena, J., Baunthiyal., and Ravi, I. (2015). *Laboratory Manual of Microbiology, Biochemistry and Molecular Biology*. Jodhpur: Scientific Publishers.
- Sharma, S. (2007). *Experiments and Techniques in Biochemistry* (1st ed.). New Delhi: Galgotia Publication.

BIOTECHNOLOGY

BT 213 Environmental Biotechnology

Max. Marks : 100	**L**	**T**	**P**	**C**
(CA: 40 + ESA: 60)	**6**	**0**	**0**	**6**

Learning Outcomes:

After successful completion of the course, students should be able to:

- understand the basic concept of the ecosystem, environment and global environmental problems
- gain knowledge of metagenomics, biopesticides, bioleaching, bioplastics, waste management processes and biosurfactants
- describe various roles played by microbes in biodegradation, bioremediation and plant growth promotion

Unit-1

- Ecosystems-Brief overview of structure and function of an ecosystem.
- Biogeochemical cycles: Carbon cycle, nitrogen cycle and water cycle.
- Environment: Basic concepts, types of pollution: Air, water and soil pollutions, causes, sources and impacts. Global environmental problems: Green house effect, global warming, ozone depletion, photochemical smog and acid rain.

Unit-2

- An overview of classification of waste, solid waste management: Incineration, pyrolysis, landfilling, composting and its types.
- Basic concepts of bioremediation of soil and water. Brief overview of phyto-remediation and its types.
- Microbial degradation of pesticides and xenobiotic compounds, metabolism and mechanism of degradation, degradative plasmids, microbes and cloning strategies.

Unit-3

- Bioinsecticides: *Bacillus thuringiensis*, baculoviruses, genetic modifications and aspects of safety in their use. Biofungicides: Mode of actions and mechanism (*Trichoderma*).
- Biofertilizers: Algal fertilizers, nitrogen fixing bacteria, phosphate solubilising microbes, VAM, plant growth promoting rhizobacteria (PGPR). Earthworm as biofertilizer.
- An overview of soil biotechnology.

Unit-4

- Basic concept of bioleaching, enrichment of ores by microorganisms (Gold, Copper and Uranium).
- Sewage treatment: Aerobic, anaerobic and advanced processes. Basic sludge treatment.
- An introduction of metagenomics.
- An overview of carbon sequestration.

Unit-5

- Bioindicators and biosensors for detection of environmental pollution.
- Biofuels: Biogas, bioethanol, biodiesel, biohydrogen.
- A brief introduction of bioplastics and biosurfactants.
- Biotechnology in biodiversity conservation.

Suggested Books:

- Allen, K. (2016). *Environmental Biotechnology*. New Delhi, India: CBS Publishers.
- Evans, G.M. and Furlong, J.C. (2003). *Environmental Biotechnology: Theory and Applications*. Wiley Publishers.
- Milton, W. (Ed.). (1999). *An Introduction to Environmental Biotechnology*. USA: Springer.

- Mohapatra, P.K. (2011). *A Text Book of Environmental Biotechnology*. I.K. International Publishing House Pvt. Ltd.New Delhi.
- Scragg A. (2005). *Environmental Biotechnology*. Pearson Education Limited.

BT 213L Environmental Biotechnology Lab

Max. Marks : 100	**L**	**T**	**P**	**C**
(CA: 40 + ESA: 60)	**0**	**0**	**4**	**2**

Learning Outcomes:

After successful completion of the course, students should be able to:

- develop the skills in the experiments of Environmental Biotechnology
- gain practical experience in determination of water quality
- gain practical understanding in the role of biofertlizers and biopesticides in the cleaning of environment

1. Estimation of Dissolved oxygen in water sample.
2. Estimation of COD in water sample.
3. Determination of total hardness of water.
4. Determination of total alkalinity of water.
5. To determine free CO_2 content in the water sample.
6. To determine the chloride content of the water sample.
7. Isolation of biofertilizer microbes by biological enrichment method.
8. Production of microbial biofertilizers.
9. Efficacy testing for biofertilizers.
10. Testing for microbiological quality of potable water (Coli form test).
11. Effect of heavy metal toxicity on seed germination and plant growth.
12. Alcohol fermentation by using Baker's yeast and its quantification by dichromate method.

Suggested books:

- Lal, S.S. (2016). *A Textbook of Practical Zoology* Vol-III (2nd ed.). Meerut: Rastogi Publication.
- Poddar, T., Mukhopadhyay, S., and Das, S.K. (2003). *An advanced Laboratory Manual of Zoology*. Kolkata: Macmillan India Limited.

CHEMISTRY

CHEM 202 Physical Chemistry-I

Max. Marks : 100	**L**	**T**	**P**	**C**
(CA: 40 + ESA: 60)	**6**	**0**	**0**	**6**

Learning Outcomes:

On completion of course, the students will be able to:

- explain the basic principles of thermodynamics and thermochemistry.
- describe the states of matter.
- explain the concepts of chemical kinetics and catalysis.
- apply the concept of thermodynamics to determine the heat of neutralization of chemical reaction.
- explain the concept of colloids.

Unit 1 Chemical kinetics and Catalysis:

Introduction, measurement of reaction rate, integration and determination of rate laws, rate constant, unit of rate constant for zero order, first order and second order reactions, order of reaction, molecularity of reaction, difference between order and molecularity of reaction, chemical kinetics and its scope, factors influencing the rate of a reaction-concentration, temperature, pressure, solvent, light, catalyst; concentration dependence of rates, mathematical characteristics of simple chemical reactions-zero order, first order, second order, pseudo order; half-life and mean life; determination of the order of reaction-differential method, graphical method, method of integration, method of half-life period and isolation method, radioactive decay as a first order phenomenon.

Theories of chemical kinetics:

Effect of temperature on rate of reaction, temperature co-efficient, Arrhenius equation, concept of activation energy, transition state theory (equilibrium hypothesis), expression for the rate constant based on equilibrium constant and thermodynamic aspects.

Unit 2 Thermodynamics-I:

Definition, significance and limitations, classical versus statistical thermodynamics, different thermodynamic terms: system, surroundings, types of systems, intensive and extensive properties, state and path functions, and their differentials, Eular reciprocity relation and cyclic rule, thermodynamic process, concept of heat and work.

First law of Thermodynamics: statement, definition of internal energy and enthalpy, heat capacity: heat capacities at constant volume and pressure and their relationship, Joule's law, Joule-Thomson coefficient and inversion temperature, calculation of w, q, dU and ΔH for the expansion of ideal gases under isothermal and adiabatic conditions for reversible process, application of first law of thermodynamics, zeroth law of thermodynamics and the absolute temperature scale.

Thermo-Chemistry:

Standard state, standard enthalpy of formation: Hess's law of heat summation and its applications, heat of reaction at constant pressure and at constant volume, various types of enthalpies of reaction: enthalpy of formation, enthalpy of combustion, enthalpy of solution, enthalpy of dilution, enthalpy of hydration and enthalpy of neutralization, bond dissociation energy and its calculation from thermochemical data, calculation of lattice energy from Born-Haber’s cycle, temperature dependence of enthalpy, Kirchhoff's equation, adiabatic flame temperature.

Unit 3 Thermodynamics-II:

Second law of thermodynamics: need for the law, different statements of the law, Carnot cycle and its efficiency, Carnot theorem, thermodynamic scale of temperature and its identity with ideal gas temperature scale.

Concept of entropy: entropy as a state function, characteristics of entropy function and Maxwell relations, entropy as a function of V and

T, entropy as a function of P and T, entropy change in physical change, Clausius inequality and its application to an isolated system, entropy as a criteria of spontaneity and equilibrium, entropy change in ideal gases: temperature and volume, temperature and pressure variations, standard entropy and entropy of mixing of ideal gases.

Chemical Equilibrium:

Free energy of spontaneous reactions and the role of temperature, equilibrium constant and free energy, thermodynamic derivation of law of mass action, Van't Hoff reaction isotherm, factors affecting the state of equilibrium, Le-Chatelier's principle and its applications to physical and chemical equilibrium, reaction isotherm and reaction isochore, Clapeyron and Clausius-Clapeyron equations and its applications for lquid-vapor, solid-vapor and solid-liquid equilibrium.

Unit 4 Gaseous State:

Postulates of kinetic theory of gases, deviation from ideal behavior, Van der waals equation of state, critical phenomena, PV isotherms of real gases, continuity of states, the isotherms of Van der waals constants, the law of corresponding states and reduced equation of state.

Molecular velocities: root mean square, average and most probable velocities, qualitative discussion of the Maxwell's distribution of molecular velocities, collision number, mean free path and collision diameter, liquification of gases (based on Joule-Thomson effect).

Liquid State:

Intermolecular forces, structural differences between solids, liquids and gases, thermography and seven-segment cell.

Surface tension :

Basic concept, effect of temperature , Surface energy

Viscosity:

Basic concept, effect of temperature and Pressure

Unit 5 Colloidal State:

Definition and classification of colloids, solid in liquid (sol): properties-kinetic, optical and electrical; stability of colloids, protective action, Hardy-Schulze law, gold number, liquid in liquid (emulsion): types and preparation of emulsions, emulsifier, liquid in solid (gel): classification,

preparation and properties, inhibition and general applications of colloids.

Solid State:

Solids-classification, properties:-electrical and magnetic; crystals– external features, symmetry, lattice point, unit cell, classification; ionic crystals - packing of constituents in crystals, relationship between edge length and ionic radii, packing efficiency, co-ordination number, interstitial voids-trigonal voids, tetrahedral voids, octahedral voids and cubic voids, radius ratio of voids.

Defects in Solids:

Definition, classification, stoichiometric and non-stoichiometric defects, consequences of defects.

Recommended Books:

1. Atkins, P., Julio, P. D. (2014). *Physical Chemistry* (10th Ed.), United Kingdom: Oxford University Press.
2. Castellan, G.W. (1983). *Physical Chemistry* (3rd Ed.), United State of America: Addision-Wesley Publishing Company.
3. West, A. R. (2014). *Solid State Chemistry and its Applications* (2nd Ed.), John Wiley andSons Ltd.
4. Puri, B.R., Sharma, L.R., Pathania, M.S.(2016). *Principle of Physcial Chemistry* (47th Ed.), India: Vishal Publishing Company.
5. Laider, K.J.(1965). *Chemical Kinetics* (2nd Ed.), New York: McGraw Hill Book Company.

Suggested e-Sources

1. National Programme on Technology Enhanced Learning

   https://nptel.ac.in

2. Online Chemistry Courses

   https://www.edx.org/learn/chemistry

3. Free Online Education SWAYAM

   https://swayam.gov.in

CHEM 202L Physical Chemistry-I Lab

Max. Marks : 100	**L**	**T**	**P**	**C**
(CA: 40 + ESA: 60)	**0**	**0**	**4**	**2**

Learning Outcomes:

On completion of course, the students will be able to:

- determine the percentage composition of unknown mixture by viscosity and surface tension methods.
- measure kinetics parameters of chemical reaction.
- evaluate the enthalpy of neutralization.
- calculate the lattice energy of $CaCl_2$ and solubility of benzoic acid at different temperatures.

Surface Tension and Viscosity:

1. To find the relative and absolute viscosity of the given liquid at room temperature.
2. To determine the percentage composition of given mixture (non-interacting systems) by viscosity method.
3. To find the surface tension of given liquid by drop number method at room temperature.
4. To determine the percentage composition of given binary mixture by surface tension method (acetone and ethyl/methyl ketone).

Chemical Kinetics:

1. To determine the specific reaction rate of the hydrolysis of methyl acetate/ethyl acetate catalyzed by hydrogen ions at room temperature.
2. To study the effect of acid strength on the hydrolysis of an ester.
3. To compare the strengths of HCl and H_2SO_4 by studying the kinetics of ethyl acetate.

4. To study the reaction rate of decomposition of iodide by H_2O_2 kinetically.

Colloids:

1. To prepare arsenious sulfide sol and compare the precipitating power of mono-, bi- and trivalent anions.

Transition Temperature:

1. Determination of the transition temperature of given substance by thermometric method (e.g. $MnCl_2.4H_2O$/ $SrBr_2.2H_2O$).

Thermo-Chemistry:

1. To determine the solubility and heat of reaction of benzoic acid at different temperatures.
2. To determine the enthalpy of neutralization of strong acid and strong base.
3. To determine the enthalpy of neutralization of weak acid and strong base.
4. To determine the enthalpy of solution of solid calcium chloride and calculate it's lattice energy using Born-Haber cycle.
5. Determination of heat of reaction and verification of Hess's law.

Partition Coefficient:

1. To find the partition coefficient of I_2 between CCl_4 and H_2O.

Recommended Books:

1. Gurtu, G.N., Gurtu, A. (2014). *Avanced Physical Chemistry*, India: Pragati Prakashan .
2. Sindhu, P.S. (2005). *Practicals in Physical Chemistry*, India: Macmillan Publishers.

Suggested e-Sources

1. National Programme on Technology Enhanced Learning
   https://nptel.ac.in
2. Online Chemistry Courses
   https://www.edx.org/learn/chemistry
3. Free Online Education SWAYAM
   https://swayam.gov.in

Fourth Semester

BIOTECHNOLOGY

BT 211 Animal and Plant Biotechnology

Max. Marks : 100	**L**	**T**	**P**	**C**
(CA: 40 + ESA: 60)	**6**	**0**	**0**	**6**

Learning Outcomes:

After successful completion of the course, students should be able to:

- learn theoretical aspects of different cell culture techniques and their uses in therapeutic applications
- gain knowledge of assisted reproductive technology, transgenic animal production and its applications
- gain an understanding of current scenario of stem cells and tissue engineering in bioartificial organs development and transplantation

Unit-1

- Historical perspective and terminology used in cell and tissue culture .
- Basic techniques of cell and tissue culture, sterilization, aseptic tissue transfer, concept of totipotency.
- Cell culture media and reagents.
- Cell viability, Cryopreservation and cell storage.

Unit-2

- Animal Cell Culture: Disaggregation techniques, primary cell cultures, secondary culture, continuous cell lines, anchorage dependent, suspension cultures, establishment and maintenance of cell cultures. Cytotoxicity assays.
- Animal reproductive biotechnology: Superovulation, Artificial insemination, embryo recovery and in vitro fertilization, microinsemination tenhniques (ICSI, PZD and SUZI).

- Culture of embryos; embryo transfer technology, transgenic manipulation of animal embryos.

Unit-3

- Transgenic animals (fish, mouse, pig, cattle, sheep, goat and monkey) and their applications. Animal cloning.
- Vaccinology: Introduction to the concept of vaccines, conventional methods of animal vaccine production, recombinant approaches to vaccine production, modern vaccines.
- Brief idea about stem cells; classification, properties and tissue engineering (use of scaffold and biomaterials) and their brief therapeutic applications.

Unit-4

- Callus culture, cell suspension culture, organogenesis, somatic embryogenesis and artificial seeds.
- Micropropagation, somaclonal variation, somatic hybridization, cybrids.
- Protoplast isolation and culture, techniques of protoplast fusion, haploid production and applications.

Unit-5

- Transgenic plants - basic concept and use of suitable promoters.
- Development of plants resistant to environmental stress and herbicides.
- Development of pathogen resistant plants (Virus and insect resistance).
- Overview of plant secondary metabolites, brief idea about plant metabolic engineering, strategies for enhancement of bioactive compounds in cell and tissue culture.
- Concept of plants as biofactories, molecular pharming.

Suggested Books:

➢ Bhojwani, S.S., and Razdan, M.K. (1996). *Plant Tissue Culture: Theory and Practice*. Netherlands: Elsevier Science.

- Boylan, M., and Brown, K.E. *Genetic Engineering: Science And Ethics On The New Frontier*.
- Brown, T.A. (2010). *Gene Cloning and DNA Analysis: An Introduction* (6th ed.). USA: Wiley-Blackwell.
- Chawla, H.S. (2009). *Introduction to Plant Biotechnology* (3rd ed.). USA: CRC Press.
- Chawla, H.S. (2009). *Plant Biotechnology* (3rded.). New Delhi, India: Oxford and IBH Publishing Co. Pvt. Ltd.
- Glick, B.R., and Patten, C.L. (2017). *Molecular Biotechnology: Principles and Applications of Recombinant DNA* (5th ed.). USA: American Society for Microbiology Press.
- Gupta, P.K. (2005). *Biotechnology and Genomics*. Meerut: Rastogi Publication.
- Gupta, P.K. (2017). *Animal Biotechnology*. Meerut: Rastogi Publication.
- Kumaresan, V. (2008). *Applied animal biotechnology*. Tamil Nadu, India: Saras Publication.
- Lanza, R., Gearhart, J., and Hogan, B. *Essentials of stem cell biology* (2nd ed.). London, UK: Academic Press.
- Lanza, R., Langer, R., and Vacanti, J. *Principles of tissue engineering* (4th ed.). London, UK: Academic Press.
- Peter, K.V., and Keshavachandran, R. (2008). *Plant Biotechnology: Methods in Tissue Culture and Gene Transfer*. India: Universities Press.
- Primrose, S.B., and Twyman, R. (2006). *Principles of Gene Manipulation and Genomics* (7th ed.) UK: Oxford University Press.
- Razdan, M.K. (2003). *Introduction to Plant Tissue Culture* (2nd ed.). USA: Science Pub Inc.
- Shrivastava, S. (2012). Molecular Techniques in Biochemistry and Biotechnology. Kolkata: New Central Book Agency.
- Singh, B., Gautam, S.K., and Chauhan, M.S. (2015). *Textbook of animal biotechnology*. New Delhi, India:Teri Publication.
- Singh, B.D. (2011). *Plant Biotechnology* (2nd ed.). New Delhi, India: Kalyani Publisher.
- Singh, B.S. (2007). *Fundamentals of Plant Biotechnology*. New Delhi, India: Satish Serial Publishing House.
- Slater, A. (2008). *Plant Biotechnology: The Genetic Manipulation of Plants* (2nded.). Oxford, UK: Oxford Publisher.

Suggested e-Resources:

- **Animal cell culture**
  https://nptel.ac.in/courses/102104059/
- **Plant Biotechnology**
  https://nptel.ac.in/courses/102103016/
- **Tissue engineering**
  https://nptel.ac.in/courses/102106036/

BT 211L Animal and Plant Biotechnology Lab

Max. Marks : 100	**L**	**T**	**P**	**C**
(CA: 40 + ESA: 60)	**0**	**0**	**4**	**2**

Learning Outcomes:

After successful completion of the course, students should be able to:

- understand Animal and Plant Biotechnology with easy to run experiments
- gain hands-on training on plant and animal tissue culture and biotechnology
- learn the technique of genomic DNA isolation from plant and animal cells and its electrophoresis

1. Introduction to the laboratory and general safety practices for plant and animal cell culture.
2. Aseptic culture techniques for establishment and maintenance of cultures.
3. Prepare culture media with various supplements for plant and animal tissue culture.
4. To select, prune, sterilize and prepare an explant for culture.
5. Establishment of callus cultures.
6. Cell suspension cultures.
7. Isolation of protoplast.

8. Isolation of plant genomic DNA by modified CTAB method.
9. Isolation of DNA from animal tissue.
10. Quantification of DNA by spectrophotometeric method.
11. Size analysis of DNA by agarose electrophoresis.
12. Effect of different light wavelengths and temperature on germinating embryos.
13. Cell counting and determination of cell viability.
14. Estimation of total phenolic content from plant leaves.
15. Seed germination under stress condition.
16. Chlorophyll estimation from the given samples.

Suggested Books:

- Saxena, J., Baunthiyal., and Ravi, I. (2015). *Laboratory Manual of Microbiology, Biochemistry and Molecular Biology*. Jodhpur: Scientific Publishers.
- Sharma, R.K., and Sangha, S.P.S. (2009). *Basic Techniques in Biochemistry and Molecular Biology*. New Delhi: I.K. International Publisher.
- Swamy, P.M. (2008). *Laboratory Manual on Biotechnology* (1st ed.). Meerut: Rastogi Publication.

BT 214 Industrial Biotechnology

	L	T	P	C
Max. Marks : 100				
(CA: 40 + ESA: 60)	**6**	**0**	**0**	**6**

Learning Outcomes:

After successful completion of the course, students should be able to:

- describe and compare different bioreactors conditions for production of various metabolites
- explain food preservation and spoilage
- distinguish between different types of IPR

Unit-1

- Introduction to industrial biotechnology, scope and applications.
- Isolation and screening (Primary and secondary screening) of microorganisms for industrial products .
- Strategies for Strain improvement (mutation, recombination).
- Solid-state and liquid-state (stationary and submerged) fermentations; Batch and continuous fermentations.

Unit-2

- Industrial Media and use of organic wastes in fermentation medium (molasses, corn steep liquor, whey and yeast extract).
- Bioreactors – basic concept of bioreactor design. Types of Bioreactors: Constantly stirred tank fermenter, tower fermenter, fixed bed and fluidized bed bioreactors and air-lift fermenter.
- Downstream processing of fermentation products – Filtration, centrifugation and basic chromatographic techniques.

Unit-3

- Study of various fermentation processes highlighting microbes, upstream and downstream processes used.
  a) Antibiotic fermentation: Penicillin.
  b) Anaerobic fermentation: Industrial alcohol, acetone-butanol fermentation.
  c) Organic acid: lactic acid.
  d) Industrial enzymes: proteolytic enzymes, amylases.
  e) Therapeutics drugs : Monoclonal antibodies, insulin.

Unit-4

- Industrial Microbiology of foods and beverages: Bread making, alcoholic beverages (beer and whisky), cheese, fermented milk products, sauerkraut.
- Protein foods: Single cell proteins (SCP), mushroom, algal proteins.
- General principles in microbial spoilage of food.
- Food preservation- principles and methods

Unit-5

- Biosafety- definition and significance. Biosafety issues in biotechnology.
- Concerns and Challenges GMOs/LMOs; Role of Institutional Biosafety Committees (IBSC), RCGM, GEAC etc in governing biotechnological concerns.
- Introduction, significance and types of Intellectual Property Rights); Procedure of patent filing in India.
- World Intellectual Property Rights Organization (WIPO), Budapest Treaty on international recognition of the deposit of microorganisms; UPOV; Farmer's rights, Patent Co-operation Treaty (PCT).

Suggested Books:

- Crueger, W., and Crueger, A. (2017). *Biotechnology: A Textbook of Industrial Microbiology* (3rd ed.). New York: Medtech.
- Goel D. and Parashar S. (2013). *IPR, Biosafety and Bioethics* (1st ed.) Pearson Education India.
- Patel, A.H. (2005). *Industrial Microbiology*. Macmillan India Ltd.
- Sateesh, M.K. (2008). *Bioethics and Biosafet*y. New Delhi: I.K. International Publishing House.
- Stanbury, P.F., Whitaker, A. and Hall, S.J. (1995). *Principles of Fermentation Technology* (2nd and 3rd ed.). US: Elsevier Science Ltd.

Suggested e-Resources:

- **Acetone-Butanol Fermentation**

  https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4894279/pdf/fnw134.pdf
- **Bioethics**

  http://www.unesco-chair-bioethics.org/?page_id=43
- **Biosafety**

  https://www.nih.gov/research-training/safety-regulation-guidance
  http://www.dbtindia.nic.in/

- **Biosafety, Risk assessment and management**
  http://www.fao.org/docrep/014/i1905e/i1905e02.pdf

BT 214L Industrial Biotechnology Lab

Max. Marks : 100	**L**	**T**	**P**	**C**
(CA: 40 + ESA: 60)	**0**	**0**	**4**	**2**

Learning Outcomes:

After successful completion of the course, students should be able to:

- learn differences between various bioreactor designs and their applications
- perform estimations for various metabolites
- understand the process of filing applications for biosafety approval and patent

1. Comparative analysis of design of a batch and continuous fermenter.
2. Study of designs of CSTR, Airlift and packed bed reactors.
3. Screening of soil for protease producers using skim milk agar plate assay.
4. Production of protease and its estimation by spectrophotometric method.
5. Determination of quality of milk by methylene blue reduction test.
6. Microbiological examination of food sample.
7. Estimation of lactic acid by titration.
8. Estimation of pectinase activity from spoiled fruits.
9. Filing applications for approval from biosafety committee (IBSC).
10. Filing primary applications for patents.

Suggested Books:

- Cappuccino, J. G., and Welsh, C. (2016). *Microbiology: A laboratory Manual*. USA: Benjamin-Cummings Publishing Company.
- Kulandaivel, S. and Janarthanan, S. (2012). *Practical Manual of Fermentation Technology*. New Delhi, India: I.K. International Publishing House Pvt. Ltd.

CHEMISTRY

CHEM 201 Inorganic Chemistry-II

Max. Marks : 100	**L**	**T**	**P**	**C**
(CA: 40 + ESA: 60)	**6**	**0**	**0**	**6**

Learning Outcomes:

On completion of course, the students will be able to:

- apply crystal field theory on different geometries and correlate it with stability.
- elucidate the nomenclature, structures, magnetic properties and reactivity of transition metal complexes.
- apply the concept of L-S coupling for the determination of term symbols of different spectroscopic states and appreciate its utility.
- elaborate the thermodynamic and kinetic stability of metal complexes.
- demonstrate the structure, bonding and reactivity of organometallic compounds.
- discuss a concise treatment of the important inorganic non-aqueous solvents and its application in various known reactions.
- apply HSAB principle on stability of molecules.

Unit 1 Crystal Field Theory:

Introduction, crystal field splitting in octahedral, tetrahedral, square planar, and trigonal bipyramidal complexes, factors affecting the crystal-field parameters, Jahn-Teller distortions, applications and limitations of crystal field theory.

Magnetic Properties of Transition Metal Complexes:

Types of magnetic behavior, methods of determining magnetic susceptibility, spin-only formula, L-S coupling, correlation of μ_S and μ_{eff} values, orbital contribution to magnetic moments, applications of magnetic data for 3*d*-metal complexes.

Unit 2 Electronic Spectra of Transition Metal Complexes:

Types of electronic transitions, selection rules for d-d transitions, spectroscopic ground states, spectrochemical series, Orgel energy level diagram for d^1 and d^9 states, discussion of the electronic spectrum of $[Ti(H_2O)_6]^{3+}$ complex ion.

Thermodynamic and Kinetic Aspects of Metal Complexes:

Lability and inertness of complexes, brief outline of thermodynamic and kinetic stability of metal complexes and factors affecting the stability, substitution reactions of square planar complexes.

Unit 3 Chemistry of Lanthanides:

Electronic structure, oxidation states, ionic radii, lanthanide contraction, complex formation, occurrence and isolation, lanthanide compounds, spectral and magnetic properties.

Chemistry of Actinides:

General features and chemistry of actinides, chemistry of separation of Np, Pu and Am from U, similarities between the later actinides and the later lanthanides.

Unit 4 Non-aqueous Solvent:

Classification of solvents, physical properties of solvents, reactions in non-aqueous solvents with reference to liquid NH_3 liquid HF and liquid SO_2.

Hard and Soft Acids and Bases (HSAB):

Classification of acids and bases as hard and soft, Pearson's HSAB concept, acid-base strength and hardness and softness, symbiosis, theoretical basis of hardness and softness.

Unit 5 Bio-Inorganic Chemistry:

Essential and trace elements in biological processes, metalloporphyrins: hemoglobin, myoglobin, hemocyanin and hemerythrin; biological role of alkali and alkaline earth metal ions with special reference to Ca^{2+} in muscle contraction, nitrogen fixation.

Organometallic Chemistry:

Definition, nomenclature and classification of organometallic compounds, preparation, properties, bonding and applications of alkyls and aryls of Li, Al, Hg, Sn and Ti, a brief account of metal-ethylenic complexes, mononuclear carbonyls and the nature of bonding in metal carbonyls.

Recommended Books:

1. Lee, J.D (1998). *Concise Inorganic Chemistry,* (5th ed.). Oxford Publications.
2. Puri, B.R, Sharma, L.R., Kalia, K.C. (2017). *Principles of Inorganic Chemistry*, (3rd ed.). Vishal Publications.
3. Cotton, F. A., Wilkinson, G. (1994). *Basic Inorganic Chemistry,* (3rd ed.). John Wiley Publications
4. *Huheey, J.E., Keiter, J.A.* and *Keiter, R.L. (*1997*), Inorganic Chemistry: Principles of Structure and Reactivity,* 4th (ed.) Pearson Publications.
5. Bhagchandani, P. (2017), *Inorganic Chemistry*, Sahitya Bhawan Publications.
6. Malik, W.U., Tuli, G.D. and Madan, R.D. (2010), *Selected Topics in Inorganic Chemistry*, Revised Ed., S. Chand Publications.

Suggested e-Sources

1. National Programme on Technology Enhanced Learning

   https://nptel.ac.in

2. Online Chemistry Courses

   https://www.edx.org/learn/chemistry

3. Free Online Education SWAYAM

   https://swayam.gov.in

CHEM 201L Inorganic Chemistry-II Lab

Max. Marks : 100	**L**	**T**	**P**	**C**
(CA: 40 + ESA: 60)	**0**	**0**	**4**	**2**

Learning Outcomes:

On completion of course, the students will be able to:

- perform the proper procedures and have the knowledge of regulations for safe handling and use of chemicals.
- predict chemical bonding or molecular geometry of various complexes based on accepted models.
- synthesize various transition metal complexes.
- Handle instruments like calorimeter and potentiometer.

Analysis of the following by Volumetrically/Gravimetrically:

1. Estimation of Barium (as sulphate)
2. Estimation of Lead (as sulphate)
3. Estimation of Zinc (as ammonium sulphate)
4. Estimation of Magnesium (as magnesium hydrogen phosphate)
5. Estimation of Copper (as thiocynate)
6. Estimation of Nickle (as nickel dimethyl glyoximate)

Complexometric Titrations using Disodium Salt of EDTA:

1. Estimation of Mg^{2+} and Zn^{2+}
2. Estimation of Ca^{2+} by substitution method

Preparation and Purification of following Complexes:

1. Sodium trioxalatoferrate (III)
2. Tetraamminecopper (II) sulphate
3. Sodium trioxalatochromate (III)
4. cis- and trans-diaquadioxalatochromate (III) ion

Colorimetric Estimation:

1. Job's method
2. Mole-ratio method

Adulteration Analysis (any one of the following):

1. Food stuffs
2. Effluents

Solvent Extraction:

1. Separation and estimation of Mg (II) and Fe (II)

Recommended Books:

1. Gurdeep, R. (2016*). Advanced Practical Inorganic Chemistry*, Krishna Prakashan publication.
2. Svehla, G. (2010). Vogel's *Qualitative Inorganic Analysis*, (7th ed.). Prentice Hall.
3. Gurtu, J. N. and Gurtu , A(2011), *Physical Chemistry Vol – I,* Pragati Prakashan publication.

Suggested e-Sources

1. National Programme on Technology Enhanced Learning

   https://nptel.ac.in
2. Online Chemistry Courses

   https://www.edx.org/learn/chemistry
3. Free Online Education SWAYAM

   https://swayam.gov.in

Fifth and Sixth Semester

Discipline Elective Courses

(BIOTECHNOLOGY)

BT 320 Microbiology and Immunology

Max. Marks : 100	**L**	**T**	**P**	**C**
(CA: 40 + ESA: 60)	**6**	**0**	**0**	**6**

Learning Outcomes:

After successful completion of the course, students should be able to:

- identify the characteristics of bacteria and viruses
- understand various tools and techniques used for culturing and preservation of microbes
- develop an understanding of the different viral infections and basic concepts of immune system

Unit 1

- Overview of history of Microbiology - Biogenesis and abiogenesis. Contributions of Pasteur, Koch, Edward Jenner and Flemming.
- Ultrastructure of bacteria. General account of different groups: Mycoplasma, cyanobacteria and archaebacteria.
- Microbial growth and reproduction: Binary fission, growth curve, methods of growth determination and factors affecting growth of bacteria.
- Bacterial nutrition: Nutritional categories of bacteria, culture media and types.

Unit 2

- Techniques for sterilization. Isolation of pure culture and preservation of cultures.
- Staining procedures: Gram staining, acid fast staining, flagella staining, endospore staining.
- Mechanism of genetic exchange: Transformation, transduction and conjugation. Brief idea of transposable elements.
- A brief idea of controlling microorganisms using chemotherapeutic agents (antibiotics).

Unit 3

- Basic concepts of virology: General characteristics of viruses. Classification of viruses (Baltimore). A brief idea of viroid and prion.
- Structures of different viruses on the basis of capsid symmetry- enveloped (Herpes virus, SARS-CoV-2), helical (TMV) and icosahedral (Polyoma viruses), and complex (Bacteriophage).
- Virus replication strategies: HIV, TMV, and bacteriophages (T_4 and λ).
- Introduction to immune system- organs and cells of immune system.

Unit 4

- Innate and acquired immune system, active and passive immunity.
- Antigen, antigenicity, factors affecting immunogenicity.
- Antibody structure and classes. Generation of antibody diversity.
- Major Histocompatibility complex – class I and class II MHC antigens, antigen processing and presentation.

Unit 5

- Humoral and Cellular immune responses and their effector mechanisms.
- Tools in diagnostic immunology- RIA, ELISA, Western blotting, Immunoprecipitation.
- Hybridoma technology: Monoclonal antibodies and their applications.
- Brief idea about autoimmunity, factors contributing development of autoimmune diseases.

Suggested Books:

- Khan, F. H. (2009). *Elements of Immunology* (1st ed.). Pearson Education India.
- Kindt, T.J., Osborne, B.A., and Goldsby, R.A. (2006). *Kuby Immunology* (6th ed.). New York, USA: W. H. Freeman and Company.
- Madigan, M. T., Martinko, J. M., Dunlap, P. V., and Clark, D. P. (2005). *Brock Biology of Microorganisms* (12th ed.). San Fransisco: Benjamin Cummings.
- Maloy, S.R., Cronan, J.E., and Friefelder, D. (1994). *Microbial Genetics* (2nd ed.). USA: Jones and Bartlett.
- Owen, J., Punt, J., Stranford, S., and Jones, P. (2018). *Kuby Immunology* (7th ed.). USA: W. H. Freeman and Company.
- Pelczar, M.J., Chan, E.C.S., and Krieg, N.R. (2007). *Microbiology* (5th ed.). New York, U.S.: Tata McGraw-Hill Inc.

- Shetty, N. (2005). *Immunology: Introductory Textbook*. New Delhi: New Age International Publishers.
- Tizard, I.R. (1995). *Immunology: Introduction* (4th ed.). Philadelphia: Saunders College Publishing.
- Tortora, G.J., Funke, B.R., and Case, C.L. (2016) *Microbiology: An Introduction* (12th ed.). London, UK: Pearson.
- Weaver, R.F. (2011). *Molecular Biology* (5th ed.). New York, USA: McGraw-Hill Education.
- Willey, J.M., Sherwood, L., and Woolverton, C.J. (2007). *Prescott, Harley and Klein's Microbiology,* (7th ed.). USA: Mc Graw Hill Higher Education.

Suggested e- Resources:

- **Immunology**

  https://nptel.ac.in/courses/102103038/3

- **Immunity**

  https://www.khanacademy.org/science/high-school-biology/hs-human-body-systems/hs-the-immune-system/a/hs-the-immune-system-review

- **Microbiology**

  https://nptel.ac.in/courses/102103015/

- **Structure of bacteria and viruses**

  https://instruct.uwo.ca/biology/090b/1290b%201-7.pdf

  http://ocw.jhsph.edu/courses/EpiInfectiousDisease/PDFs/EID_lec2_Dick.pdf

BT 320L Microbiology and Immunology Lab

Max. Marks : 100	**L**	**T**	**P**	**C**
(CA: 40 + ESA: 60)	**0**	**0**	**4**	**2**

Learning Outcomes:

After successful completion of the course, students should be able to:

- learn techniques of different culture media preparation and their sterilization
- perform the microbial isolation, culture, maintenance and their enumeration
- develop an understanding of immunological techniques

1. To prepare basic liquid media, solid media, agar slants and agar deep tube for the routine cultivation of bacteria.
2. Isolation of pure culture by streak plate method.
3. Isolation of microorganisms from soil by serial dilution and determination of CFU.
4. To perform the spread plate method and pour plate method for enumeration of microorganisms.
5. Isolation of microorganisms from air by direct plate exposure method.
6. To perform Gram's staining and endospore staining of bacteria.
7. Testing of blood groups including Rh factors to observe the phenomenon of agglutination.
8. To study the various lymphoid glands (spleen and thymus).
9. To study different type of cells participating in non-specific immunity (Blood film preparation).
10. Immunoprecipitation by double diffusion technique.

Suggested Books:

- Aneja, K.R. (1996). *Experiments in Microbiology, Plant Pathology, Tissue Culture and Mushroom Cultivation* (2nd ed.). New Delhi: Wishwa Prakashan.
- Ghose, K., and Manna, B. (2016). *Practical Zoology* (4th ed.). Kolkata: New Central Book Agency.
- Kumar, V. (2011). *Laboratory Manual of Microbiology*. New Delhi: Scientific Publishers.
- Mahajan, R., Sharma, J., and Mahajan, R.K. (2010). *Practical Manual of Biotechnology* (1st ed.). New Delhi: Vayu Education of India.

BT 317 Advances in Biotechnology

Max. Marks : 100	**L**	**T**	**P**	**C**
(CA: 40 + ESA: 60)	**6**	**0**	**0**	**6**

Learning Outcomes:

After successful completion of the course, students should be able to:

- understand the different techniques of DNA sequencing, gene synthesis, gene silencing, PCR and blotting
- understand the basic concepts of recent techniques of genome editing
- gain an understanding of the introductory nanobiotechnology: Synthesis, characterization and applications of nanoparticles

Unit 1

- DNA sequencing methods: Maxam and Gilbert, Sangers method and automated sequencing.
- Chemical synthesis of oligonucleotides: Solid phase automated synthesis using phosphoramidite.
- Molecular probes: Preparation, labeling and applications.
- Blotting techniques: Principles and applications of Southern, Northern and Western blotting and hybridization.

Unit 2

- PCR and its applications.
- Molecular techniques for identification of organism: Nucleic acid hybridization, Ribotyping and ARDRA.
- DNA fingerprinting: Principle, procedure and applications.
- DNA microarray: Principle, procedure and applications.

Unit 3

- Gene silencing techniques: Antisense gene approach, antisense oligonucleotides, aptamers and RNA interference.
- Genome editing: Meganucleases, zinc finger nucleases (ZFNs) and transcription activator-like effector-based nucleases (TALEN).
- Clustered regularly interspaced short palindromic repeats (CRISPR/Cas9) system.

Unit 4

- Gene therapy: An overview of its types and vectors used.
- Terminator seed technology.

- Gene Targeting: Knock-ins and Knock-outs.
- Molecular priming.

Unit 5

- An introduction of nanobiotechnology.
- Brief idea of carbon based nanomaterials: Quantum dots, nanowires, nanotubes, dendrimers, 2D films, and 3D nanomaterials.
- Synthesis of nanomaterials: Bottom up and top down approach; physical, chemical and biological methods.
- Applications of nanotechnology.

Suggested Books:

- Balasubramanian, D., Bryce, C.F.A., Dharmalingam, K., Green, J., and Jayaraman, K. (2004). *Concepts in Biotechnology*. Hyderabad: University Press.
- Borem, A., Santos, F.R., and Bowen, D.E. (2003). *Understanding Biotechnology* (1st ed.). USA: Prentice Hall.
- Brown, T.A. (2010). *Gene Cloning and DNA Analysis: An Introduction* (6th ed.). USA: Wiley-Blackwell.
- Crueger, W., and Crueger, A. (2017). *Biotechnology: A Textbook of Industrial Microbiology* (3rd ed.). New York: Medtech.
- Gupta, P.K. (2005). *Biotechnology and Genomics*. Meerut: Rastogi Publication.
- Kumar, H.D. (1998). *Modern Concept of Biotechnology*. New Delhi: Vikas Publishing House.
- Niemeyer, C.M., and Mirkin, C.A. (2013). *Nanobiotechnology: Concepts, Applications and Perspectives*. India: Wiley.
- Shah, M.A., and Shah, K.A. (2013). *Nanotechnology: The Science of Small*. India: Wiley.
- Shrivastava, S. (2012). *Molecular Techniques in Biochemistry and Biotechnology*. Kolkata: New Central Book Agency.
- Srivastava, S. (2013). *Introductory Nanobiotechnology*. Kolkata: New Central Book Agency.
- Sudbery, P. (2010). *Human Molecular Genetics* (3rd ed.). USA: Pearson Education.

Suggested e- Resources:

- **Gene therapy**

  https://nptel.ac.in/courses/102103041/

- **PCR, hybridization and blotting technique**

  http://www.tulane.edu/~wiser/methods/notes.pdf

- **RNA interference**

  https://www.ncbi.nlm.nih.gov/pmc/articles/PMC309050/

- **Genome editing**

  https://www.nature.com/articles/nprot.2013.143

- **Synthetic Biology**

  https://www.sciencedirect.com/science/article/abs/pii/S0734975019301466

  https://www.sciencedirect.com/science/article/abs/pii/S0734975019301521

BT 317L Advances in Biotechnology Lab

Max. Marks : 100	**L**	**T**	**P**	**C**
(CA: 40 + ESA: 60)	**0**	**0**	**4**	**2**

Learning Outcomes:

After successful completion of the course, students should be able to:

- develop the skills in the experimental part of advanced biotechnology
- understand the advanced biotechnology by easy to run experiments such as DNA isolation, restriction digestion, electrophoresis, PCR etc
- apply acquired skills of nanotechnological techniques in the field of biotechnology

1. Isolation and quantification of plasmid DNA from *E.coli*.
2. Restriction digestion of the DNA.
3. Agarose gel electrophoresis for analysis of DNA.
4. Preparation of competent *E.coli.* cells.
5. Demonstration of PCR.
6. To prepare the melting curve of DNA.
7. To find out absorption spectrum of the oxidized and reduced form of a molecular species (NAD and NADH).
8. Synthesis of nanoparticles (iron).

9. To study the effect of synthesized nanoparticles on mung seeds germination.
10. Demonstration of DNA quantification using NANO-DROP.

Suggested Books:

- Saxena, J., Baunthiyal., and Ravi, I. (2015). *Laboratory Manual of Microbiology, Biochemistry and Molecular Biology*. Jodhpur: Scientific Publishers.
- Sharma, R.K., and Sangha, S.P.S. (2009). *Basic Techniques in Biochemistry and Molecular Biology*. New Delhi: I.K. International Publisher.
- Swamy, P.M. (2008). *Laboratory Manual on Biotechnology* (1st ed.). Meerut: Rastogi Publication.
- Vats, S. (2015). *A laboratory Text book of Biochemistry, Molecular Biology and Microbiology*. Germany: GRIN Verlag.

BT 318 Genomics and Proteomics

Max. Marks : 100	**L**	**T**	**P**	**C**
(CA: 40 + ESA: 60)	**6**	**0**	**0**	**6**

Learning outcomes:

After successful completion of the course, students should be able to:

- develop an understanding of basic principles of functional genomics
- learn the usage of different techniques in the field of genomics and proteomics
- explain different applications of genomics and proteomics

Unit 1:

- Introduction to Genomics, origin of genomes. Acquisition of new genes. DNA sequencing methods: Maxam-Gilbert and Sanger's method.
- Genome Sequencing: Shotgun and Hierarchical (clone contigs) methods. Restriction mapping. DNA and RNA fingerprinting. DNA footprinting.
- Basic concept of Gene networks.

Unit 2:

- Prediction of genes, promoters, splices sites, regulatory regions: basic principles, application of methods to prokaryotic and eukaryotic genomes.
- Concept of DNA microarray.
- Managing and Distributing Genome Data: Web based servers and softwares for genome analysis: ENSEMBL, UCSC Genome Browser, NCBI genome.

Unit 3:

- Genome assembly and annotation. Genome databases of plants, animals and pathogens.
- Introduction to protein structure. Determination of sizes (Sedimentation analysis, gel filteration, SDS-PAGE); Native PAGE, determination of covalent structures –Edman degradation.
- Introduction to Proteomics. 2D-PAGE. Sample preparation, solubilization, reduction, and resolution.

Unit 4:

- Reproducibility of 2D-PAGE. Mass spectrometry based methods (MALDI – TOF, electospray ionization coupled tandem Mass spectrometry, and triple quadrupole mass analyzer) for protein identification.
- *De novo* sequencing using mass spectrometric data.
- Applications of proteomics.

Unit 5:

- Modeling of three-dimensional structure of a protein from amino acid sequence.
- Evaluating protein structure.
- Protein-protein interactions: databases such as MIPS, STRINGS, PPI server and tools for analysis of protein-protein interactions.

Suggested Readings

- Brown, S.M. (2015). *Next-generation DNA sequencing Informatics* (2nd ed.). Cold Spring Harbor, NY: Cold Spring Harbor Laboratory Press.

- Lesk, A.M. (2015). *Introduction to Genomics* (2nd ed.). Oxford, UK: Oxford University Press.
- Liebler, D.C. (2001). *Introduction to proteomics tools for the new biology*. US: Humana Press.
- Pennington, S. R. and Dunn, M. J. (Eds.). (2000). *Proteomics: From protein sequence to function*. Oxford, UK: Bios Scientific Pub Ltd.
- Pevsner, J. (2017). *Bioinformatics and Functional Genomics* (3rd ed.). New Jersey, USA: John Wiley and Sons Ltd.
- Primrose, S.B. (1987). *Modern Biotechnology*. 2nd Edition, Blackwell Publishing.
- Thangadurai, D. and Sangeetha, J. (2015). *Genomics and Proteomics: Principles, Technologies, and Applications*. USA: CRC Press.
- Twyman, R.M. (2004). *Principles of Proteomics*. New Delhi, India: CBS Publishers.

Suggested e- Resources:

- **Proteomics**

  https://nptel.ac.in/courses/102101055/4

- **Genomics**

  https://edu.t-bio.info/learn-to-analyze-omics-data/

BT 318L Genomics and Proteomics Lab

Max. Marks : 100	**L**	**T**	**P**	**C**
(CA: 40 + ESA: 60)	**0**	**0**	**4**	**2**

Learning outcomes:

After successful completion of the course, students should be able to:

- develop understanding of various tools and databases for genomics and proteomic studies
- perform computational analysis of genomes
- perform proteome analysis

1. Accessing UCSC Genome browser and ENSEMBL genome browser.
2. Use of SNP, OMIM databases.
3. Detection of Open Reading Frames using ORF Finder.
4. The 2-D PAGE database.
5. Construction and Analysis of biological networks (Gene-gene interactions, Protein-protein interactions).
6. Hydropathy plots.

7. To perform a native-PAGE.
8. To perform a SDS-PAGE.
9. To perform Ion exchange chromatography.
10. Sample preparation for 2D-PAGE.

Suggested Books:

- Twyman, R.M. (2004). *Principles of Proteomics*. New Delhi, India: CBS Publishers.

BT 319 Medical Biotechnology

Max. Marks : 100	**L**	**T**	**P**	**C**
(CA: 40 + ESA: 60)	**6**	**0**	**0**	**6**

Learning outcomes:

After successful completion of the course, students should be able to:

- understand various diagnostic techniques used in medical biotechnology
- gain knowledge about gene therapy and regenerative medicine techniques used for the treatment of diseases
- learn the applications of stem cells and tissue engineering

Unit 1

- An overview of medical biotechnology.
- Diagnosis using protein and enzyme markers, monoclonal antibodies: ELISA, DNA/RNA based diagnosis; Hepatitis, SARS-CoV-2, and HIV-CD 4 receptor.
- Karyotyping of human chromosomes and pedigree analysis. Chromosome banding: G banding and R-banding technique.

Unit 2

- Microarray technology: genomic and cDNA arrays; application to diseases.
- Prenatal diagnosis, invasive techniques: Amniocentesis, fetoscopy, and chorionic villi sampling (CVS).
- Noninvasive techniques: Ultrasonography, X-ray, maternal serum and fetal cells in maternal blood.

Unit 3

- Gene therapy: *Ex-vivo, in vivo, in situ* gene therapy, vectors used in gene therapy: viral (retroviruses, adenoviruses, and adeno-associated viruses) and non-viral vectors.

- Gene therapy trials, familial hypercholesterolemia, cystic fibrosis, and solid tumors. Strategies of gene therapy: gene augmentation–ADA deficiency; Prodrug therapy/ suicide gene – glioma.
- Synthetic therapy: Brief idea of synthetic DNAs, therapeutic ribozymes, synthetic drugs.

Unit 4

- Production of insulin and erythropoietin using recombinant DNA technology.
- Animal cell products: Growth factors, interferons, enzymes, recombinant proteins, hormones, monoclonal antibodies and vaccines.
- DNA based vaccines, subunit vaccines: Herpes simplex virus, recombinant attenuated vaccines– Cholera.

Unit 5

- Nanomedicine, drug designing, drug delivery (Conventional and new approaches) and drug targeting.
- Stem cell (Mesenchymal stem cell, adult stem cells and embryonic stem cells) and their therapeutic applications.
- Tissue engineering (Use of cells, scaffolds and biomaterials) in bone, cartilage and skin regeneration.

Suggested Books

- Aschengrau, A., and Seage, G. R. (2014). *Essentials of epidemiology in public health*.
- Bongso, Ariff. and Lee, EngHin. (2005). *Stem cells: from bench to bedside*. Singapore: World Scientific Publishing.
- George, A.J., and Urch, C.E. (Eds.). (2000). *Diagnostic and therapeutic antibodies* (Vol. 40). Springer Science and Business Media.
- Pagano, M., and Gauvreau, K. (2000). *Principles of biostatistics*. Australia: Duxbury.
- Strachan, T., Read, A.P., and Strachan, T. (2011). *Human molecular genetics*. New York: Garland Science.

Suggested e- Resources:

- **Prenatal Diagnosis**
  http://semmelweis.hu/noi1/files/2017/02/Prenatal-diagnostic-methods.pdf

https://www.health.wa.gov.au/docreg/Education/Prevention/Genetics/HP3131_prenatal.pdf

- **Gene Therapy**
  https://nptel.ac.in/courses/102103013/pdf/mod8.pdf
  http://uniqure.com/patients/Gene-Therapy-Information.pdf
- **Nanomedicine**
  https://noharm-europe.org/sites/default/files/documents-files/2462/HCWH%20Europe%20Nanoreport.pdf
- **Stem cells and Tissue Engineering**
  https://nptel.ac.in/content/storage2/nptel_data3/html/mhrd/ict/text/113108071/lec18.pdf
  https://nptel.ac.in/courses/102106036/

BT 319L Medical Biotechnology Lab

Max. Marks : 100	**L**	**T**	**P**	**C**
(CA: 40 + ESA: 60)	**0**	**0**	**4**	**2**

Learning outcomes:

After successful completion of the course, students should be able to:

- develop the practical understanding of various diagnostic techniques used in medical biotechnology
- learn various tools and techniques of animal cell culture
- apply the gained knowledge to initiate a start-up venture in the field of medical biotechnology

1. Introduction to animal cell culture techniques.
2. Karyotyping of normal and abnormal human chromosome sets.
3. Human pedigree analysis.
4. Study of preparation of nanoparticle and coating.
5. To perform Dot ELISA.
6. Estimation of glucose and ketone bodies using diagnostic kits.
7. Detection of pregnancy using kit.
8. Estimation of progesterone using ELISA kit.
9. Genotyping by RFLP.
10. Blood group and Rh factor determination by slide agglutination test.

Suggested Books:

- George, A. J., and Urch, C. E. (Eds.). (2000). *Diagnostic and therapeutic antibodies* (Vol. 40). Springer Science and Business Media.
- Strachan, T., Read, A. P., and Strachan, T. (2011). *Human molecular genetics*. New York: Garland Science.

Suggested e-Resources:

- https://nptel.ac.in/content/storage2/nptel_data3/html/mhrd/ict/text/102107028/lec41.pdf
- https://nptel.ac.in/content/storage2/courses/102103012/pdf/mod2.pdf

BOT 306 Angiosperms: Morphology, Anatomy and Embryology

Max. Marks : 100	**L**	**T**	**P**	**C**
(CA: 40 + ESA: 60)	**6**	**0**	**0**	**6**

Learning outcomes:

After successful completion of the course, students should be able to:

- understand structure and functions of plant cells and tissues
- identify and compare structural differences among different taxa of vascular plants with ecological adaptations
- gain fundamental knowledge of plant embryology

Unit-I

- Habit and habitat of plants.
- Characteristics functions and types of root system: Modification for storage, support and vital functions: (Respiratory, Photosynthetic, Haustorial and Epipyhtic).
- Stem: Characteristics and functions, types of underground, aerial and sub-aerial and modifications.
- Leaf: Structure and functions, types of leaves, phyllotaxy, venation, modifications in leaves.
- Types of inflorescence (in brief), flower parts, types of aestivation, types of placentation.
- Fruits: Structure and types (in brief).

Unit-2

- Angiosperm tissues types: structure and function of meristematic and permanent tissues, simple, complex and secretory tissue.
- Root and shoot apex organization, apical cell theory, histogen theory, tunica-carpous theory, korper-kappe theory, concept of Quiscent zone.
- Anatomy of dicot and monocot, root and stem.
- Secondary growth in dicot root and stem.
- Anomalous secondary growth in stem/roots: *Boerhaavia, Bignonia, Salvadora, Nycatanthes, Dracaena* and *Aristolochia.*

Unit-3

- Ecological Anatomy: General adaptations of hydrophytes, xerophytes and halophytes.
- Anatomical adaptations of Hydrophytes: *Hydrilla,* and *Nymphaea.*
- Anatomical adaptation of Xerophytes: *Calotropis, Nerium,* and *Capparis.*
- Halophytes: Mangrove plants- *Rhizophora.*

Unit-4

- Angiosperm Embryology: Structure and development of male gametophyte and ovule.
- Monosporic, bisporic and tetrasporic types of embryo sacs (one example each of *Polygonum, Allium* and *Adoxa*).
- Pollination, fertilization, sexual incompatibility, embryo development (monocot and dicot), and Polyembryony.

Unit-5

- Experimental Embryology: Apomixis, Agamospermy and Apospory, Parthenocarpy.
- Adventive embryony.
- Control of fertilization.
- Endosperm and embryo development.

Suggested Books:

- Bhojwani, S.S. and Bhatnagar (1979). *Embryology of Angiosperms*. Vikas Publications.
- Bhojwani, S.S. and Razdan, M.K. (1996) *Plant Tissue Culture*.
- Bhojwani, S.S., Bhatnagar, S.P., and Dantu, P.K. (2014). *The embryology of Angiosperms* (6th ed.). Vikas Publishing House Pvt. Ltd.

- Eames, A.J. (1961). *Morphology of the Angiosperms*. New York: McGraw Hill.
- Eames, A.J., and MacDaniels, L.H. (1947). *Introduction to Plant Anatomy*. New York: McGraw Hill.
- Fahn, A. (1997). *Plant Anatomy*. New Delhi: Aditya Books (Pvt) Ltd.
- Kumar, V. (2011). *Methods in Plant tissue culture* (3rd ed.). Jodhpur: Agrobios.
- Maheswari, P. (1950). *Introduction To The Embryology Of Angiosperms*. New York: McGraw Hills.
- Pandey, B.P. (2018). *A Text Book of Botany: Angiosperms Taxonomy, Anatomy and embryology*. New Delhi: S Chand and Company Ltd.
- Pandey, S.N., and Chadha, A. (2007). *Plant Anatomy And Embryology*. New Delhi: UBS publishers and distributors Pvt. Ltd.
- Razdan, M.K. (2018). *Introduction To Plant Tissue Culture*. New Delhi: CBS Publishers and Distributors Pvt. Ltd.
- Tayal, M.S. (2004). *Plant Anatomy*. Meerut: Rastogi Publication.

Suggested e-Resources:

- **Plant tissues types, structure and functions**

  http://edudel.nic.in/PAHAL/biology_260309/biology_dt_270309.pdf

  http://lib.du.ac.ir/documents/10157/60298/Anatomy+of+Flowering+Plants.pdf

- **Secondary anomalous structures**

  http://www.biologydiscussion.com/anatomy/anatomy-of-anomalous-dicot-stems-botany/56969

- **General account of angiosperms**

  http://www.nhptv.org/natureworks/nwep14f.htm

- **Secondary growth**

  http://egyankosh.ac.in/bitstream/123456789/16401/1/Unit-10.pdf

- **Embryology of angiosperms**

  krishikosh.egranth.ac.in/bitstream/1/2023583/1/BPT10611.pdf

BOT 306L Angiosperms: Morphology, Anatomy and Embryology Lab

Max. Marks : 100	**L**	**T**	**P**	**C**
(CA: 40 + ESA: 60)	**0**	**0**	**4**	**2**

Learning outcomes:

After successful completion of the course, students should be able to:

- gain practical knowledge of identification and characterization of morphological and anatomical structures of angiospermic plants
- understand different types of anomalous secondary growth and anatomical differences in plants with ecological adaptations with the help of slides preparation and study
- gain fundamental knowledge of plant embryology by studying models and permanent slides

1. Study of habit and habitat of plants.
2. Study of modified angiospermic plant parts.
3. Study of inflorescence types.
4. Study of fruit types.
5. Anatomical studies of dicot and monocot's roots and stems.
6. Anamolous secondary growth in stem/root of angiosperms (*Boerhaavia, Bignonia, Salvadora, Aristolochia, Nyctanthes* and *Dracaena*).
7. Vegetative structure of hydrophytes and xerophytes (ecological anatomy of *Calotropis, Capparis, Nerium, Hydrilla* and *Nymphaea*).
8. Slides and models on embryology.

Suggested Books:

- Bendre, A., and Kumar, A. (2010). *A Textbook of Practical Botany*- II. Meerut: Rastogi Publications.

BOT 309 Plant Physiology

Max. Marks : 100	**L**	**T**	**P**	**C**
(CA: 40 + ESA: 60)	**6**	**0**	**0**	**6**

Learning Outcomes:

After successful completion of the course, students should be able to:

- comprehend about life processes of plants and their adaptation in various stress conditions
- understand the various plant growth hormones and their significance
- gain in-depth knowledge of biochemical mechanisms of various metabolic pathways

Unit 1

- Plant water relations: Importance of water to plant life; movement of water across the membranes.
- Ascent of sap; transpiration.
- Mineral nutrition: Methods to study the availability of macro and micro elements, uptake and roles of mineral elements.

Unit 2

- Translocation of organic substances: General principle and mechanism.
- Photosynthesis: Structure of chloroplast, and photosynthetic pigments.
- Mechanism of photosynthesis, Light reaction: Noncyclic and cyclic photophosphorylation.
- Carbon dioxide assimilation in dark reactions, C3 and C4 plants, photorespiration.

Unit 3

- Respiration: Aerobic and anaerobic respiration. Respiratory quotient, factors affecting respiration.
- Seed germination and dormancy.
- Plant movements.

Unit 4

- Plant growth regulators:- Auxins, gibberellins, cytokinins, ethylene and abscissic acid, their physiological importance.
- Flowering: Photoperiodism.

- Vernalization.

Unit 5

- Nitrogen cycle: ammonification, nitrification and denitrfication.
- Nitrogen fixation: symbiotic and non-symbiotic.
- Assimilation of nitrate and ammonia.

Suggested Books:

- Dutta, S.C. (2012). *Plant Physiology*. New Delhi: New age International Publishers.
- Hopkins, W.G., and Huner, N.P.A. (2008). *Introduction to Plant Physiology*. New Jersey: John Wiley and Sons Inc.
- Jain V. K., (2018) Fundamentals of Plant Physiology. New Delhi S. Chand and company limited.
- Narst, V., Devlin and Witham. (1974) *Plant Physiology*. New Delhi: East West Press.
- Noggle, G.R., and Fritz, G.J. (1992). *Introductory Plant Physiology*. New Delhi: Prentice Hall of India.
- Pandey, S.N., and Sinha, B.K. (2015). *Plant Physiology*. New Delhi: Vikas Publishing House.
- Salisbury and Ross. (2012). *Plant Physiology*. New Delhi: Prentice Hall of India.
- Srivastava, H.S. (2005). *Plant Physiology*: Meerut: Rastogi Publications.
- Stiles, W. (2006). Principals of Plant Physiology, Discovering Publishing House.
- Taiz, L., and Zeiger, E. (2010). *Plant Physiology*. London: Sinauer Associates.
- Verma V. Text book of Plant Physiology. Ane's student edition.

Suggested e- Resources:

- **Plant Physiology**

  https://www.udemy.com/plant-physiology/?siteID=zOCYiUhWwNM-1RExiYvhsJfnMd_rZR_ivgandLSNPUBID=zOCYiUhWwNM

BOT 309L Plant Physiology Lab

Max. Marks : 100	**L**	**T**	**P**	**C**
(CA: 40 + ESA: 60)	**0**	**0**	**4**	**2**

Learning Outcomes:

After successful completion of the course, students should be able to:

- understand the physiological details of plant photosynthesis and respiration
- design the experiments, collect and critically evaluate data related to plant physiology
- gain basic skills of laboratory practices and field studies

1. Osmosis
   a. To demonstrate the process of imbibitions by using raisins.
   b. To demonstrate osmosis in living plant cells by potato osmoscope.
   c. To demonstrate the process of plasmolysis in onion cells.
2. Root pressure
   a. To demonstrate root pressure in plants.
   b. To demonstrate that ascent of sap takes place by xylem (ringing experiment).
3. Transpiration
   a. Ganong's potometer and Farmer's photometer.
   b. Unequal transpiration from two surfaces of a leaf
      i. Cobalt chloride paper method.
      ii. Four leaf method with greased surface.
   c. Demonstration of water lifting power of transpiration (suction force).
   d. Study of stomata
4. Photosynthesis
   a. Separation of plant pigments (chlorophyll) by chromatography.
   b. To demonstrate that oxygen is liberated in the process of photosynthesis.
   c. To demonstrate that light and CO_2 are essential for photosynthesis (Moll's half leaf experiment).
   d. To demonstrate that Chlorophyll is necessary for photosynthesis.
5. Respiration

a. To demonstrate that some energy is released in the form of heat during respiration.
b. To demonstrate that CO_2 is produced during respiration.
c. To demonstrate anaerobic respiration.
d. To determine the Respiratory quotient (R.Q) of different types of respiratory substrates (starch, proteins and fats).

6. Plant Movement
   a. To determine following types of movements**:**
      I. Phototropism
      II. Geotropism

Suggested Books:

- Bendre, A., and Kumar, A. (2010). *A Textbook of Practical Botany- II.* Meerut: Rastogi Publications.

BOT 308 Plant Pathology

Max. Marks : 100	**L**	**T**	**P**	**C**
(CA: 40 + ESA: 60)	**6**	**0**	**0**	**6**

Learning Outcomes:

After successful completion of the course, students should be able to:

- understand the concept of pathogenesis, disease cycles and the role of various factors impacting pathogenecity
- gain knowledge of plant resistance development towards pathogens
- identify the disease symptoms and control measures for plant diseases

Unit 1

- History of plant pathology and geographical distribution of plant diseases.
- Types of plant pathogens, host pathogen relationship.
- Concept of plant disease-definitions of disease, disease cycle, pathogenticity and symptoms.
- Stages in disease development, plant disease epidemiology, role of environment in disease cycle.

Unit 2

- Concepts of constitutive defense mechanisms in plants.

- Concepts of inducible structural defenses (histological-cork layer, abscission layer, tyloses, and gums), inducible biochemical defenses [hypersensitive response (HR), systemic acquired resistance (SAR), phytoalexins, pathogenesis related (PR) proteins, plantibodies, phenolics, quinones, and oxidative bursts].

Unit 3

- Bacterial diseases: General symptoms and types of bacterial diseases.
  (i) Soft rot of vegetable
  (ii) Stewart's wilt of maize
  (iii) Brown rot of potato
  (iv) Citrus canker
  (v) Common scab of potato

Unit 4

- Fungal diseases: General symptoms and disease cycle.
  (i) Wart disease of potato
  (ii) Black rust
  (iii) Smut - Wheat
  (iv) White rust of crucifers
  (v) Early blight of potato

Unit 5

- Viral diseases: General symptoms, survival and transmission of plant viruses.
  (i) Tungro disease of rice
  (ii) Tobacco Mosaic disease
  (iii) Yellow vein Mosaic of Bhindi
- Diseases caused by parasitic higher plant: Dodder, Dwarf mistletoe of conifers and Kudzu vine.
- Control of plant disease: Physical, chemical, and biological.

Suggested Books:

- Agrios, G.N. (2005). *Plant Pathology* (5th ed.). Elsevier Science.
- Biswas, S.B. (2009). *An Introduction to Viruses*. New Delhi: Vani Education.
- Butler, E.J. *Plant Pathology- Fungi and Diseases in Plants.* Kolkata: Thanker Spink and Co.

- Dubey, H.C. (2013). *Introduction to Fungi.* Jodhpur: Scientific Publishers.
- Dubey, R.C., and Maheshwari, D.K. (2008). *A Text book of Microbiology*. New Delhi: S. Chand and Company.
- Mehrotra R.S. (2006). *Plant Pathology*. New Delhi: Tata McGraw-Hill.
- Sharma, P.D. (2016). *Microbiology and Plant Pathology*. Meerut: Rastogi Publications
- Sharma, P.D. (2017). *Plant Pathology*. Meerut: Rastogi Publications
- Singh, R.S. (2013). *Plant Disease*. New Delhi: Oxford and IBH.

Suggested e- Resources:

- **Plant diseases: Identification and control**
  https://www.planetnatural.com/pest-problem-solver/plant-disease/

BOT 308L Plant Pathology Lab

Max. Marks : 100	**L**	**T**	**P**	**C**
(CA: 40 + ESA: 60)	**0**	**0**	**4**	**2**

Learning Outcomes:

After successful completion of the course, students should be able to:

- perform isolation of various plant pathogens for study
- identification of plant diseases and disease symptoms
- develop an understanding of pathogenesis in plants through slides and other assays

1. Study of bacterial and viral diseases of plants mentioned in the syllabus with help of specimens and charts.
2. Study of fungal and nematode diseases in plants mentioned in the syllabus by museum specimens.
3. Screening for antagonistic activity of *Trichoderma* against *Aspergillus* and *Fusarium* strains.
4. Isolation of fungal pathogen from infected plant part.
5. Isolation of bacterial pathogen from infected plant part.
6. Preparation of temporary mount of
   a) *Alternaria solani* (early blight of potato)
   b) *Ustilago tritici* (loose smut of wheat)

7. Induction of pathogenesis in mung seedlings by *Macrophomina phaseolina* and study of pathogenesis through temporary slides.
8. Extraction of cellulase from diseased plant and its estimation.
9. Comparative of uninfected and infected plant on the basis of polyphenol/salicylic acid content.

Suggested Books:

- Aneja, K.R. (2003). *Experiments in microbiology, plant pathology and biotechnology*. New Age International Publishers.

BOT 307 Economic Botany and Ethnobotany

Max. Marks : 100	**L**	**T**	**P**	**C**
(CA: 40 + ESA: 60)	**6**	**0**	**0**	**6**

Learning outcomes:

After successful completion of the course, students should be able to:

- gain awareness about importance of traditional and modern uses of native flora
- understand the distribution and life style of ethnic plant groups in India along with their applications
- gain an understanding of commercial products such as beverages, herbs and spices derived from plants and its economic value

Unit 1: Ethnobotany

- Introduction, concept, scope and objectives of ethnobotany.
- The relevance of ethnobotany in the present context.
- Major and minor ethnic groups, tribals of India and their life styles.
- Plants of mythological and religious.
- Plants mentioned in folklore and folk songs.

Unit 2: Ethnobotanical uses

- Plants as totems, taboos and superstition.
- Major centers of ethnobotany in India.
- Ethnobotany as a tool to protect interests of ethnic groups. Sharing of wealth concept with few examples from India.
- Biopiracy, Intellectual property rights and traditional knowledge.

Unit 3: Role of ethnobotany in modern medicine

- Medico-ethnobotanical sources in India; Significance of the following plants in ethno botanical practices (along with their habitat and morphology): (a) *Azadirachta indica* (b) *Ocimum sanctum* (c) *Vitex negundo* (d) *Gloriosa superba* (e) *Tribulus terrestris* (f) *Pongamia pinnata* (g) *Cassia auriculata* (h) *Indigofera tinctoria*.
- Role of ethnic groups in conservation of plant genetic resources.
- The relevance of ethnobotany in the present context.

Unit 4: Economic Botany

- Origin of cultivated plants, concept of centres of origin, and their importance.
- Cereals: Wheat, maize, and bajra -Origin, morphology, and uses.
- Legumes: General account with special reference to gram and soybean.
- Spices: General account with special reference to coriander, turmeric, chillies, fennel, green cardamom, *Asafoetida*, cumin clove and black pepper (Botanical name, family, part used, morphology and uses).

Unit 5:

- Beverages: Tea and coffee.
- Oils and fats: General description with special reference to Mustard, groundnut and coconut.
- Fibre yielding plants: General description with special reference to Cotton, Coir and Jute.
- Drug plants: *Cinchona, Rauwolfia,* and *Papaver.*
- Timber plants: *Tectona, Dalbergia,* and *Pinus.*
- Rubber: *Hevea brasiliensis.*

Suggested Readings

- Alam, A., and Sharma, V. (2012). *Economic Botany*. Jaipur: Pointer Publishers.
- Colton C.M. (1997). *Ethnobotany – Principles and applications*. John Wiley and sons, Chichester
- Sharma, V., and Alam, A. (2017). *Ethnobotany*. Rastogi Publishing House, Meerut
- Faulks, P.J. (1958). *An introduction to Ethnobotany*. Moredale pub. Ltd.

- Jain S.K. (1990). *Contributions of Indian ethnobotany*. Scientific publishers, Jodhpur.
- Jain S.K. (1995). *Glimpses of Indian. Ethnobotny*, Oxford and I B H, New Delhi – 1981
- Jain S.K. (1995). *Manual of Ethnobotany*, Scientific Publishers, Jodhpur, 1995.
- Jain S.K. (ed.) (1989). *Methods and Approaches in Ethnobotany*. Society of ethnobotanists, Lucknow, India.
- Kochhar, S.L. (2016). *Economic Botany of the Tropics*. London: Macmillan India Limited
- Kumar, A., and Bendra, A. (1983). *Economic Botany: for university students*. Meerut: Rastogi Publications.
- Rajiv K. Sinha (1996). *Ethnobotany The Renaissance of Traditional Herbal Medicine* – INA –SHREE Publishers, Jaipur
- Rama Ro, N and Henry, A.N. (1996). *The Ethnobotany of Eastern Ghats in Andhra Pradesh, India*. Botanical Survey of India. Howrah.
- Verma, V. (2010). *A text book of economic botany.* New Delhi: Emkay publications.

Suggested e- Resources:

- **Economic botany**

  http://nsdl.niscair.res.in/jspui/bitstream/123456789/130/1/beverages.pdf

  http://botanicaldimensions.org/what-is-ethnobotany/

  https://www.plantsnap.com/blog/casual-ethnobotany/

  https://trove.nla.gov.au/work/36470887?selectedversion=NBD44743330

BOT 307L Economic Botany and Ethnobotany Lab

Max. Marks : 100	**L**	**T**	**P**	**C**
(CA: 40 + ESA: 60)	**0**	**0**	**4**	**2**

Learning outcomes:

After successful completion of the course, students should be able to:

- identify and collect plants of ethnic importance from the local regions
- gain basic skills of herbarium preparation
- identify and study economically important plant and their products along with their usefulness

Ethnobotany

1. Study of wild plants of different families at taxonomical level.
2. Collection of locally growing plants of ethnic importance.
3. Herbarium preparation.
4. Study of ethnic groups through photographs and available literature.
5. Preparation of plants' extract.
6. Analysis of phytochemicals.

Economic Botany

7. Study of economically important plant products as mentioned in the syllabus.
8. Cereals: Wheat, Maize, and Bajra; Legumes: Gram and soybean.
9. Spices: Coriander, Turmeric, Chillies, Fennel, Green cardamom *Asafoetida*, Cumin clove and black pepper.
10. Beverages: Tea and coffee. Oils and fats: Mustard, groundnut and coconut.
11. Fibre plants: Cotton, coir and jute. Drug plants: *Cinchona, Rauwolfia* and *Papaver*. Timber plants: *Tectona, Dalbergia,* and *Pinus*.

Suggested Books:

- Alam, A., and Sharma, V. (2012). *Economic Botany*. Jaipur: Pointer Publishers.
- Colton C.M. (1997). *Ethnobotany – Principles and applications*. John Wiley and sons, Chichester
- Jain S.K. (1995). *Manual of Ethnobotany*, Scientific Publishers, Jodhpur, 1995.

BOT 305 Horticulture

Max. Marks : 100	**L**	**T**	**P**	**C**
(CA: 40 + ESA: 60)	**6**	**0**	**0**	**6**

Learning outcomes:

After successful completion of the course, students should be able to:

- develop skills in the basic and advanced techniques of plant propagation
- gain fundamental knowledge of various aspects of green house technology
- understand commercially important plants and their cultivation techniques

Unit 1

- Basic horticultural techniques (soil preparation, bed preparation, transplantation and pruning).
- Vegetative propagation of plants (a) cutting (b) grafting (c) budding (d) layering (e) other special structures.

Unit 2

- Soil less culture (hydroponic, and aeroponics).
- Application of coco peat, perlite, vermiculite and peat moss in horticultural practices.
- Indoor and outdoor plants.
- Bonsai: Types, forms, structure and styles.

Unit 3

- Greenhouse technology: Importance, types and operation techniques.
- Commercial uses of green house technology.
- Benefits and risks associated with green house technology.

Unit 4

- Commercial cultivation of cut flowers (Roses, gerberas and carnations).
- Study of foliage plants (*Ficus,* croton and coleus).
- Study of one locally available vegetables (root, leafy, and cole crops).

Unit 5

- Study of tropical fruits (Mango, amla, and date palm).

- Study of temperate fruits (Apple).
- Commercial cultivation of exotic fruits.

Suggested Books

- Ankur: (Magazine).
- Bajaj, Y.P.S. and Narosa. *Biotechnology in agriculture and forestry*.
- Chalam, Venkateshwarlu, G.V.I. *Introduction to Agricultural Botany in India*. Asia Publishing House, New Delhi.
- Hartmann and Kester. *Plant Propagation*.
- Jain, S.K. and Rao, R.R. *A Hand book of Field and Herbarium Methods*. Today and Tomorrow's Printers and Publications, New Delhi.
- Sandhu, M.K. *Plant Propagation*.

Suggested e- Resources:

https://icar.org.in/content/horticultural_division

http://tnhorticulture.tn.gov.in/horti/

https://www.onionseek.com/in/search/web/?pk=nQMhNzQd8g9IZLslSBEH6gandq=Online%20Horticulture%20Degree%20Programandid_event=5cc7d0693778ea7e85ea4bc6

https://www.longdom.org/horticulture.html

BOT 305L Horticulture Lab

Max. Marks : 100	**L**	**T**	**P**	**C**
(CA: 40 + ESA: 60)	**0**	**0**	**4**	**2**

Learning outcomes:

After successful completion of the course, students should be able to:

- explore the commercial cultivation practices of vegetables and plants
- apply acquired knowledge for compost preparation and its use for crop improvement
- propagate, grow and maintain plants through vegetative propagation

1. Layout of kitchen garden.
2. Vegetative propagation by cutting and grafting.

3. Herbarium preparation.
4. Vegetative propagation by budding and layering (Gootee).
5. To perform emasculation and hybridization.
6. Preparation of compost.

Suggested Books

- Chadha, K.L. 2019. *Handbook of Horticulture*. ICAR Publications, Govt. Of India.
- Gupta, S. N. 2018. *Instant Horticulture*. Jain Brothers, India
- Singh, J. 2018. *Fundamentals of Horticulture*. Kalyani Publishers, India
- Muthukumar, P. 2013. *Glaustas Horticulture*. New Vishal Publications, India
- Raj, D. 2017. *Floriculture At A Glance*. Kalyani Publishers, India

Suggested e- Resources:

- http://www.agrimoon.com/horticulture-icar-ecourse-pdf-books/
- https://www.scribd.com/doc/4678612/Handbook-of-Horticulture

ZOO 306 Animal Physiology

Max. Marks : 100	**L**	**T**	**P**	**C**
(CA: 40 + ESA: 60)	**6**	**0**	**0**	**6**

Learning Outcomes:

After successful completion of the course, students should be able to:

- acquire in-depth knowledge of structure and functions of various physiological systems of human
- apply the gained knowledge for research work in the field of animal sciences
- understand the mechanism of thermoregulation

Unit 1

- Physiology of digestion: Various kinds of digestive enzymes (carbohydrases, proteinases and lipases) and their digestive action to corresponding food stuffs in the alimentary canal of mammals; hormonal control of digestive functions; mechanism of absorption

of various end-products of digestion and other materials such as vitamins, minerals and trace elements.

- Physiology of respiration in mammals: Mechanism and control of breathing; transport of oxygen and carbon dioxide; oxygen dissociation curves of hemoglobin, Bohr effect, chloride shift, Haldane effect, lung volumes and capacities, regulation of respiration, and respiration at cellular level.

Unit 2

- Physiology of excretion: Kinds of nitrogenous excretory products, structure of kidney, role of liver in the formation of urea; composition and formation of urine; role of hormones in urine formation; micturition.
- Physiology of vascular system: Composition and functions of blood; lymph and lymphatic system; blood groups, Rh factor; platelet plug formation; blood clotting mechanism and its significance; structure and functions of hemoglobin. Blood pressure and its regulation; origin, conduction and regulation of heart beat; nervous and hormonal regulation of heart beat; cardiac cycle.

Unit 3

- Physiology of muscle contraction: Functional architecture of smooth, skeletal and cardiac muscles; mechanism of muscle contractions (skeletal muscle). Fuel for muscle contraction, mechanical properties of muscle: simple muscle twitch; wave summation, tetanus and muscle fatigue.
- Physiology of nerve impulse and reflex action: Functional architecture and classification of neuron; nature, origin and propagation of nerve impulse along a neuron (myelinated and unmyelinated), synapse; reflex arc, reflex action and its central control.

Unit 4

- Thermoregulation: Heat balance in animals, Adaptations to temperature extremes, torpor, aestivation and hibernation, counter and current heat exchangers.
- Physiology of sensory organs: Eye-Retinal components, photoreceptors, mechanism of image formation. Ear-Cochlea,

basilar membrane, and organ of corti, mechanism of hearing and equilibrium.

Unit 5

- Physiology of endocrine glands: Structure and functions of hypothalamus; pituitary; thyroid; parathyroid; adrenal and pancreas.
- An elementary idea about neuro-secretion.
- Physiology of reproduction: Structure and physiology of human male and female reproductive system; reproductive cycles- estrous and menstrual cycle.
- Hormonal regulation of ovulation, fertilization, implantation, abortion, gestation, parturition and lactation.

Suggested Books:

- Chaterjee, C.C. (2005). *Human Physiology* Vol-II (11thed.).
- Chaterjee, C.C. (2018). *Human Physiology* Vol-I (12thed.). New Delhi: CBS Publishers and Distributors.
- Guyton, A.C. and Hall, J.E. (2015). *Textbook of Medical Physiology* (13thed.). USA: Saunders.
- Jurd, R.D. (2003). *Instant notes in Animal Biology*. New Delhi: Viva Books Pvt. Ltd.
- Kumar, N. (2016). *Animal Physiology*. Jaipur: RSBA Publishers.
- Pandey, K. and Shukla, J.P. (2005). *Regulatory Mechanism in Vertebrates*. Meerut: Rastogi Publications.
- Randall, D., Burggren, W., and French, K. (2001). *Eckert Animal Physiology* (5thed.). W. H. Freeman.
- Roy, R.N. (2018). *Textbook of Physiology: with Biochemistry and Biophysics* Vol-I. Kolkata: New Central Book Agency.
- Tortora, G.J. and Grabowski. (2003). *Principles of Anatomy and Physiology* (10thed.). New Jersey, USA: John Wiley and Sons.
- Verma, P.S., Tyagi, B.S. and Agarwal, V.K. (2000). *Animal Physiology*. New Delhi: S. Chand publisher.

Suggested e-Resources:

- **Digestive system**

https://www2.estrellamountain.edu/faculty/farabee/biobk/BioBookDIGEST.html

- **Unsaturated fatty acid oxidation**

  https://pharmaxchange.info/2013/10/oxidation-of-unsaturated-fatty-acids/

- **Urine formation**

  http://medschool.slu.edu/gpbs/syllabus/2008/renal2/Kidney%20Lecture-2%20Core%202008.pdf

- **Muscles**

  http://www.onlinebiologynotes.com/muscular-tissue-skeletal-smooth-cardiac-muscle/

- **Endocrine glands**

  http://what-when-how.com/nursing/the-endocrine-system-structure-and-function-nursing-part-1/

- **Physiological systems**

  https://nptel.ac.in/courses/102104042/

  https://nptel.ac.in/courses/122103039/18

ZOO 301L Animal Physiology Lab

Max. Marks : 100	**L**	**T**	**P**	**C**
(CA: 40 + ESA: 60)	**0**	**0**	**4**	**2**

Learning Outcomes:

After successful completion of the course, students should be able to:

- acquire hands-on experience in hematological parameters such as counting of RBCs, WBCs, preparation of haemin crystals and determination of blood haemoglobin
- gain expertise in qualitative estimation of calcium, cholesterol, sugar and protein in blood
- develop practical understanding of pathological analysis of urine through the detection glucose and albumin

1. To prepare haemin crystals.
2. Estimation of Haemoglobin percentage by Haemometer.
3. Enumeration of the total number of red blood corpuscles (R.B.C.).

4. Enumeration of the total number for white blood corpuscles (W.B.C.).
5. Determination of ABO blood groups and Rh factor.
6. Study of effect of isotonic, hypotonic and hypertonic solutions on R.B.C.
7. Determination of the presence of sugar and albumin in the urine sample.
8. Determination of blood sugar content.
9. Estimation of total protein from blood.
10. Estimation of total calcium from blood.
11. Estimation of total cholesterol from blood.
12. Determination of the clotting time of blood.
13. Demonstrate the activity of salivary amylase enzyme.

Suggested Books:

- Poddar, T., Mukhopadhyay, S. and Das, S.K. (2003). *An advanced Laboratory Manual of Zoology*. Kolkata: Macmillan India Limited.
- Sharma, S. (2007). *Experiments and Techniques in Biochemistry* (1st ed.). New Delhi: Galgotia Publication.
- Sharma, S. and Sharma, R. (2016). *Practical Manual of Biochemistry* (2nd ed.). New Delhi: Medtech.

ZOO 307 Developmental Biology

Max. Marks : 100	**L**	**T**	**P**	**C**
(CA: 40 + ESA: 60)	**6**	**0**	**0**	**6**

Learning Outcomes:

After successful completion of the course, students should be able to:

- gain in-depth knowledge of developmental biology
- acquire knowledge about the understanding of early and late embryonic development
- gain fundamental understanding of reproductive techniques and reproductive disorders

Unit 1 Introduction to developmental biology

- History and scope of developmental biology.
- Gametogenesis: Spermatogenesis, (Spermeiogenesis, spermateoleosis and structure of mammalian sperm).
- Oogenesis: (Previtellogenesis, vitellogenesis and structure of ovum).
- Fertilization and Implantation in mammals.

Unit 2 Early embryonic development with respect to mammals

- Cleavage.
- Morulation, blastulation and gastrulation.
- Fate maps and their significance.
- Organizers.

Unit 3 Late embryonic development with respect to mammals

- The embryonic period.
- The fetus, fetal membranes and placenta.
- Development of male reproductive system (Gonads, genital ducts, and glands).
- Development of female reproductive system (Gonads, genital ducts, and glands).

Unit 4 Reproductive disorders

- Birth defects and principles of teratology.

- Menstrual disorders: Precocious, delayed or absent puberty; Amenorrhea.
- Fertility disorders: Sexual dysfunction; Infertility; Spontaneous pregnancy loss.
- Pregnancy disorders: Pre-eclampsia, IUGR, labour abnormalities.

Unit 5 Reproductive techniques

- Super-ovulation, *In Vitro* Fertilization (IVF) and embryo transfer
- Intra-Cytoplasmic Sperm Injection (ICSI)/ micromanipulation.
- Cryopreservation of gametes and embryos; Vitrification.
- Prenatal diagnosis: Amniocentesis and CVS.
- Pre-implantation genetic diagnosis (PGD).

Suggested Books

- Balinsky, B.I. and Fabian, B.C. (1981). *An Introduction to Embryology* (5th ed.). International Thompson Computer Press.
- Carlson, B. (2013). *Human Embryology and Development Biology* .5th Ed. Saunders.
- Carlson, B.M. (1999). *Patten's foundations in embryology*. (6th ed.). New York, USA: McGraw Hill.
- Chattopadhyay, S. (2017). *An introduction to developmental Biology*. Kolkata, India: Books and Allied.
- Gilbert, S.F. (2000). Developmental Biology (6th ed). Sinauer Associates.
- Gilbert, S.F. (2010). *Developmental Biology* (9th ed.). Sinauer Associates, Inc., Publishers, Sunderland, Massachusetts, USA.
- Kalthoff, (2008). *Analysis of Biological Development* (2nd ed.). McGraw-Hill Publishers.
- Lewis, Wolpert (2002). *Principles of Development* (2nd ed.). Oxford University Press.
- Rastogi, V.B. and Jayaraj, M.S. (2005). *Developmental Biology (A Text book of embryology*). Kedar Nath Ram Nath Publisher, Meerut.
- Richard, E. Jones and Kristin, H Lopez. (2014). *Human Reproductive Biology*. 4th Ed. Academic press
- Singh, I. and G.P. *Human Embryology*. Pal Press Jaypee Brothers Pub

Suggested e-Resources:

- Developmental Biology

https://nptel.ac.in/courses/nptel_download.php?subjectid=102101068

http://cmb.i-learn.unito.it/mod/book/tool/print/index.php?id=3288

ZOO 307L Developmental Biology Lab

Max. Marks : 100	**L**	**T**	**P**	**C**
(CA: 40 + ESA: 60)	**0**	**0**	**4**	**2**

Learning Outcomes:

After successful completion of the course, students should be able to:

- understand and identify different stages of development of mammalian embryo
- learn the basic concept of qualitative detection of pregnancy in urine sample
- gain practical understanding of the female reproductive cycle-estrous cycle

1. Specimens of different developmental stages of mammalian embryos.
2. Study of different developmental stages of mammals using slides/ charts/CD's.
3. Qualitative detection of pregnancy in urine sample.
4. Demonstration of estrous cycle.

Suggested Books

- Lal, S.S. (2015). *Practical Zoology: Vertebrates* (11th ed.). Meerut: Rastogi Publication.
- Verma, P.S. (2010). *A Manual of Practical Zoology: Chordates* (11th ed.). New Delhi: S Chand Publishing.

ZOO 309 Economic and Applied Zoology

Max. Marks : 100	**L**	**T**	**P**	**C**
(CA: 40 + ESA: 60)	**6**	**0**	**0**	**6**

Learning Outcomes:

After successful completion of the course, students should be able to:

- explore the importance of earthworms in agro-ecosystems and utilize gained knowledge for production of vermicompost in small scale for garden/household plant
- apply acquired knowledge for setting up poultry farm, sericulture, apiculture, lacculture plant
- understand biology, life cycle and control measures of insect pests of crops and stored grains

Unit-1

- **Introduction to host-parasite relationship:** Host, definitive host, intermediate host, parasitism, symbiosis, commensalism, reservoir, zoonosis.
- **Parasitic protozoans:** Life history and pathogenicity of *Plasmodium vivax,* and *Trypanosoma gambiense.*
- **Parasitic helminthes:** Life history and pathogenicity of *Ancylostoma duodenale* and *Wuchereria bancrofti*.

Unit-2

- Life history and economic importance of ticks and mites.
- **Insects of medical importance and their control**: *Pediculus humanus, Anopheles, Culex* and *Aedes.*
- **Insects of agriculture importance and their control**: Biology and damage caused by crop pests (*Helicoverpa armigera, Pyrilla perpusilla*) and stored grain pests (*Callosobruchus chinensis, Sitophilus oryzae* and *Tribolium castaneum*).

Unit-3

- **Apiculture:** Different species of honey bees, pollen calendar, bee keeping and management practices, honey extraction techniques, bee products, diseases of honey bees and their control.
- **Sericulture:** Different silkworm species and their host plants, silkworm rearing and management practices, diseases of silkworms and their control.

- **Lac culture:** Lac insect, culture practices, diseases of lac insect and their control.

Unit-4

- **Fisheries:** Types of fishery: Marine, inland. Composite fish culture, induced breeding and hybridization. Transportation of fish seed. Fish diseases and their control.
- **Prawn culture:** Life history and culture practices of fresh water prawn.
- **Pearl culture**: Pearl formation, composition, colour, size and quality of pearl.

Unit-5

- **Vermiculture:** Definition, scope and importance, culture methods: indoors and out door, monoculture and polyculture, vermicomposting.
- **Poultry farming:** Principles of poultry breeding, management of breeding stock and broilers, processing and preservation of eggs, diseases of poultry and their control.
- **Animal husbandry:** Preservation and artificial insemination in cattle, induction of early puberty and synchronization of estrus in cattle.

Suggested Books:

- Arora, D.R and Arora, B. (2001). *Medical Parasitology* (2nd ed.). CBS Publications and Distributors.
- Atwal, A.S. (1986). *Agricultural Pests of India and South East Asia*, Kalyani Publishers.
- Dennis, H. (2009). *Agricultural Entomology*. Timber Press (OR).
- Dunham R.A. (2004). *Aquaculture and Fisheries Biotechnology Genetic Approaches*. CABI publications, U.K.
- Hafez, E.S.E. (1962). *Reproduction in Farm Animals*. Lea and Fabiger Publisher.
- Kumar and Corton. *Pathological Basis of Diseases*.
- Pedigo, L.P. (2002). *Entomology and Pest Management*, Prentice Hall.
- Sarkar, S., Kundu, G. and Chaki, K.K. (2014). *Introduction to Economic Zoology*. Kolkata: New Central Book Agency (P) Ltd.
- Shukla and Upadhyaya (1999-2000). *Economic Zoology*. Meerut: Rastogi Publishers.
- Venkitaraman (1983). *Economic Zoology*. Sudarsana Publishers.

Suggested e-Resources:

- **Sericulture**
  https://swayam.gov.in/courses/152-silkworm-crop-protection

ZOO 309L Economic and Applied Zoology Lab

Max. Marks : 100	**L**	**T**	**P**	**C**
(CA: 40 + ESA: 60)	**0**	**0**	**4**	**2**

Learning Outcomes:

After successful completion of the course, the students should be able to:

- understand the life cycle of protozoan and helminthes parasites through microscopic slides
- explore the knowledge of life cycle of honey bees, silk moths and lac insects for setting up apiculture, sericulture and lac culture farm
- gain knowledge of plant parasitic nematodes and control of insect pests of stored grains and crops

1. Study of life cycle of *Plasmodium vivax, Leishmania, Trypanosoma gambiense, Ancylostoma duodenale* and *Wuchereria bancrofti* through permanent slides/photomicrographs or specimens.
2. Study of arthropod vectors associated with human diseases: *Pediculus* and *Xenopsylla* through permanent slides.
3. Study of permanent slides of eggs, larvae, pupae and adults of *Culex, Anopheles,* and *Aedes*.
4. Study of some stored grains insect pests through damaged products/photographs.
5. Study of life cycle of honey bee through photographs/specimens/models.
6. Study of life cycle of silk moth through photographs /specimens/models.
7. Study of life cycle of lac insect through photographs /specimens/models.
8. Study of different types of pearls through photomicrographs or specimens.
9. Aquarium design and maintenance.
10. Demonstration of vermicomposting.
11. Demonstration of insect culture.
12. Isolation of plant parasitic nematodes from soil using decanting and sieving method**.**

13. Population dynamics of plant parasitic and free living nematodes.

Suggested Books:

- Kotpal, R.L. (2014). *Modern Textbook of Zoology: Invertebrates* (11th ed.). Meerut: Rastogi Publications.
- Lal, S.S. (2015). *Practical Zoology: Invertebrates* (11th ed.). Meerut: Rastogi Publication.
- Verma, P.S. (2010). *A Manual of Practical Zoology: Invertebrates* (11th ed.). New Delhi: S Chand Publishing.

ZOO 308 Ecology and Biodiversity

Max. Marks : 100	**L**	**T**	**P**	**C**
(CA: 40 + ESA: 60)	**6**	**0**	**0**	**6**

Learning Outcomes:

After successful completion of the course, students should be able to:

- acquire in-depth knowledge about the physical and biological inter-relationship
- gain knowledge of biodiversity for maintaining ecological balance
- understand the various methods of conservation of biodiversity

Unit 1

- Definition, branches and significance of ecology.
- Biosphere, biomes, ecosystem and its components (abiotic and biotic).
- Principles of limiting factors-Leibig's law of minimum, Shelford's law of tolerance, combined concept of limiting factors.
- Biogeochemical cycles: Carbon, oxygen, nitrogen and phosphorus cycles.

Unit 2

- Ecosystem ecology: Structure and dynamics of the ecosystem including food chain, food webs trophic levels, productivity and energetics.
- Fresh water ecosystem: Physiochemical factors, biotic communities and lake eutrophication.
- Marine ecosystem: Zonation factors and biotic communities of deep sea only.

- Terrestrial ecosystem: Salient features of grass land, forest and desert ecosystem.

Unit 3

- Population ecology: Definition and attributes of population: Population density and its measurement, natality, mortality, growth form, age distribution, age pyramids, sex ratio, dispersal and dispersion.
- Regulation of population density: Population fluctuations and interactions.
- Community ecology: Definition of types of communities (micro and macro communities), community dominance and species diversity, ecotone, edge effect and ecological niche.
- Ecological succession: types and concept of climax.

Unit 4

- Biodiversity: Basic concepts, importance and conservation needs. Levels of biodiversity-genetic, species and ecosystem.
- Significance of biodiversity: consumptive use, productive use, social, ethical, aesthetic and option values.
- Brief idea on biodiversity at global, National and local levels. India as a mega diversity nation; phytogeographic and zoogeographic zones of the country.
- Biodiversity hotspots, endangered and threatened species of plants and animals in India.

Unit 5

- Threats to biodiversity: habitat loss, poaching of wildlife, man-wildlife conflicts.
- IUCN Red List categorization: guidelines, practice and application; Red Data book.
- Biodiversity conservation: *In-situ* conservation (Biosphere reserves, National parks, and Wildlife sanctuaries); *Ex-situ* conservation (botanical gardens, zoological gardens, gene banks, seed and seedling banks, pollen culture, tissue culture and DNA banks).
- Indian biodiversity act, Man and the Biosphere Programme (MAB).

- Environmental pollution: Sources, impacts and control measures of air, water and land pollution.

Suggested Books:

- Alllee W.C., Emerson, A.E., Park, O., Parl, T., and Schmidt, K.P. (1967). *Principles of Animal Ecology*. USA: W.B. Saunders Company.
- Chaudhary, B.L., and Pandey, J. (2007). *Fundamentals of Ecology and Environment*. Jaipur: Apex Publishing House.
- Clarke, G.L. (1965). *Elements of Ecology.* New Jersey: John Wiley and Sons Inc.
- Hillary, E. (1984). *Ecology 2000: The Changing Face of Earth*. Michael Joseph Ltd.
- Kendeigh, S.C. (1974). *Ecology with special reference to animal and man*. New Jersey: Prentice Hall.
- Krebs, C.J. (2001). *Ecology* (5th ed.). San Francisco, USA: Benjamin Cummings.
- Kumar, A. (2015). *Biodiversity and Conservation*. New Delhi: APH Publishing Corporation.
- Miller, G.T. (2004). *Environmental Science: Working with the Earth* (10th ed.). Singapore: Thomson Asia.
- Misra, S.P., and Pandey, S.N. (2016). *Essentials of Environmental Sciences* (4th ed.). New Delhi: Ane Books Pvt. Ltd.
- Odum, E.P. (1965). *Ecology*, New Delhi: Amerind Publishing.
- Saxena, M.M. (1990). *Environmental Analysis*: Bikaner: Agro Botanical.
- Sharma, P.D. (2011). *Ecology and Environment*. Meerut: Rastogi Publication.
- Singh, S.P. (2005.). *Animal Ecology*. Meerut: Rastogi Publications.
- Tripathi, G. (2002). *Modern Trends in Environmental Biology*. New Delhi: CBS Publishers and Distributors.

Suggested e-Resources:

- **Aquatic ecology**

  https://nptel.ac.in/courses/120108002/

- **Ecosystem**

  https://nptel.ac.in/courses/122103039/38

- **Population characteristics**

http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.534.5462and rep=rep1andtype=pdf

ZOO 308L Ecology and Biodiversity Lab

Max. Marks : 100	**L**	**T**	**P**	**C**
(CA: 40 + ESA: 60)	**0**	**0**	**4**	**2**

Learning Outcomes:

After successful completion of the course, students should be able to:

- gain hands-on skills in the quality assessment of water
- understand the physical and chemical characteristics of soil with easy to run experiment
- gain knowledge about plant community and zoogeographical distribution

1. To find the depth and visibility in a pond by Sachi disc method.
2. To determine the pH of water sample.
3. To determine the content of dissolved oxygen in the water sample.
4. To determine the chemical oxygen demand in the water sample.
5. To determine free CO_2 content in the water sample.
6. To determine the chloride content of the water sample.
7. To determine the total hardness of water.
8. To determine the soil temperature by soil thermometer.
9. To measure relative humidity of the atmosphere by wet and dry–bulb thermometer or psychrometer.
10. To determine soil texture.
11. To test the presence of carbonate, nitrate, pH value and base deficiency in soil.
12. To measure the light intensity.
13. To study the structure of the plant community of an area by quadrat method and to determine the plant density, abundance and frequency.
14. To determine the water holding capacity of different soils.
15. Draw a map of world and identify the phytogeographical and zoogeographical regions of the world along with their major fauna.

Suggested books:

- Lal, S.S. (2015). *Practical Zoology: Invertebrates* (11th ed.). Meerut: Rastogi Publication.
- Lal, S.S. (2015). *Practical Zoology: Vertebrates* (11th ed.). Meerut: Rastogi Publication.
- Lal, S.S. (2016). *A Textbook of Practical Zoology* Vol-III (2nd ed.). Meerut: Rastogi Publication.
- Poddar, T., Mukhopadhyay, S. and Das, S.K. (2003). *An advanced Laboratory Manual of Zoology*. Kolkata: Macmillan India Limited.
- Verma, P.S. (2010). *A Manual of Practical Zoology: Chordates* (11th ed.). New Delhi: S Chand Publishing.

Discipline Elective Courses- V and VI

CHEMISTRY

CHEM 302 Organic Chemistry-II

Max. Marks : 100	**L**	**T**	**P**	**C**
(CA: 40 + ESA: 60)	**6**	**0**	**0**	**6**

Learning Outcomes:

On completion of course, the students will be able to:

- explain the structures and properties of biomolecules: carbohydrates, amino acids, proteins and nucleic acids.
- explain the structures, synthesis and properties of different class of organic compounds: nitro compounds, amines, diazonium salts, enolates, pyrrole, thiophene, furan, pyridine, indole, quinoline and isoquinoline.
- discuss the basic principles of UV-visible, IR and NMR spectroscopy.
- elucidate the structure of organic compounds using UV-visible, IR and NMR spectral data.

Unit 1 Carbohydrates:

Classification and nomenclature, monosaccharides: chain lengthening and chain shortening of aldoses, configuration, mechanism of osazone formation, mechanism of mutarotation, interconversion of glucose and fructose, epimerization (conversion of glucose into mannose), determination of ring size of D (+)-glucose and fructose; disaccharides: - sucrose, lactose and maltose (without involving structure determination); polysaccharides: starch and cellulose (without involving structure determination).

Biomolecules:

(a) Amino acids: Classification, structure, acid-base behaviour, isoelectric point; preparation, physical properties and chemical reactions of α-amino acids.

(b) Peptides and Proteins: Classification, structure determination, and end group analysis, selective hydrolysis of peptides, solid-phase peptide synthesis.

(c) Nucleic acids: Introduction, constituents of nucleic acids, ribonucleosides and ribonucleotides, double helical structure of DNA.

Unit 2 UV-visible Spectroscopy:

Introduction to electromagnetic spectrum, basic principle, types of electronic transitions, factors affecting the position of absorption bands: conjugation and solvent; concept of chromophore and auxochrome; bathochromic, hypsochromic, hyperchromic and hypochromic shifts; UV-visible spectra of conjugated enes and enones: Woodward and Fieser rules, calculation of λ_{max} of simple molecules; applications: strength of hydrogen bond, geometrical isomerism, keto-enol tautomerism.

Infrared Spectroscopy:

Basic principle, molecular vibrations, Hooke's law, selection rule, intensity and position of IR bands, factors affecting vibrational frequencies: coupled vibrations, Fermi resonance, electronic effects, hydrogen bonding and angle strain; fingerprint region, characteristic absorptions of various functional groups, interpretation of IR spectra of simple organic compounds, applications of IR spectroscopy.

Unit 3 Organic Compounds of Nitrogen:

(a) Nitro Compounds: Nomenclature, preparation of nitroalkanes and nitroarenes, physical properties, chemical reactions of nitroalkanes: acidic character, mechanism of nucleophilic and electrophilic substitution, reduction; chemical reactions of nitroarenes: mechanism of nucleophilic and electrophilic substitution, reduction in acidic, neutral and alkaline media, picric acid: methods of preparation, physical and chemical properties, halonitroarenes: methods of preparation and reactivity.

(b) Amines: Nomenclature and structure, stereochemistry, separation of mixture of amines, preparation of amines: reduction of nitro compounds, Gabriel-phthalimide reaction, Hofmann bromamide reaction, Curtius, Schmidt and Lossen rearrangements, physical

properties, chemical reactions: structural features affecting basicity of amines, amine salts as phase-transfer catalysts, electrophilic aromatic substitution, diazotization.

(c) Diazonium Salts: Nomenclature and structure, preparation, physical properties, chemical reactions: replacement of diazo group by H, OH, F, Cl, Br, I, NO_2, CN and aryl group; synthetic applications.

Unit 4 Heterocyclic Compounds:

Introduction, classification, nomenclature of five and six-membered rings, molecular orbital picture and aromatic characterstics of pyrrole, furan, thiophene and pyridine; methods of synthesis and chemical reactions with particular emphasis on the mechanism of electrophilic substitution; mechanism of nucleophilic substitution reactions in pyridine derivatives; comparison of basicity of pyridine, piperidine and pyrrole.

Introduction of condensed five and six membered heterocycles; preparation and reactions of indole, quinoline and isoquinoline with special reference to Fischer-indole synthesis, Skraup synthesis and Bischier-Napieralski synthesis; mechanism of electrophilic substitution reactions of indole, quinoline and isoquinoline.

Unit 5 Organic Synthesis via Enolates:

Introduction, acidity of α-hydrogens, reactive methylene group-alkylation of diethyl malonate and ethyl acetoacetate, synthesis and reaction of ethyl acetoacetate, Keto-enol tautomerism of ethyl aectoacetate, alkylation of 1,3-dithianes, alkylation and acylation of enamines.

Nuclear Magnetic Resonance Spectroscopy:

Introduction, basic principle, chemical shift, chemical shift parameters, factors affecting the chemical shift, equivalence and non-equivalence protons, spin-spin coupling, coupling constant, interpretation of PMR spectra of simple organic molecules such as ethyl bromide, n-propyl bromide, isopropyl bromide, 1,1-dibromoethene, 1,1,2-tribromoethene, ethyl alcohol, ethyl acetate, acetaldehyde, benzaldehyde, toluene and acetophenone.

Recommended Books:

1. Clayden, J., Greeves, N., Warren, S., and Wothers, P. (2001). *Organic chemistry*. (2nd ed.). Oxford University Press.
2. Sykes, P. (1986). *A guide book to mechanism in organic chemistry* (6th ed.).Pearson.
3. Ingold, C. K.(1970). *Structure and mechanism in organic chemistry*. Cornell University Press.
4. Morrison, R.T., and Boyd, R.N. (2002). *Organic chemistry* (6th ed.). Prentlce Hall.
5. Nasipuri, D. (1994). *Stereochemistry of organic compounds*. (2nd ed.). New Age International
6. Singh, M.S. (2005). *Advanced organic chemistry-reactions and mechanisms*. Pearson Education, Singapore.
7. Wade, L.G., and Singh, M. S. (2008). *Organic chemistry*. Pearson Education.
8. Singh, M.S. (2014). *Reactive intermediates in organic chemistry-structure, mechanism and reactions*. Wiley, VCH and Weinheim
9. Kemp, W. (1991). *Organic Spectroscopy*. (3rd ed.).Palgrave Houndmills. New York.
10. Mohan, J. (2001). *Organic Spectroscopy:* Principles and Applications. Narosa Publication, New Delhi.
11. Kalsi, P. S., (2016). *Organic Spectroscopy*. (7th ed.). New Age International Publishers, New Delhi
12. Silverstein, R. M., Webster, F. X. and Kiemle, D., (2005). *Spectrometric Identification of Organic Compounds*. (7th ed.). John Wiley and Sons.

Suggested e-Sources

1. National Programme on Technology Enhanced Learning
   https://nptel.ac.in
2. Online Chemistry Courses
   https://www.edx.org/learn/chemistry
3. Free Online Education SWAYAM
   https://swayam.gov.in

CHEM 302L Organic Chemistry-II Lab

Max. Marks : 100	**L**	**T**	**P**	**C**
(CA: 40 + ESA: 60)	**0**	**0**	**4**	**2**

Learning Outcomes:

On completion of course, the students will be able to:

- separate compounds by steam distillation.
- understand concept of chromatography (TLC) by separation of green leaf pigment, mixture of dyes and organic compounds.
- separate organic mixture containing two solid components and their qualitative analysis.
- synthesize organic compounds by synthetic methods: acetylation, benzoylation, diazotization or coupling reaction and electrophilic substitution.

Steam Distillation (any one of the following)

1. Naphthalene from its suspension in water.
2. Clove oil from clove.
3. Separation of o and p-nitrophenols.

Thin Layer Chromatography

Determination of R_f values and identification of organic compounds:

1. Separation of green leaf pigment (spinach leaves may be used).
2. Preparation and separation of 2,4-dinitrophenyl hydrazones of acetone, 2-butanone, hexan-2 and 3-one using toluene and light petroleum (40:60).
3. Separation of a mixture of dyes using cyclohexane and ethyl acetate (8.5:1.5).

Qualitative Analysis

Analysis of an organic mixture containing two solid components using water, $NaHCO_3$, NaOH for separation and preparation of suitable derivatives.

Synthesis of Organic Compounds (any two of the following)

(i) Acetylation

- Salicyclic acid
- Aniline
- Glucose
- Hydroquinone

(ii) Aliphatic Electrophilic Substitution

- Preparation of iodoform from ethanol and acetone

(iii) Aromatic Electrophilic Substitution

- Nitration:

  Preparation of m-dinitrobenzene

  Preparation of p-nitroacetanilide

- Halogenation:

  Preparation of p-bromoacetanilide

  Preparation of 2, 4, 6-tribromophenol

(iv) Diazoitization / Coupling

- Preparation of methyl orange and methyl red

(v) Oxidation

- Preparation of benzoic acid from toluene

(viii) Reduction

- Preparation of aniline from nitrobenzene
- Preparation of m-nitroaniline from m-dinitrobenzene

Recommended Books:

1. Furniss, B.S., Hannaford, A.J., Smith, P.W.G. and Tatchell, A.R. (1989). *Practical Organic Chemistry* (5th ed.), John Wiley and Sons, Inc., New York.

Suggested e-Sources:

1. National Programme on Technology Enhanced Learning

   https://nptel.ac.in

2. Online Chemistry Courses

   https://www.edx.org/learn/chemistry

3. Free Online Education SWAYAM

   https://swayam.gov.in

CHEM 305 Molecular Modeling and Drug Design

Max. Marks : 100	**L**	**T**	**P**	**C**
(CA: 40 + ESA: 60)	**6**	**0**	**0**	**6**

Learning Outcomes:

On completion of course, the students will be able to:

- describe and comprehend the fundamental concepts of molecular modeling and computational-driven drug discovery.
- understand the physicochemical properties of drugs including solubility, distribution, adsorption, and stability.
- understand the Molecular modeling and computer graphics
- develop the theoretical and practical aspects of molecular modeling

Unit 1. **Introduction to Molecular Modeling:** Useful Concepts in molecular modeling: Coordinate Systems, Potential Energy Surfaces, Molecular Graphics, Computer Hardware and Software.

Force Fields: Fields, Bond Stretching, Angle Bending, Introduction to nonbonded interactions, Electrostatic interactions, van der Waals Interactions, Hydrogen bonding in Molecular Mechanics, Force Field Models for the Simulation of Liquid Water.

Unit 2. **Energy Minimization and Computer Simulation:** Minimization and related methods for exploring the energy surface, Non-derivative method, First and second order minimization methods, Computer simulation methods, Simple thermodynamic properties and Phase Space, Boundaries, Analyzing the results of a simulation and estimating Errors.

Unit 3. **Molecular Dynamics and Monte Carlo Simulation:** Molecular Dynamics Simulation Methods, Molecular Dynamics using simple models, Molecular Dynamics with continuous potentials, Molecular Dynamics at constant temperature and pressure, Metropolis method, Monte Carlo simulation of molecules, Models used in Monte Carlo simulations of polymers.

Unit 4. **Structure Prediction and Drug Design:** Structure prediction - Introduction to comparative Modeling, Sequence alignment, Constructing and evaluating a comparative model, Predicting protein structures by 'Threading', Molecular docking, Structure based de novo ligand design, Drug Discovery - Chemoinformatics -QSAR.

Unit 5. **Pharmaceutical Compounds:** Structure and Importance Classification, structure and therapeutic uses of antipyretics: Paracetamol (with synthesis), Analgesics: Ibuprofen (with synthesis), Antimalarials: Chloroquine (with synthesis), artemisinin, An elementary treatment of Antibiotics and detailed study of chloramphenicol, Medicinal values of curcumin (haldi), azadirachtin (neem), vitamin C and antacid (ranitidine).

Recommended Books:

1. Leach, A.R. (2001). *Molecular Modelling Principles and Application*, Longman.

2. Haile, J.M. (1997). *Molecular Dynamics Simulation Elementary Methods*, John Wiley and Sons.

3. Gupta, S.P. (2008). *QSAR and Molecular Modeling,* Springer - Anamaya Publishers.

Suggested e-Sources

1. National Programme on Technology Enhanced Learning

   https://nptel.ac.in

2. Online Chemistry Courses

   https://www.edx.org/learn/chemistry

3. Free Online Education SWAYAM

   https://swayam.gov.in

CHEM 305L Molecular Modeling and Drug Design Lab

Max. Marks : 100	**L**	**T**	**P**	**C**
(CA: 40 + ESA: 60)	**0**	**0**	**4**	**2**

Learning Outcomes:

On completion of course, the students will be able to:

- describe and comprehend the fundamental concepts of molecular modeling and computational-driven drug discovery.
- understand the physicochemical properties of drugs including solubility, distribution, adsorption, and stability.
- understand the Molecular modeling and computer graphics
- develop the theoretical and practical aspects of molecular modeling

1. Compare the optimized C-C bond lengths in ethane, ethene, ethyne and benzene. Visualize the molecular orbitals of the ethane σ bonds and ethene, ethyne, benzene and pyridine π bonds.
2. (a) Perform a conformational analysis of butane. (b) Determine the enthalpy of isomerization of cis and trans 2-butene.
3. Visualize the electron density and electrostatic potential maps for LiH, HF, N_2, NO and CO and comment. Relate to the dipole moments. Animate the vibrations of these molecules.

4. (a) Relate the charge on the hydrogen atom in hydrogen halides with their acid character. (b) Compare the basicities of the nitrogen atoms in ammonia, methylamine, dimethylamine and trimethylamine.

5. (a) Compare the shapes of the molecules: 1-butanol, 2-butanol, 2-methyl-1-propanol, and 2-methyl-2-propanol. Note the dipole moment of each molecule. (b) Show how the shapes affect the trend in boiling points: (118 ºC, 100 ºC, 108 ºC, 82 ºC, respectively).

6. Build and minimize organic compounds of your choice containing the following functional groups. Note the dipole moment of each compound: (a) alkyl halide (b) aldehyde (c) ketone (d) amine (e) ether (f) nitrile (g) thiol (h) carboxylic acid (i) ester (j) amide.

7. (a) Determine the heat of hydration of ethylene. (b) Compute the resonance energy of benzene by comparison of its enthalpy of hydrogenation with that of cyclohexene.

8. Arrange 1-hexene, 2-methyl-2-pentene, (E)-3-methyl-2-pentene, (Z)-3-methyl-2- pentene, and 2,3-dimethyl-2-butene in order of increasing stability.

9. (a) Compare the optimized bond angles H_2O, H_2S, H_2Se. (b) Compare the HAH bond angles for the second row dihydrides and compare with the results from qualitative MO theory.

10. Titrimetric estimation of drugs: Paracetamol, Ascorbic acid, Aspirin, etc.

    Note: Software: ChemSketch, ArgusLab (www.planaria-software.com), TINKER 6.2 (dasher.wustl.edu/ffe), WebLab Viewer, Hyperchem, or any similar software.

Recommended Books:

1. Leach, A.R. (2001). *Molecular Modelling Principles and Application*, Longman.

2. Haile, J.M. (1997). *Molecular Dynamics Simulation Elementary Methods*, John Wiley and Sons.

3. Gupta, S.P. (2008). *QSAR and Molecular Modeling,* Springer - Anamaya Publishers.

Suggested e-Sources

1. National Programme on Technology Enhanced Learning

   https://nptel.ac.in

2. Online Chemistry Courses

   https://www.edx.org/learn/chemistry

3. Free Online Education SWAYAM

   https://swayam.gov.in

CHEM 303 Physical Chemistry-II

Max. Marks : 100	**L**	**T**	**P**	**C**
(CA: 40 + ESA: 60)	**6**	**0**	**0**	**6**

Learning Outcomes:

On completion of course, the students will be able to:

- explain the basic principles of nuclear chemistry.
- discuss the surface phenomenon, surface properties of solid and calculate the surface area of the adsorbent.
- discuss conductance, Arrhenius theory, Debye-Huckel-Onseger's equation and Nernst equation.
- explain the concept of corrosion and factors affecting corrosion.
- explain the colligative properties of solution.
- Understand the congruent and non-congruent melting points, and azeotropic mixtures.

Unit 1. Nuclear Chemistry:

Nuclear particles, nuclear size, nuclear spin, nuclear magnetic moment, of a nucleus, discovery of radioactivity, decay processes-average life, half life; Rutherford and Soddy transformation, nuclear forces, packing fraction, binding energy, nuclear shell model, liquid drop model, applications of radioisotopes, hot atom chemistry-Szilard-Chalmers reaction.

Surface Chemistry:

General terms used in adsorption, adsorption of gases by solids, factors effecting adsorption, mono and multi layer adsorption, heat of adsorption Freundlich adsorption isotherm, Langmuirs adsorption isotherm and its limitations, determination of surface area of adsorbents, change in enthalpy, entropy and free energy of adsorption, competitive adsorption, mechanism of surface reaction and activation energy.

Unit 2 Solutions, Dilute Solutions and Colligative Properties:

Ideal and non-ideal solutions, deviation from ideal behaviour, method of expressing concentrations of solutions: - normality, molarity, molality, formality, mole fraction, percentage by mass, parts per million (ppm), activity and activity coefficient, dilute solution, Roult's law, colligative properties: relative lowering of vapour pressure, measurement of vapour pressure lowering, molecular weight determination, osmosis, law of osmotic pressure and its measurement, determination of molecular weight from osmotic pressure, relationship between osmotic pressure and vapor pressure, lowering of an ideal solution, measurement of osmotic pressure (The Morse-Frazer method, the Berkeley-Hartley method), elevation in boiling point, depression in freezing point, thermodynamic derivation of relation between molecular weight and elevation in boiling point and depression in freezing point, experimental methods for determining various colligative properties, abnormal molar mass and Van't Haff factor, degree of dissociation and association of solutes.

Unit 3 Electrochemistry-I:

Electric transport in electrolytic solutions, specific conductance and equivalent conductance, measurement of equivalent conductance, variation of equivalent and specific conductance with dilution, migration of ions and Kohlrausch law, Arrhenius theory of electrolyte dissociation, its uses and limitations, weak and strong electrolytes, Ostwald's dilution law and its uses and limitations, Debye-Huckel-Onsager's equation for strong electrolytes (elementary treatment only), transport number, definition and determination by Hittorf method and moving boundary method, applications of conductivity measurement: determination of degree of dissociation, determination of K_a of acids, determination of solubility product of sparingly soluble salt, conductometric titrations.

Unit 4 Electrochemistry-II:

Types of reversible electrodes:-gas-metal ion, metal-metal ion, metal-insoluble salt-anion and redox electrode reactions, relationship between EMF and equilibrium constant, Nernst equation, effect of electrolytic concentration on electrode potential, standard hydrogen electrode, reference electrode, standard electrode potential, derivation of cell EMF and single electrode potential, sign conventions, electrochemical series and its significance.

Electrolytic and Galvanic Cells: reversible and irreversible cells, conventional representation of electrochemical cells, EMF of a cell and its measurements, calculation of thermodynamic quantities of cell reactions (ΔG, ΔH and K), irreversible electrode potentials-polarization, over potential and its applications, hydrogen over voltage, concentration cell with and without transport, liquid junction potential, applications of concentration cells, valency of ions in doubtful cases, solubility, solubility product and activity coefficient; potentiometric, acid-base, precipitation and redox titrations; brief introduction of redox indicators, definition of pH and pK_a, determination of pH potentiometric methods.

Corrosion: types, theory, factors affecting corrosion and methods of combating of iron against corrosion.

Unit 5 Phase Equilibrium:

Introduction, terminology: phase, component, degree of freedom or variance, criteria of phase equilibrium, dynamic equilibrium, metastable equilibrium, statement of phase rule; solid solutions: compound formation with congruent melting point (Benzophenone-Diphenylamine) and incongruent melting point (Benzene-Picric acid); liquid-liquid mixtures: ideal liquid mixtures, Raoult's and Henry's laws, non-ideal system; azeotropes: - HCl-H_2O and ethanol-water systems; partially miscible liquids: -phenol-water, trimethylamine-water, nicotine-water systems; lower and upper consulate temperature, effect of impurity on consulate temperature.

Distribution Law: thermodynamic derivation, association, dissociation and chemical combination of solute, applications**.**

Recommended Books:

1. Atkins, P., Julio, P. D. (2014). *Physical Chemistry* (10th Ed), United Kingdom: Oxford University Press.
2. Castellan, G.W. (1983). *Physical Chemistry* (3rd Ed), United State of America: Addision-Wesley Publishing Company.
3. West, A. R. (2014). *Solid State Chemistry and its Applications* (2nd Ed), John Wiley andSons .Ltd
4. Puri, B.R., Sharma, L.R., Pathania, M.S. (2016). *Principle of Physcial Chemistry* (47th Ed). India: Vishal Publishing Company.
5. Arniker, H. J. (2005). *Essentials of Nuclear Chemistry* (4th Ed), India: New Age International Ltd. Publisher.

Suggested e-Sources:

1. National Programme on Technology Enhanced Learning

   https://nptel.ac.in

2. Online Chemistry Courses

   https://www.edx.org/learn/chemistry

3. Free Online Education SWAYAM

   https://swayam.gov.in

CHEM 303L Physical Chemistry-II Lab

Max. Marks : 100	**L**	**T**	**P**	**C**
(CA: 40 + ESA: 60)	**0**	**0**	**4**	**2**

Learning Outcomes:

On completion of course, the students will be able to:

- handle instruments like calorimeter, conductometer and potentiometer.
- perform the proper procedures and have the knowledge of regulations for safe handling and use of chemicals.
- evaluate physical properties of analytes viz. the molecular weight, conductivity, optical rotation.

Colorimetry

1. To verify Beer-Lambert law for $KMnO_4/K_2Cr_2O_7$ and determine the concentration of the given solution of the substance.

Conductometry (any two)

1. To determine the strength of the given acid conductometrically using standard alkali solution.
2. To determine the solubility and solubility product of a sparingly soluble electrolyte conducotometrically.
3. To study the saponification of ethyl acetate conductometrically.
4. To determine the ionization constant of a weak acid conductometrically.

Potentiometry

1. To titrate potentiometrically the given ferrous ammonium sulphate solution using $KMnO_4/K_2Cr_2O_7$ as titrant and calculate the redox-potential of Fe^{2+} / Fe^{3+} on system on the hydrogen scale.

Molecular Weight Determination (one of the following)

1. Determine of molecular weight of a non-volatile solute by Rast method/Beckmann freezing point method.
2. Determination of the apparent degree of dissociation of an electrolyte (e.g. NaCl) in aqueous solution at different concentrations by ebullioscopy.

Refractometry and Polarimetry (one of the following)

1. To determine the concentration of a given unknown solution of optically active compound cane sugar and tartaric acid.
2. To determine the specific rotation of a given optically active compound.

Recommended Books:

1. Gurtu, G.N., Gurtu, A. (2014). *Avanced Physical Chemistry*, India: Pragati Prakashan .
2. Sindhu, P.S. (2005). *Practicals in Physical Chemistry*, India: Macmillan Publishers.

Suggested e-Sources

1. National Programme on Technology Enhanced Learning

   https://nptel.ac.in
2. Online Chemistry Courses

   https://www.edx.org/learn/chemistry
3. Free Online Education SWAYAM

   https://swayam.gov.in

CHEM 304 Analytical Methods in Chemistry

Max. Marks : 100	**L**	**T**	**P**	**C**
(CA: 40 + ESA: 60)	**6**	**0**	**0**	**6**

Learning Outcomes:

On completion of course, the students will be able to:

- apply knowledge of basic statistics to validate the results of analysis.
- understand various chromatographic techniques and it's applications in separation of mixtures, purification of samples, and qualitative and quantitative analysis.
- understand the basic principles of optical, thermal and electro analytical methods and apply its concepts to interpretation of compounds.
- explain the principle and applications of thermal methods of analysis and atomic spectroscopy

Unit 1. **Qualitative and Quantitative aspects of analysis:** Sampling, evaluation of analytical data, errors, accuracy and precision:, methods of their expression, normal law of distribution if indeterminate errors, statistical test of data; F, Q, and T test, rejection of data, and confidence intervals. Steps involved in chemical analysis, Principles of volumetric analysis: Theories of acid-base, redox, complexometric, iodometric and precipitation titrations - choice of indicators for these titrations, Principles of gravimetric analysis: precipitation, coagulation, peptization, coprecipitation, post precipitation, digestion, filtration and washing of precipitate, drying and ignition.

Unit 2. **Optical methods of analysis:** Origin of spectra, interaction of radiation with matter, fundamental laws of spectroscopy and selection rules, validity of Beer-Lambert's law. UV-Visible Spectrometry: Basic principles of instrumentation (choice of source, monochromator and detector) for single and double beam instrument; Basic principle of quantitative analysis: estimation of metal ions from aqueous solution. Determination of composition of metal complexes using

Job's method of continuous variation and mole ratio method. Infrared Spectrometry: Basic principles of instrumentation (choice of source, monochromator and detector) for single and double beam instrument; sampling techniques. Effect and importance of isotopic substitution

Unit 3. **Thermal and Atomic Absorption methods of analysis:** Theory of thermogravimetry (TG),basic principle of instrumentation. Techniques for quantitative estimation of Ca and Mg from their mixture. Atomic Absorption Spectrometry: Introduction, Principal of AAS. Classification of atomic spectroscopic methods, Advantages and disadvantages of AAS. Measurement of atomic absorption, Instrumentation for atomic absorption spectrometer and application of AAS.

Unit 4. **Electro analytical methods**: Classification of electroanalytical methods, Types of reversible electrodes:-gas-metal ion, metal-metal ion, metal-insoluble salt-anion and redox electrode reactions, basic principle of pH metric: determination of streingth of unknown acids (Strong, Weak and mixture), potentiometric: principle, instrumrntation and application (determination of transport number. Detternimation of valency of an ions in doubtful cases, solubility, solubility product and activity coefficient, acid-base, precipitation and redox titrations), definition of pH and pK_a, determination of pH by potentiometric methods and conductometric titrations. Electrophoreses: principle, instrumentation and types of electrophoreses methods. Electro osmosis: principle and instrumentation.

Unit 5. **Separation Techniques**: Chromatography: Classification of chromatography methods, principles of differential migration adsorption phenomenon, Nature of adsorbents, solvent systems, Rf values, factors effecting Rf values. Paper Chromatography: Principles, Rf values, experimental procedures, choice of paper and solvent systems, developments of chromatogram - ascending, descending and radial. Two dimensional chromatography, applications. Thin layer Chromatography (TLC): Advantages. Principles, factors effecting Rf values. Experimental procedures. Adsorbents and solvents.

Preparation of plates. Development of the chromatogram. Detection of the spots. Applications. Column Chromatography: Principles, experimental procedures, Stationary and mobile Phases, Separation technique and Applications.

Recommended Books:

1. Christian, G. D., *Analytical Chemistry*, John wiley; 6th edition.
2. Skoog, D. A., West, D. M., Hollar, F. J. and Crouch S. R.; *Fundamentals of Analytical Chemistry,* Cengage Learning; 9 ed.
3. Willard, H. L., Merritt, Dean, J. A. and Settle, F. A. (2004) *Instrumental Methods of Analysis*; HCBS publishing New Delhi: 7th ed.
4. Ewing, G. W. Ewing, *Instrumental Methods of Chemical Analysis*, Mcgraw-Hill Int 5th ed.
5. Holler, F. J., Skoog, D. A. and Crouch, S. R. *Principles of Instrumental Analysis*, Thomson Books/Cole , 6th ed..
6. Willard, H. H., Merritt, J. A., Dean, l. l. and Settle, F. A. *Instrumental methods of Analysis*, CBS Publishing New Delhi, 7th ed.
7. Kaur, H., (2010). Spectroscopy, Pragati Prakashan, India.

Suggested e-Sources:

1. National programme on technology enhanced learning

   https://nptel.ac.in

2. Online chemistry courses

   https://www.edx.org/learn/chemistry

3. Free online education swayam

   https://swayam.gov.in

CHEM 304L Analytical Methods in Chemistry Lab

Max. Marks : 100	**L**	**T**	**P**	**C**
(CA: 40 + ESA: 60)	**0**	**0**	**4**	**2**

Learning Outcomes:

On completion of course, the students will be able to:

- develop their skills for qualitative and quantitative research in different fields.
- perform various analytical operations to qualify and quantify different analytes.
- outline synthetic strategies for important chemicals.
- check the purity of synthesized compounds through TLC, UV, FT-IR spectral data
- analysis of soil through determination pH, estimation of ions and by total dissolve salts.
- able to determine the Chemical and biological oxygen demand by spectroscopic techniques.

Separation Techniques

1. Chromatography:

(a) Separation of mixtures

(i). Paper chromatographic separation of Fe3+, Al3+, and Cr3+.

(ii). Separation and identification of the monosaccharides present in the given mixture (glucose and fructose) by paper chromatography. Reporting the Rf values.

(b) Separate a mixture of Sudan yellow and Sudan Red by TLC technique and identify them on the basis of their Rf values.

(c) Chromatographic separation of the active ingredients of plants, flowers and juices by TLC.

2. Solvent Extractions:

(a) To separate a mixture of Ni2+ and Fe2+ by complexation with DMG and extracting the Ni2+- DMG complex in chloroform, and determine its concentration by spectrophotometry.

(b) Solvent extraction of zisconium with amberliti LA-1, separation from a mixture of irons and gallium.

(c) Determine the pH of the given aerated drinks fruit juices, shampoos and soaps.

(d) Determination of Na, Ca, Li in cola drinks and fruit juices using fame photometric techniques.

(e) Analysis of soil:

(i). Determination of pH of soil.

(ii). Total soluble salt

(iii). Estimation of calcium, magnesium, phosphate, nitrate

(f) Ion exchange:

(i). Determination of exchange capacity of cation exchange resins and anion exchange resins.

(ii). Separation of metal ions from their binary mixture.

(iii). Separation of amino acids from organic acids by ion exchange chromatography.

Spectrophotometry

1. Determination of pKa values of indicator using spectrophotometry.
2. Structural characterization of compounds by infrared spectroscopy.
3. Determination of dissolved oxygen in water.
4. Determination of chemical oxygen demand (COD).
5. Determination of Biological oxygen demand (BOD).

6. Determine the composition of the Ferric-salicylate/ ferric-thiocyanate complex by Job's method.

Recommended Books:

1. Gurdeep, R (2016*), Advanced Practical Inorganic Chemistry*, revised Ed., Krishna Prakashan publication.
2. Svehla, G. (2010), Vogel's *Qualitative Inorganic Analysis*, 7th Edition, Prentice Hall.
3. Gurtu, J. N. and Gurtu, A(2011), *Physical Chemistry Vol – I,* Pragati Prakashan publication.
4. Furniss, B.S., Hannaford, A.J., Smith, P.W.G. and Tatchell, A.R. (1989). *Practical Organic Chemistry* (5th ed.). New York, John Wiley and Sons, Inc.
5. Christian, Gary D. (2004*), Analytical Chemistry*, New York, 6th Ed. John Wiley and Sons.
6. Khopkar, S.M. (2009), *Basic Concepts of Analytical Chemistry*, New Age, International Publisher.
7. Christian, Gary D. (2004), *Analytical Chemistry*, New York , 6th Ed. John Wiley and Sons.

Suggested e-Sources

1. National Programme on Technology Enhanced Learning

   https://nptel.ac.in

2. Online Chemistry Courses

   https://www.edx.org/learn/chemistry

3. Free Online Education SWAYAM

   https://swayam.gov.in
