PONDICHERRY UNIVERSITY

B.Sc. MICROBIOLOGY

(Choice Based Credit System)

From 2021-22 onwards

PONDICHERRY UNIVERSITY

B.Sc. Microbiology

REGULATIONS

(Effective from the academic year 2021-22)

AIM OF THE COURSE

The B.Sc. Microbiology course aims to impart the students with basic principles of Microbiology and their applications to humankind.

ELIGIBILITY FOR ADMISSION

Candidates for admission to B.Sc. Microbiology shall be required to have passed H.Sc., (+2) or its equivalent with Botany/Zoology/Biology as one of the subjects of study.

DURATION OF THE COURSE

Prescribed studies in B.Sc. Microbiology shall be of six consecutive semesters (three years). The maximum duration allowed for each student to acquire prescribed number of credits in order to complete the Programme of Study shall be twelve consecutive semesters (six years).

AGE LIMIT

The rules as applicable to other Under Graduate courses as prevailing in Pondicherry University.

MEDIUM OF INSTRUCTION

The medium of instruction shall be English

PATTERN OF EXAMINATION

- The End-Semester examination for each course in a B.Sc. Microbiology shall be conducted by the Pondicherry University for a maximum of 75 marks and Internal Continuous Assessment for 25 marks.
- Internal Assessment for all theory courses shall be done on the basis of at least two Internal Assessment tests (15 marks), term papers/assignments/seminars/case demonstrations/ presentations/write-ups/*viva voce* etc. (5 marks) and attendance (5 marks).

The following weightage shall be given to attendance:

95% - 100% (5 marks)

90% - 94% (4 marks)

85% - 89% (3 marks)

80% - 84% (2 marks)

75% - 79% (1 mark)

- For Skill Enhancement Course of Semester VI (SEC- 4 /APMB-361) Microbes and Their Applications (Advanced Credit Seminar) course's End-Semester examination (75 marks) shall be internally conducted and evaluated by the Department of Microbiology.
- The Practical End-Semester examination for each course in a Programme of Study shall be conducted by the Pondicherry University for a maximum of 35 marks and Internal Continuous Assessment for 15 marks.
- Internal Assessment for all Practical courses involving Laboratory/Field work/Project work shall be done on the basis of one Internal Assessment test (5 marks), practical observation/ demonstration/*viva voce*/model making or presenting (5 marks) and attendance (5 marks).
- End-semester examination shall be conducted for all courses offered. The duration of the end-semester examination shall be 3 hours.
- Every student has to pay examination fee per Credit basis as fixed by the University.
- A schedule of end-semester examinations will be prepared and displayed by the University much in advance.
- No student with less than 75 % in any particular course shall be permitted to attend the end-semester examination and shall be given grade FA-failure due to lack of attendance. However, an overall condonation of 10 % is permitted for medical reasons. A student who has been awarded FA shall repeat the course when offered. The Principal/Head of the Department shall ensure that the candidate is informed about the lack of attendance before the commencement of end-semester examination and confirm that such candidates are not permitted to write the examination.
- To pass a course the student must secure minimum of 40 out of 100 marks (40 %) in the internal and in the end-semester examination.

- ❖ A student who has earned the required number of 120 credits by clearing all the required courses shall be declared as pass even if he/she could not clear optional courses which were taken in excess of the required number of courses.
- ❖ Result Passing Board for each Programme of Study shall be constituted by the Pondicherry University from time to time.
- ❖ Revaluation and re totaling of the answer scripts shall be allowed within the stipulated period of time as decided by the Controller of Examinations (COE) after paying the required amount of fee.

DISTRIBUTION OF MARKS

THEORY

Total: 100 Marks

End-Semester University Examination: 75 marks

Continuous Internal Assessment: 25 marks

[comprises of Internal assessment tests - 15 marks; term papers/assignments/seminars/case demonstrations/ presentations/write-ups/*viva voce* - 5 marks; Attendance - 5 marks]

- Requirement for minimum pass in Continuous Internal Assessment: 10 marks (40 %) out of 25 Marks
- Requirement for minimum pass in Term End University Examination: 30 marks (40 %) out of 75 Marks

For Skill Enhancement Course of Semester VI (SEC- 4 /APMB-361) Microbes and Their Applications (Advanced Credit Seminar) course's End-Semester examination (75 marks) shall be internally conducted and evaluated by the Department of Microbiology.

PRACTICALS

Total: 50 Marks

End-Semester University Practical Examination: **35 marks**

Continuous Internal Assessment: 15 marks

[one Internal Assessment test (5 marks), practical observation/ demonstration/*viva voce*/model making or presenting (5 marks) and attendance (5 marks)].

- Requirement for minimum pass in Continuous Internal Assessment: 6 marks (40 %) out of 15 Marks
- Requirement for minimum pass in Term End University Examination: 14 marks (40 %) out of 35 Marks

SUPPLEMENTARY EXAMINATION

- ❖ A failed student who meets the attendance requirement may be permitted to register for the next end-semester examination in the following semester itself.
- ❖ Students who have failed due to insufficient attendance and /or less than 40 % Internal Assessment marks should repeat the course as and when offered.

GRADING AND GRADE CARD

Letter grades shall be used to assess the performance of students in each course by converting final marks (out of 100) into grades. In case of fractions the marks shall be rounded off to next integer. The following shall be used to convert marks into awarding grades:

Range of Marks	**Letter Grade**	**Grade Point**
96-100	O	10
86-95	A+	09
76-85	A	08
66-75	B+	07
56-65	B	06
46-55	C	05
40-45	P	04
Below 40	F	00
Lack of Attendance	FA	00

- ❖ The Semester grade point average (SGPA) shall also be calculated by taking all courses taken by the student in the semester and Cumulative grade point average (CGPA) shall also be calculated by taking all the courses taken by the student in all the semesters.

- The University shall award "class" to students who acquired 120 (or as prescribed by Board of Studies) according to the following:

CGPA	**Class**
9.00 - 10.00	First class with Distinction (should not have failed in any course)
7.00 - 8.99	First Class
5.50 - 6.99	Second Class
4.00 – 5.49	Pass

- The Grade card shall be issued to the students containing grades obtained by the student in the previous semester SGPA and CGPA.

The Grade card shall list the following:

a. Title of the course taken by the student

b. Number of credits allotted to the course

c. The grades secured by the student in each course

d. Total number of credits earned by the student in that semester

e. SGPA of the student

f. Total number of credits earned by the student till that semester

g. CGPA of the student

QUESTION PAPER PATTERN

Theory External Examination (75 marks)

Time: 3 hours Max. Marks: 75

Part – A 10 X 2 = 20 Marks
(2 questions from each unit)

Part – B 5 X 5 = 25 Marks
(Short answer type - all 5 questions need to be answered, either or choice, minimum one question from each unit)

Part – C 3 X 10 = 30 Marks
(Essay answer type – 3 out of 5 questions to be answered, out of one question from each unit)

Practical External Examination (35 marks)

Time: 3 hours Max. Marks: 35

I. Question 1 (20 Marks)

II. Question 2 Spotters (5 Marks)

III. Record (10 Marks)
(Submission of practical record for the End Semester Practical Examination is mandatory).

Course Structure for B.Sc. Microbiology
Implemented from 2021-22 onwards

COURSE	SUBJECT CODE#	TITLE OF THE PAPER	CREDIT ALLOTED		Hours per week	
			Lecture	Tutorial/lab	Theory	Practicals
SEMESTER - I		**20 CREDITS**				
MIL – 1	LBEN/LHIN/LMAL/LSAN/LTAM/LTEL 111	Language – I	03		5	
ENGLISH – 1	ENGL 112	English – I	03		5	
DSC – 1A	APMB 111	Fundamentals of Microbiology	03		4	
DSC – 2A	APMB 112	Cell Biology	03		4	
DSC – 3A	APMB 113	Fundamentals of Biochemistry (Allied -I)	03		4	
DSC – 4A	APMB 111P	*Practicals - I Fundamentals of Microbiology*		01		2
DSC – 5A	APMB 112P	*Practicals - II Cell Biology*		01		2
DSC – 6A	APMB 113P	*Practicals - III Fundamentals of Biochemistry (Allied-I)*		01		2
AECC – 1	PADM 113	Public Administration	02		2	
SEMESTER - II		**20 CREDITS**				
MIL – 2	LBEN/LHIN/LMAL/ LSAN/LTAM/LTEL 121	Language – II	03		5	
ENGLISH – 2	ENGL 122	English – II	03		5	
DSC – 1B	APMB 121	Molecular Biology	03		4	
DSC – 2B	APMB 122	Immunology	03		4	
DSC – 3B	APMB 123	Clinical Biochemistry (Allied -II)	03		4	
DSC – 4B	APMB 121P	*Practicals - IV Molecular Biology*		01		2
DSC – 5B	APMB 122P	*Practicals - V Immunology*		01		2
DSC – 6B	APMB 123P	*Practicals - VI Clinical Biochemistry (Allied-II)*		01		2
AECC – 2	ENVS 123	Environmental Studies	02		2	

COURSE	SUBJECT CODE#	TITLE OF THE PAPER	CREDIT ALLOTED		Hours per week	
			Lecture	Tutorial/lab	Theory	Practicals
SEMESTER - III		**20 CREDITS**				
MIL – 3	LBEN/LHIN/LMAL/ LSAN/LTAM/LTEL 231	Language – III	03		5	
ENGLISH – 3	ENGL 232	English – III	03		5	
DSC – 1C	APMB 231	Bacterial Physiology and Metabolism	03		4	
DSC – 2C	APMB 232	Recombinant DNA Technology	03		4	
DSC – 3C	APMB 233	Economic and Medical Entomology (Allied - III)	03		4	
DSC – 4C	APMB 231P	*Practicals - VII Bacterial Physiology and Metabolism*		01		2
DSC – 5C	APMB 232P	*Practicals - VIII Recombinant DNA Technology*		01		2
DSC – 6C	APMB 233P	*Practicals - IX Economic and Medical Entomology (Allied-III)*		01		2
SEC – 1	APMB 234	Public Health Microbiology	02		2	
SEMESTER - IV		**20 CREDITS**				
MIL – 4	LBEN/LHIN/LMAL/ LSAN/LTAM/LTEL 241	Language – IV	03		5	
ENGLISH – 4	ENGL 242	English – IV	03		5	
DSC – 1D	APMB 241	Virology	03		4	
DSC – 2D	APMB 242	Medical Bacteriology	03		4	
DSC – 3D	APMB 243	Plant Pathology (Allied - IV)	03		4	
DSC – 4D	APMB 241P	*Practicals - X Virology*		01		2
DSC – 5D	APMB 242P	*Practicals - XI Medical Bacteriology*		01		2
DSC – 6D	APMB 243P	*Practicals - XII Plant Pathology (Allied-IV)*		01		2
SEC – 2	APMB 244	Mushroom and *Spirulina* Cultivation	02		2	

COURSE	SUBJECT CODE[#]	TITLE OF THE PAPER	CREDIT ALLOTED		Hours per week	
			Lecture	Tutorial/lab	Theory	Practicals
SEMESTER - V		**20 CREDITS**				
SEC – 3	APMB 351	Management of Microbiology Laboratory (Basic credit seminar)	02		4	
*DSE – 1A *DSE – 2A *DSE – 3A	APMB 352	Microbial Diversity and Bacterial Phylogeny	04		5	
	APMB 353	Medical Mycology and Parasitology	04		5	
	APMB 354	Pharmaceutical Microbiology	04		5	
	APMB 355	Industrial Microbiology	04		5	
	APMB 356	Biostatistics and Computer Applications	04		5	
	APMB 352P	*Practicals - XIII Microbial Diversity and Bacterial Phylogeny*		01		2
	APMB 353P	*Practicals - XIV Medical Mycology and Parasitology*		01		2
	APMB 354P	*Practicals - XV Pharmaceutical Microbiology*		01		2
	APMB 355P	*Practicals - XVI Industrial Microbiology*		01		2
	APMB 356P	*Practicals - XVII Biostatistics and Computer Applications*		01		2
GE – 1	APMB 357	Bioinformatics	03		5	
SEMESTER - VI		**20 CREDITS**				
SEC – 4	APMB 361	Microbes and their Applications (Advanced credit seminar)	02		4	
*DSE – 1B *DSE – 2B *DSE – 3B	APMB 362	Food and Dairy Microbiology	04		5	
	APMB 363	Microbial Ecology and Environmental Microbiology	04		5	
	APMB 364	Soil and Agricultural Microbiology	04		5	
	APMB 365	Haematology and Blood Banking	04		5	
	APMB 366	Microbial Production of Pigments, Flavour and Aroma Compounds	04		5	
	APMB 362P	*Practicals - XVIII Food and Dairy Microbiology*		01		2
	APMB 363P	*Practicals - XIX Microbial Ecology and Environmental Microbiology*		01		2
	APMB 364P	*Practicals - XX Soil and Agricultural Microbiology*		01		2
	APMB 365P	*Practicals - XXI Haematology and Blood Banking*		01		2
	APMB 366P	*Practicals - XXII Microbial Production of Pigments, Flavour and Aroma Compounds*		01		2
GE – 2	APMB 367	Microbial Genomics	03		5	

Total number of Credits - 120

[#] APplied MicroBiology; the first numeral stands for year of collegiate education; second numeral stands for number of the semester; third numeral is for serial number of the course: P - denotes practical course

*Among five papers, student have the choice of selecting any three papers (theory with practical course)

Abbreviations used : DSC- Discipline Specific Core course; AECC - Ability Enhancement Compulsory Course; SEC - Skill Enhancement Course; GE - Generic Elective course; DSE - Discipline Specific Elective course; MIL - Modern Indian languages

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SEMESTER – I

DSC - 1A

APMB111 FUNDAMENTALS OF MICROBIOLOGY (3 credits)

Course Objectives:

The objectives of the course include (i) to learn the basics of microbiology including, historical events (ii) to understand about the types of microscopy and intricate details of the bacterial cell. (iii) to appreciate various methods of sterilization employed to ensure aseptic conditions in microbiology works and (iv) lastly to know about the types of culture media employed to isolate the microorganisms.

Unit - I

History and scope of microbiology, spontaneous generation – biogenesis theory – contributions of Leeuwenhoek, Louis Pasteur, Robert Koch, Edward Jenner, Paul Ehrlich and Fleming.

Unit - II

Microscope– principles and application – simple and compound microscope – dark field – phase contrast, fluorescent microscope, SEM and TEM. Types of staining – simple, differential (Gram's, AFB), special – capsular staining (negative), spore, LPCB, KOH mount.

Unit - III

Ultrastructure of bacteria, cell envelope, cell wall– Gram positive and Gram negative bacterial cell wall, slime, flagella, capsule, pili.

Unit - IV

Sterilization and disinfection – principles – methods of sterilization – physical methods – dry heat –moist heat – radiation– filtration (membrane and HEPA)– chemical sterilization – chemical agents – mode of action. Preservation and maintenance of culture.

Unit - V

Culture and media preparation – solid and liquid. Types of media –semi synthetic, synthetic, enriched, enrichment, selective and differential media. Pure culture techniques – tube dilution, pour, spread, streak plate. Anaerobic cultivation of bacteria.

Text Books

1. Willey J.M., Sherwood L.M. and Woolverton C.J. (2013) Prescott's Microbiology, 9th Edn. McGraw-Hill Higher Education.
2. Madigan M.T., Bender K.S., Buckley D.H., Sattley W.M. and Stahl D.A. (2017) Brock Biology of Microorganisms, 15th Edn. (Global Edn.) Pearson Education.

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Reference Books

1. Talaro K.P. and Chess B. (2012) Foundations in Microbiology, 8th Edn. The McGraw Hill Companies.
2. Tortora G.J., Funke B.R. and Chase C.L. (2013) Microbiology: An Introduction, 11th Edn. Pearson-Benjamin Cummings.
3. Brown A. and Smith H. (2015) Benson's Microbiological Applications: Laboratory Manual in General Microbiology, 13th Edn. McGraw-Hill Companies.

Course Outcome:

Upon successful completion of the course the candidate will

- *be familiar with the history and development of Microbiology with the broad perspective of the scope of Microbiology.*
- *understand the principles and applications of the different microscopes and staining methods.*
- *have gained knowledge on the ultrastructure of bacteria.*
- *be acquainted with different methods of sterilization and preservation of cultures.*
- *understand the different types of media used for the cultivation of microbes.*

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DSC – 4A

APMB111P Practicals – I: FUNDAMENTALS OF MICROBIOLOGY (1 credit)

1. Handling of instruments and laboratory safety measures.
2. Handling and maintenance of compound microscope.
3. Cleaning of glasswares and preparation of cleaning solutions.
4. Staining techniques a. simple, b. differential staining (Gram's and Ziehl-Neelsen), c. special staining (spore and capsular staining methods) and wet-mount.
5. Hanging drop technique – motility.
6. Handling of laboratory instruments a. autoclave b. hot air oven c. laminar air flow d. pH meter.
7. Media preparation: a. liquid media – peptone water, nutrient broth; b. solid media – nutrient agar (agar slant, agar plate); c. enriched medium – blood agar; d. differential medium –Mac Conkey agar; e. enrichment medium – selenite F broth; f. selective medium – EMB, MSA.

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SEMESTER – I

DSC – 2A

APMB112 CELL BIOLOGY (3 credits)

Course Objectives:

The objectives of this course is to understand the basics of cell biology which is an essential part of any life science programme, it includes (i) to know about the history and broad classification of the cells types (ii) to appreciate the structural and functional roles of the cells in the daily life such as appreciating the role of the organelles and to value the life processes such as respiration and photosynthesis (iii) finally to comprehend the role of cell communication in life systems.

Unit - I

History of cell biology, cell as basic unit of life, cell theory, protoplasm theory and organismal theory, broad classification of cell types, Bacteria, Archaea (prokaryotic) and Eukaryotic cells and their similarities and differences.

Unit - II

Structure and functions of cell wall: bacterial cell wall – plant cell wall and fungal cell wall, plasma membrane – exocytosis, endocytosis, phagocytosis – vesicles and their importance in transport. Cytoskeleton structure – microtubules, microfilaments, intermediate filament.

Unit - III

Structure and functions of cell organelles – endoplasmic reticulum (rough endoplasmic reticulum and smooth endoplasmic reticulum), golgi apparatus, lysosomes, microbodies (peroxysomes and glyoxysomes), vacuoles, ribosomes, centriole and basal bodies.

Unit - IV

Mitochondria – organization of respiratory chain, chloroplasts – photophosphorylation, nucleus, nucleolus, nuclear membrane and organization of chromosomes, cell cycle and its check points, cell division (mitosis and meiosis).

Unit - V

Cell communication – overview – types of cell signaling – signal molecules – signal amplification – receptor types – quorum sensing.

Text Books

1. Verma P.S. and Agarwal V.K. (2016) Cell Biology (Cytology, Biomolecules, Molecular Biology), Paperback, S. Chand and Company Ltd**.**
2. Hardin J. and Bertoni G. (2017) Becker's World of the Cell, 9th Edn (Global Edition). Pearson Education Ltd.

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Reference Books

1. Cooper G.M. and Hausman R.E. (2016) The Cell – A Molecular Approach, 7th Edn. Sinauer Associates Inc.
2. Mason K.A., Losos J.B. and Singer S.R. (2017) Raven Johnson's Biology, 11th Edn. McGraw-Hill Education.
3. Karp G. (2010) Cell and Molecular Biology – Concepts and Experiments, 6th Edn. John Wiley and Sons.

Course Outcome:

Upon successful completion of the course the candidate will

- *be able to understand the history of cell biology and broad classification of cell types.*
- *have gained knowledge on the structure and functions of cell wall, plasma membrane, vesicles and cytoskeleton.*
- *understand the structure and functions of the nucleus and different cell organelles.*
- *understand cell division and the significance of cell cycle and its check points.*
- *have gained insight on types of cell signaling, signal amplification and quorum sensing.*

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DSC – 5A

APMB112P Practicals–II: CELL BIOLOGY (1 credit)

1. Study of plant and animal cell types basic structure using micrographs or model.
2. Study of bacterial cell structure, shape and arrangement using micrographs or model.
3. Blood as liquid tissue – demonstrating the different types of blood cells.
4. Cytoplasmic streaming in eukaryotic cells.
5. Stomatal cell type in plant tissues.
6. Mitosis demonstrated using onion root tip method
7. Studying the different cellular organelles of the eukaryotic and prokaryotic cells with animation and micrographs.
8. Demonstration of quorum sensing in bacteria using animation or micrographs.

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SEMESTER – I

DSC – 3A

APMB113 FUNDAMENTALS OF BIOCHEMISTRY (3 credits)
(Allied – I)

Course Objectives:

The objectives of including a basic biochemistry paper are (i) to learn about the structural and functional role of vital biomolecules like carbohydrates, proteins, fats, and nucleic acids in biological systems) (ii) to appreciate the role of biochemical processes in living organisms.

Unit-I

Chemistry of carbohydrates: definition and classification of carbohydrates, linear and ring forms (Haworth formula) for monosaccharides–disaccharides and glycosidic bond. Physical properties – mutarotation and kiliani cyanohydrin synthesis. Chemical properties – oxidation, reduction, osazone formation. Polysaccharides (homo and hetero): starch and cellulose – occurrence, structure, physical and chemical properties – reducing and non reducing sugar.

Unit-II

Chemistry of aminoacids and proteins: standard and non-standard amino acids and their properties, amphoteric nature, isoelectric point, isoelectric pH and Zwitter ion – Ramachandran plot for amino acids. Proteins: classification – shape and size, solubility, physical properties and functional properties. Primary, secondary, tertiary and quaternary structure of protein –protein folding – molecular chaperones.

Unit-III

Chemistry of lipids: definition, classification and functions. Occurrence, chemistry and biological functions – simple lipids: tertiary compound lipids (e.g. phospholipids), derived lipids: steroids (e.g. cholesterol). Saturated and unsaturated fatty acids physical property–emulsification. Chemical properties – saponification, rancidity, definition of acid number, saponification number, iodine number and Reichert-Meissl number. Bile acid and bile salt functions.

Unit-IV

Chemistry of nucleic acids: definition, sugar pucker – nucleoside, nucleotide and polynucleotide. Double helical model of DNA – super coil forms and linking numbers of DNA. Structure of RNA's– occurrence, chemistry and biological functions. Differences between DNA and RNA, properties– quantification of nucleic acids – thermal denaturation – cot curve and cot value, T_m, hypo and hyperchromicity.

Unit -V

Metabolic pathways: Glycolysis, TCA cycle and its energetics, electron transport chain and oxidative phosphorylation: Gluconeogenesis, Glyoxylate cycle; Entner-Doudoroff pathway. Deamination, transamination reaction, β – oxidation of fatty acids, Urea cycle.

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Text Books

1. Satynarayana T. (2005) Biochemistry, Books and Allied Pvt. Ltd.
2. Moore J.T. and Langley R. (2008) Biochemistry for Dummies, Wiley Publishing Company.

Reference Books

1. Nelson D.L and Cox M.M. (2017) Lehninger Principles of Biochemistry, 7th Edn. Intl. Edition, WH Freeman and Company.
2. Voet D. and Voet J.G. (2011) Biochemistry, 4th Edn. John Wiley and Sons Ltd.
3. Campbell M.K., Farrell S.O. and McDougal O.M. (2018) Biochemistry, 9th Edn. Brooks /Cole Cenage Learning.

Course Outcome:

Upon successful completion of the course the candidate will

- *understand the chemistry of carbohydrates and its classification.*
- *understand the chemistry of amino acids and hierarchy of protein structure – primary, secondary, tertiary and quaternary structure.*
- *able to comprehend the chemistry of lipids and nucleic acids.*
- *able to understand the metabolic pathways which occurs in living organisms.*

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DSC - 6A

APMB113P **Practicals – III: FUNDAMENTALS OF BIOCHEMISTRY (Allied -I)** **(1 credit)**

1. Estimation of HCl using Na_2CO_3 as link and NaOH as primary standard.
2. Estimation of iron in ferrous ammonium sulphate using potassium permanganate as link solution and oxalic acid as primary standard.
3. Estimation of glucose by Benedict's test.
4. Estimation of ascorbic acid.
5. Preparation of starch from potatoes.
6. Qualitative analysis of protein.
7. Qualitative analysis of fats.
8. Preparation of ovalbumin from egg.
9. Paper chromatography – analysis of amino acid.

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SEMESTER – II

DSC – 1B

APMB121 MOLECULAR BIOLOGY (3 credits)

Course Objectives:

The objective of exposing the molecular biology paper in this programme is (i) to understand the historical discoveries that shaped the molecular biology such as DNA discovery (ii) to appreciate the central dogma of molecular biology including transcription and translation (iii) to recognize the role of mutation in shaping the stability of life forms during the course of evolution

Unit-I

History of molecular biology, DNA and RNA as genetic materials, experiments of Griffith, Avery, Macleod and McCarty. Hershey and Chase, Leaderberg and Tatum, Chargaff's principles, primary and secondary structure of DNA and RNA. Alternative forms of DNA double helices – types of RNA.

Unit-II

DNA replication in prokaryotes: Replicons – models of DNA replication– origin and termination of replication – rolling circle replication – proof for semi conservative replication (Meselson and Stahl Experiment) – enzymes and proteins involved in DNA replication (nucleases, polymerases, ligases, helicases, gyrases, single strand binding protein, replisome and primosome) – mechanism of semi discontinuous replication.

Unit-III

Steps involved in transcription of prokaryotes, promoters, transcription factors, RNA polymerases I, II and III – ribosomal RNA transcription and processing – genetic code, deciphering the genetic code, characteristics of genetic code, Wobble hypothesis, central dogma of life and reversal of central dogma.

Unit-IV

Steps involved in translation of prokaryotes– role of proteasomes in protein degradation – mechanism of action of antibiotics on protein synthesis (puromycin, chloramphenicol and streptomycin). Regulation of gene expression in prokaryotes – polycistronic mRNA and operons (*lac* operon and *trp* operon and attenuation mechanism).

Unit-V

Mutation: spontaneous and induced mutations–UV and X - rays –mechanism of action of base analogues, alkylating agents, intercalating agents and teratogens – reversion suppressor mutations and mutation rate – repair of damaged DNA–excision repair, SOS, photoreactivation.

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Text Books

1. Verma P.S. and Agarwal V.K. (2016) Cell Biology (Cytology, Biomolecules, Molecular Biology), Paperback, S. Chand and Company Ltd**.**
2. McLennan A., Bates A., Turner P. and White M. (2012) Bios Instant Notes Molecular Biology, 4th Edn. Taylor & Francis.

Reference Books

1. Watson J.D., Baker T.A., Bell S.P., Gann A., Levine M., Losick R. and Harrison S.H. (2014) Molecular Biology of Gene, 7th Edn. Pearson Benjamin-Cummings.
2. Cox M.M., Doudna J.A. and O'Donnell M. (2012) Molecular biology: Principles and Practice, WH Freeman and Company.
3. Lodish H., Berk A., Kaiser C.A., Krieger M., Bretscher A., Ploegh H., Amon A. and Martin K.C. (2016) Molecular Cell Biology, 8th Edn. WH Freeman and Company.

Course Outcome:

Upon successful completion of the course the candidate will

- *comprehend the history behind the development of molecular biology*
- *acquaint oneself with the knowledge on DNA replication in prokaryotes.*
- *understand the steps involved in transcription of prokaryotes.*
- *understand the steps involved in translation of prokaryotes.*
- *understand the basis of spontaneous and induced mutation.*

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DSC – 4B

APMB121P Practicals– IV: MOLECULAR BIOLOGY (1 credit)

1. Introduction to molecular biology laboratory techniques and development skills.
2. Elaboration of DNA and RNA structure and forms using micrograph or animation.
3. Working on Agarose gel electrophoresis.
4. DNA isolation from *E .coli*.
5. DNA estimation– spectrophotometric method.
6. UV irradiation– Percent survival curve.
7. Transformation (demonstration).
8. Isolation of plasmids (demonstration).
9. Isolation of RNA from cells (demonstration).
10. Identification of bacterial phylogeny using 16S rRNA gene sequencing (demonstration).

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SEMESTER – II

DSC – 2B

APMB122 IMMUNOLOGY (3 credits)

Course Objectives:

The objectives of learning immunology are (i) to understand about the nature of infections and the natural immunity systems functioning in our body (ii) to appreciate the different type of immunoglobulin types and their unique role in immunity (iii) to identify the different assays used to quantify immunoglobulin molecules and to understand about hypersensitive reactions of cells.

Unit - I

History of immunology, host parasitic relationships, microbial infections – types – sources of infection – steps involved in infection – transmission of infection , virulence – toxigenicity and invasiveness, host resistance. Innate immunity and acquired immunity.

Unit - II

Structure, functions and properties of immune cells: stem cell, T cell, B cell, NK cell, macrophage, neutrophil, eosinophil, basophil, mast cell, dendritic cell and immune organs – bone marrow, thymus, lymph node, spleen, GALT, MALT, CALT.

Unit - III

Antigens– types, properties, haptens, adjuvants, vaccines – types – toxoids – antitoxins. Immunoglobulins – structure, types and properties. Hybridoma Technology, complement structure, properties, function of complement components and pathways.

Unit - IV

Antigen and antibody reactions: agglutination, precipitation, complement fixation, immunofluorescence, enzyme linked immuno sorbent assay (ELISA), radioimmunoassay.

Unit - V

Hypersensitivity reactions: antibody mediated – type I anaphylaxis – type II antibody dependent cell cytotoxicity – type III – immune complex reactions – type IV – delayed type hypersensitivity reactions. Cell mediated immune responses –lymphokines, cytokines.

Text Books

1. Owen J., Punt J. and Stranford S. (2013) Kuby Immunology, 7thEdn. Macmillan Education, India.
2. Shetti N. (2005) Immunology: Introductory Text book, 2nd Edn. New Age International Limited.

Reference Books

1. Lydyard P., Whelan A. and Fanger M. (2011) Bios Instant notes in Immunology, 3rd Edn. Garland Science publishers.
2. Delves P.J., Martin S.J., Burton D.R. and Roitt I.M. (2011) Roitt's Essential Immunology, 12th Edn. Wiley publishers.

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3. Brooks G., Carrol K.C., Butel J. and Morse S. (2012) Jawetz Melnick and Adelberg Medical Microbiology, 26th Edn. Lange Medical Publications.

Course Outcome:

Upon successful completion of the course the candidate will

- *understand the history of immunology and host parasitic relationships.*
- *understand the structure and functions of the cells and organs of immune system.*
- *gain insight on antigens, antibodies and complements.*
- *understand the different antigen-antibody reaction.*
- *gain knowledge on hypersensitivity and cell mediated immune response.*

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DSC –5B

APMB122P **Practical –V: IMMUNOLOGY** **(1 credit)**

1. Identification of human blood groups – forward and reverse grouping.
2. Separation of serum from blood sample (demonstration).
3. Separation of plasma from blood (demonstration).
4. Differential leukocyte count of the given blood sample.
5. Precipitation reaction: Ouchterlony double immunodiffusion test.
6. Radial immunodiffusion.
7. Counter immunoelectrophoresis (CIE).
8. Rocket electrophoresis.
9. Rapid plasma reagin (RPR) test.
10. Agglutination Test – Widal test.
11. Antistreptolysin O (ASLO) test.
12. ELISA (demonstration).

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SEMESTER – II
DSC – 3B

APMB123 CLINICAL BIOCHEMISTRY (3 credits)
(Allied – II)

Course Objectives:
Learning clinical biochemistry is (i) to appreciate the applications of biochemistry in clinical background (ii) to understand about the disorders and their impacts which resulted due to malfunctioning of carbohydrate, protein and lipid metabolism (iii) lastly to enlighten about the diagnostic enzymology under clinical conditions.

Unit-I

Basic concepts of clinical biochemistry: A brief review of units and abbreviations used in expressing concentrations and standard solutions. Biological samples – specimen collection–anticoagulant– preservatives for blood and urine – transport of specimens.

Unit - II

Disorders related to carbohydrate metabolism: diabetes mellitus–definition–WHO criteria – classification of diabetes mellitus – signs, symptoms and complications – GTT– galactosemia, galactosuria, fructosuria.

Unit - III

Disorders related to amino acid and lipid metabolism: Inborn errors of metabolism– phenylketonuria, alkaptonuria, albinism and tyrosinosis. Exogenous and endogenous transport of lipids–chylomicron transport, VLDL transport – reverse cholesterol transport– atherosclerosis–fatty liver– risk and anti-risk factors.

Unit - IV

Liver function test: detoxification and excretory functions – protein changes in liver disease- differential diagnosis of jaundice –hemolytic hepatic and obstructive jaundice– Bilirubin metabolism, bile pigment levels in blood and urine – gastric function test– fractional test meal analysis and its interpretation. GI hormones – gastrin, secretin, CCK and gastric inhibitory peptide.

Unit - V

Diagnostic enzymology: plasma enzymes–functional and non-functional enzymes– isoenzymes – enzyme patterns in acute pancreatitis, liver diseases and myocardial infarction.

Text Books

1. Ahmed N. (2010) Clinical Biochemistry. Oxford University Press.

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2. Vasudevan D.M. (2008) Textbook of Biochemistry for Medical Students, 5th Edn, Jaypee publishers.

Reference Books

1. Rodwell V.W., Bender D.A., Botham K.M., Kennelly P.J. and Weil P.A. (2015) Harper's Biochemistry, 30th Edn. McGraw Hill Education.
2. Sathya Narayana U. (1999) Biochemistry, 2nd Edn. Kolkata, Allied Publishers.
3. Mallikarjuna Rao N. (2002) Medical Biochemistry, 2nd Edn. New Age Publishers.

Course Outcome:

Upon successful completion of the course the candidate will

- *understand the basic concepts in clinical biochemistry.*
- *comprehend disorders related to carbohydrate metabolism.*
- *understand the disorders related to amino acid and lipid metabolism.*
- *understand the importance of liver functions and gastric functions and diagnosis of their disorders.*
- *understand the role of various enzymes in disease diagnosis, prognosis and assessment of response therapy.*

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DSC – 6B

APMB123P Practicals – VI: CLINICAL BIOCHEMISTRY (1 credit)

(Allied -II)

1. Blood sugar analysis.
2. Blood urea analysis.
3. Serum – creatinine estimation.
4. Serum –uric acid estimation.
5. Serum – cholesterol estimation.
6. Serum –bilirubin estimation.
7. Estimation of total protein.
8. Determination of A/G ratio.
9. Urine analysis.
10. Estimation of SGOT and SGPT.

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SEMESTER – III

DSC – 1C

APMB231 BACTERIAL PHYSIOLOGY AND METABOLISM (3 credits)

Course Objectives:

This subject is in congruent with the basic biochemistry paper leading (i) to gain knowledge about the types and role of nutrients in bacterial metabolism (ii) to provide a basic understanding about the transport of nutrients in cells (iii) to appreciate the anabolic and catabolic pathways which lies central to bacterial metabolism.

Unit–I

Nutritional classification of microorganisms – importance of various macro, micro elements and growth factors – Microbial growth – turbidometry and nephlometery. Continuous culture – synchronous culture – sporulation.

Unit-II

Transport of nutrients – uptake of nutrient – passive diffusion– facilitated diffusion– active transport (periplasmic binding protein and ABC transport) simple transport (uniport, symport and antiport) – group translocation and protein export system. Role of osmoregulatory proteins – permiomics.

Unit–III

Biosynthesis of cell structures from glucose (cell wall, capsule, flagella structure and synthesis, cell inclusions) – biochemistry of nitrogen fixation – nitrogenase enzyme – nitrogen assimilation – sulfate assimilation – Anaplerotic reactions in the catabolic pathways.

Unit–IV

Photosynthesis – characteristics and metabolism of autotrophs, anoxygenic photosynthetic bacteria and cyanobacteria – CO_2 fixation and mechanism of photosynthesis – chemotlithotrophs – hydrogen bacteria – nitrifying bacteria, sulphur bacteria and iron bacteria – methanogens – methylotrophs.

Unit–V

Central catabolic pathways – glycolysis, hexose monophosphate pathway, Entner Doudoroff pathway, tricarboxylic acid cycle – electron transport system–components – adenosine tri phosphate structure and their generation types – fermentations – types – anaerobic respirations.

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Text Books

1. Drummond J.T., White D. and Fuqua C. (2012) The Physiology and Biochemistry of Prokaryotes, 4thEdn. Oxford University Press.
2. Kim B.H. and Gadd G.M. (2008) Bacterial Physiology and Metabolism, Cambridge University Press.

Reference Books

1. Schaechter M. (Ed.) (2009) Physiology In: Encyclopedia of Microbiology, 3rd Edn. Academic Press.
3. Moat A.G., Foster J.W. and Spector M.P. (2002) Microbial Physiology, 4th Edn. Wiley-Liss Publishers.
2. Rosenberg E., Delong E.F., Lory S., Stackebrandt E. and Thompson F. (2013) The Prokaryotes: Prokaryotic Communities and Ecophysiology, 4th Edn. Springer Reference.

Course Outcome:

Upon successful completion of the course the candidate will

- *be familiar with the different nutritional classification of bacteria with an in depth knowledge on bacterial growth, growth curve and measurement of microbial growth.*
- *be able to get acquainted with different transport systems.*
- *have an added knowledge on biosynthesis of cell structures and physiology of nitrogen fixation.*
- *have got acquainted with carbon dioxide fixation and mechanism of photosynthesis.*
- *have acquired knowledge on central catabolic pathways*.

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DSC – 4C

APMB231P Practicals –VII: BACTERIAL PHYSIOLOGY AND METABOLISM

(1 credit)

1. Determination of growth curve of bacteria.
2. Bacterial population count by turbidity method.
3. Estimation of fungal growth by gravimetric estimation.
4. Effect of temperature on bacterial growth.
5. Effect of pH on bacterial growth.
6. Biochemical characterization of bacterial cultures: catalase, urease, cytochrome oxidase and sugar fermentation, citrate utilization, gelatin liquefaction, sulfide indole motility test.
7. Nitrification and denitrification by bacteria.
8. Biolog/API based biochemical tests (demonstration).

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SEMESTER – III

DSC – 2C

APMB232 **RECOMBINANT DNA TECHNOLOGY** **(3 credits)**

Course Objectives:

This course serves as an extension of molecular biology paper as its practical application, the specific objectives are (i) to get introduced about the concept of recombinant DNA (rDNA) technology (ii) to appreciate the types and role of vectors in rDNA technology (iii) to know the steps in gene library construction (iv) to translate the rDNA basics as application in various fields.

Unit - I

Introduction to recombinant DNA technology –tools for rDNA technology –DNA manipulative enzymes: restriction enzymes, ligases, polynucleotide kinase, phosphatase, cutting of DNA molecules – joining of DNA molecules – homopolymer tails, linkers, adapters.

Unit - II

Gene cloning vectors: salient features, plasmids – properties, types, pBR322 and pUC18, bacteriophage vectors –λ, λZAP, λgt11, cosmids, artificial chromosomes – BAC, YAC, MAC. Cloning bovine somatotropin gene in *E. coli*.

Unit - III

Transformation of r-DNA into target host organisms: calcium chloride mediated gene transfer, *Agrobacterium* mediated DNA transfer, electroporation, microinjection, liposome fusion, particle gun bombardment. Screening and selection of recombinant host cells: blue/white screening.

Unit - IV

Construction of gene libraries: genomic and cDNA libraries. Blotting techniques, polymerase chain reaction (PCR) and its applications.

Unit - V

Applications of rDNA technology in industry, medicine, agriculture and pharmacy.

Text Books

1. Primrose S.B. and Twyman R.M. (2006) Principle of Gene Manipulation and Genomics, 7th Edn. Blackwell Publishing.
2. Nicholl D.S.T (2008) An Introduction to Genetic Engineering, 3rd Edn. Cambridge University Press.

Reference Books

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1. Brown T.A. (2016) Gene Cloning and DNA Analysis – An Introduction, 7th Edn. Wiley-Blackwell.
2. Glick B.R. and Patten C.L. (2017) Molecular Biotechnology. Principles and Application of Recombinant DNA, 5th Edn. ASM Press, Washington.
3. Watson J.D., Gann A., Baker T.A., Levine M., Bell S.P. and Losick R. (2014) Molecular Biology of Gene, 7th Edn. Pearson publishers.

Course Outcome:

Upon successful completion of the course the candidate will

- *get acquainted with the basic tools used in recombinant DNA technology.*
- *understand the different gene cloning vectors.*
- *have learnt the techniques in transformation of recombinant DNA into target host organisms.*
- *understand the construction of gene libraries, blotting techniques and PCR.*
- *understand the various applications of recombinant DNA technology in various fields.*

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DSC – 5C

APMB232P Practicals-VIII: RECOMBINANT DNA TECHNOLOGY (1 credit)

1. Agarose gel electrophoresis.
2. Isolation of total bacterial DNA.
3. Isolation of yeast DNA.
4. Isolation of DNA from red blood cells.
5. Isolation of plasmid DNA.
6. Restriction digestion.
7. Ligation.
8. Production of competent *E. coli* cells.
9. Transformation of bacteria and isolation of transformants.

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SEMESTER – III

DSC – 3C

APMB233 ECONOMIC AND MEDICAL ENTOMOLOGY (3 credits)
(Allied – III)

Course Objectives:

The paper emphasis the economic and medical entomological importance to human kind. The objectives are (i) to impart a basic knowledge about the beneficial insects to human kind (ii) to appreciate the importance of pest management strategies (iii) to develop an understanding over the various types of pests attacking the crop plants and human disease vectors.

Unit-I

Classification of insects according to Order –Pests of crops: any three pests for each crop, their life cycle and control measures: food crops – rice, sorghum; pulses – red gram, green gram, black gram; cash crops – sugarcane; fibre – cotton; oilseeds – groundnut, coconut; vegetables – brinjal, tomato, ladies' finger; spices; condiments and beverages – cardamom, chilly, tea, coffee; fruit trees – mango, citrus, grapes.

Unit-II

Pests of stored products, their life cycle and control: beetles – red grain beetle; rice weevil, paddy bore beetle, pulse beetle, carpet beetle; moths– paddy grain moth, rice meal worm. Termites and their control– insect vectors of plant diseases and their control.

Unit-III

Beneficial insects: honeybee, silkworm, lac insects – their biology, life cycle and uses to humankind. Insect predators, parasites and parasitoids that destroy crop pests and other harmful insects of human live stocks.

Unit-IV

Principles of insect pest management using physical mechanical, biological, chemical and legal methods. Classification of pesticides and their formulations, both inorganic and organic – mode of their action. Biocides and their efficacy – a brief outline – precautions in handling pesticides and environmental pollution – biological control agents used in agriculture.

Unit-V

Vector borne human diseases– mechanisms of transmission– types of vectors and their identification. (tsetse flies, black flies, sand flies, ticks, mites, lice, bed bugs, fleas, mosquitos) – vector borne disease, mode of infection and control – lyme disease– typhus – Rickettsia – Rocky mountain spotted fever –Equine infectious anemia– Chagas disease.

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Text Books

1. David B.V. and Ramamurthy V.V. (2016) Elements of Economic Entomology, Paperback, 8th Edn. Brillion Publishing.
2. Shukla A. (2009) A Handbook Economic Entomology, Daya Publishing House.

Reference Books

1. Prasad T.V. (2015) Handbook of Entomology, 3rd Edn. New Vishal Publications.
2. Riley W.A. (2017) Handbook of Medical Entomology (Classic Reprint), Forgotten Books.
3. Dhooria M.S. (2008) Ane's Encyclopedic Dictionary of General and Applied Entomology, Ane's Books India, Co published by Springer, Netherlands.

Course Outcome:

Upon successful completion of the course the candidate will

- *understand the classification of insects according to Order, pests of crops, their life cycle and control measures.*
- *be able to gain knowledge on pests of stored products, their life cycle and control measures*
- *be familiar with the beneficial insects, harmful insects of human live stocks.*
- *be able to understand the principles of insect pest management.*
- *have acquired knowledge on vector borne diseases.*

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DSC – 6C

APMB233P Practicals–IX: ECONOMIC AND MEDICAL ENTOMOLOGY (1 credit) (Allied -III)

1. Collection, preservation and display of insects (representing any 15 insect orders).
2. External morphology of an insect (e.g. grasshopper).
3. Demonstration of Insects metamorphosis.
4. Life cycle of honey bee; beehive and their parts.
5. Rearing of mulberry silkworms.
6. Collection, observation and importance of crop pests.
7. Collection, observation and importance of storage pests.
8. Collection of medically important pests and understanding their role in human diseases.

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SEMESTER – III

SEC– 1

APMB234 PUBLIC HEALTH MICROBIOLOGY (2 credits)

Course Objectives:

This paper helps in skill enhancement with the objectives (i) to comprehend the role of microbiology in public health (ii) to discern the airborne and food borne pathogens in public health (iii) to develop an understanding over nosocomial infections.

Unit - I

Introduction to public health: definition, scope, concept and importance of public health microbiology – roles of microbiologist in public health – microbial association of water, air and soil.

Unit - II

Air borne infections: air and its composition – indoor air – outdoor air – air borne diseases (bacterial, fungal and viral) – methods of enumeration of microorganisms in air

Unit - III

Water borne infections: kinds of water – water borne diseases (viral, bacterial, protozoan) – methods of enumeration of microorganisms in water – indicator organism – water treatment, control of water borne diseases.

Unit - IV

Food borne diseases: definition and importance of food hygiene – types (spoilage of meat and its products, fish and fish products and eggs) – role of microorganisms in food spoilage and poisoning – food borne diseases – types of food borne diseases

Unit - V

Hospital acquired infection: Prophylactic immunization – disposal of infective hospital and laboratory materials – monitoring of sanitation in community – techniques used for the diagnosis of hospital acquired infection.

Text books

1. Ghimire P. and Parajuli K. (2005) A Text Book of Microbiology, Vidhyarthi Pustak Bhandar Publication, Kathmandu.
2. Brownson, R.C., Baker, E.A., Leet T.L. and Follespie K.N. (2003) Evidence Based Public Health, Oxford University Press.

Reference books

1. Engelkirk P.G. and Duben-Engelkirk J. (2015) Burton's Microbiology for the Health Sciences, 10th Edn. Wolters Kluwer Health.

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2. Park K. (2017) Parks Text Book of Preventive and Social Medicine, Banarsidas Bhanot Publishers.
3. Jay J.M., Loessner M.J. and Golden D.A. (2005) Modern Food Microbiology, 7th Edn. Springer.

Course Outcome:

Upon successful completion of the course the students will

- *understand the importance of Public Health Microbiology.*
- *have gained understanding on the air borne diseases and methods used in the enumeration of microorganisms in air.*
- *have an understanding on water borne diseases and enumeration of microorganisms in water.*
- *have a basic knowledge on food borne diseases and its types.*
- *have an understanding on hospital acquired infections*.

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SEMESTER – IV

DSC – 1D

APMB241 **VIROLOGY** **(3 credits)**

Course Objectives:

This course exposes the students (i) to learn about the classification of various types of viruses (ii) to familiarize about the replication and morphological features of the viruses (iii) to impart knowledge about the mode of transmission, multiplication, infection and control of commonly occurring viruses.

Unit - I

General properties – structural – classification – cultivation – isolation and identification of animal viruses, plant viruses, bacterial, algal and fungal viruses and insect viruses.

Unit - II

Eukaryotic DNA virus replication, eukaryotic RNA virus replication. Viral propagation – chick embryo and cell lines. Purification and assay. Laboratory diagnosis of viral diseases. Viral vaccines, interferons and antiviral drugs.

Unit - III

Morphology, classification, characteristics pathogenicity, laboratory diagnosis, prevention and control of infections produced by the following group of viruses. Adeno virus, Pox virus, Herpes virus, Papilloma virus, viral Hepatitis, Ebola and Zika viruses.

Unit – IV

Morphology, classification, characteristics pathogenicity, laboratory diagnosis, prevention and control of infections produced by the following group of viruses. Polio, HIV, Picorna viruses, Influenza and Rhabdo viruses. Teven and Todd phages, viriods and prions.

Unit - V

Arbo viruses: Flavi viruses – Yellow fever viruses – Dengue virus – Chickungunya virus – Japanese encephalitis virus.

Text Books

1. Singh V. (2010) Text book of Virology, 1st Edn. IBDC publishers.
2. Oarsman S.N.J., van Zyl G.U., Nutt L., Anderson M.I. and Preiser W. (2012) Virology Illustrated colour text, 1st Edn. Elsevier Health Sciences.

Reference Books

1. Carter J. and Saunders V. (2013) Virology: Principles and Applications (paperback) 2nd Edn. Wiley-Blackwell Publishers.

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2. Dimmock, N.J., Easton A.L. and Leppard, K.N. (2007). Introduction to Modern Virology. 6th Edn. Blackwell Publishing Ltd.
3. Flint, S.J., Enquist, L.W., Krug, R.M., Racaniello V.R. and Skalka A.M. (2004). Principles of Virology, Molecular Biology, Pathogenesis and Control, 2nd Edn. ASM press Washington DC.

Course Outcome:

Upon successful completion of the course the candidate will

- *have learnt about the general properties, classification and cultivation of viruses.*
- *be conversant in eukaryotic DNA and RNA virus replication, viral propagation and laboratory diagnosis of viral diseases.*
- *have gained an insight on the spectrum of diseases caused by viral pathogens and their control*

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APMB241P **Practicals – X: VIROLOGY** **(1 credit)**

1. Isolation of bacteriophage from sewage sample.
2. Preparation of bacteriophage stock.
3. Titration of bacteriophage.
4. One step growth of bacteriophage.
5. Plaque assay.
6. Chick embryo inoculation (demonstration).
7. Study of plant viral symptoms (demonstration).
8. Study of disease symptoms caused by viroids (demonstration).
9. Animal inoculation (demonstration).

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SEMESTER – IV

DSC – 2D

APMB242 MEDICAL BACTERIOLOGY (3 credits)

Course Objectives:

It is one of the applied papers of microbiology and the course learning objectives are (i) to understand about the role of microbes in causing diseases (ii) to acquaint with the morphology, cultural, pathogenicity and laboratory diagnosis characteristics of common human pathogens.

Unit - I

Infection: definition, sources of infection, types of infections, methods of transmission of infections. General attributes and virulence factors of bacteria causing infections**.**

Unit - II

Collection and transport of specimens for microbiological examination. Clinical diagnosis of sexually transmitted diseases, urinary tract infections and hospital acquired infections. Methods of disposal of hospital waste.

Unit - III

Morphology, classification, cultural characteristics, pathogenicity, laboratory diagnosis and prevention of infections caused by the following organisms: *Staphylococcus aureus, Streptococcus pyogenes, Streptococcus pneumoniae, Neisseria meningitidis, Neisseria gonorrhoeae, Corynebacterium diphtheriae, Clostridium tetani.*

.

Unit – IV

Morphology, cultural characteristics, pathogenicity, laboratory diagnosis and prevention of infections caused by the following organisms: *Escherichia coli, Shigella, Salmonella, Vibrio cholerae, Pseudomonas, Mycobacterium tuberculosis, Mycobacterium leprae.*

Unit - V

Morphology, cultural characteristics, pathogenicity, laboratory diagnosis and prevention of infections caused by the following organisms: Zoonotic bacterial diseases such as plague, anthrax, leptospirosis, brucellosis.

Text Books

1.Collee, J.C., Fraser A.C., Marmion B.P. and Simmons A. (2007) Mackie & McCartney Practical Medical Microbiology, 14th Edn. Elsevier Health Sciences.

2. Ananthanarayan R. and Kapil A. (2013) Ananthanarayan & Panicker's Text book of Microbiology, 9thEdn. Paperback, Orient Black Swan.

Reference Books

1. Forbes B.A., Sham D.E. and Weissfeld A.S. (2007) Bailey and Scotts Diagnostic Microbiology 12th Edn, Mosby Publications.

2. Brooks G., Carrol K.C., Butel J. and Morse S. (2012) Jawetz Melnick and Adelberg Medical Microbiology, 26th Edn. Lange Medical Publications.

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3. Greenwood D., Slack R.C.B., Barer M.R. and Irving W.L. (2012) Medical Microbiology, 18th Edn. Elsevier Churchill Livingstone.

Course Outcome:

Upon successful completion of the course the candidate will

- *understand the basis of infection and the virulence of bacteria causing infections.*
- *become acquainted with the basic concepts of collection and transport of clinical specimens.*
- *have gained knowledge on variety of bacteria causing infections and their prevention.*
- *understand zoonotic bacterial diseases and their prevention.*

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DSC – 5D

APMB242P Practicals XI: MEDICAL BACTERIOLOGY (1 credit)

1. General requirements of collection, transport of clinical specimens, direct examination, staining of specimens, methods of enriched, selective, and enrichment culture techniques used to isolate organisms from clinical specimens.
2. Simple, differential and special staining of clinical material.
3. Isolation of microflora from human throat.
4. Differential test of *Staphylococcus* by examining growth on agar plates.
5. Antimicrobial sensitivity Testing.
6. Quantitative urine culture.
7. Isolation and identification of bacterial pathogens from clinical specimens.
8. Biochemical tests for identification of selected pathogens.
9. Identification of ectoparasites – mosquitoes, fleas, lice, mites, ticks, etc. (spotters only).

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SEMESTER – IV

DSC – 3D

APMB243 **PLANT PATHOLOGY** **(3 credits)**

(Allied – IV)

Course Objectives:

An application oriented paper of microbiology focusses with primary objectives for (i) understanding the disease triangle with emphasis on disease cycle and pathogenicity (ii) identifying the role of virulence factors and their impact as physiological response (iii) imparting knowledge on the common plant diseases from the stand point of etiological agents.

Unit- I

Concept of plant disease – definitions of disease, disease cycle and pathogenicity, symptoms associated with microbial plant diseases, types of plant pathogens, economic losses and social impact of plant diseases. Significant contributions by scientists in the field of plant pathology.

Unit-II

Infection, invasion, colonization, dissemination of pathogens and perennation. Concepts of monocyclic, polycyclic and polyetic diseases, disease triangle and disease pyramid, forecasting of plant diseases and its relevance in Indian context.

Unit-III

Virulence factors of pathogens: enzymes, toxins (host specific and nonspecific) growth regulators, virulence factors in viruses (replicase, coat protein, silencing suppressors) in disease development. Effects of pathogens on host physiological processes (photosynthesis, respiration, cell membrane permeability, translocation of water and nutrients, plant growth and reproduction).

Unit-IV

Concept of resistance (*r*) gene and avirulence (*avr*) gene; gene for gene hypothesis, types of plant resistance–Concepts of constitutive defense mechanisms in plants, inducible structural defenses –inducible biochemical defenses hypersensitive response (HR), systemic acquired resistance (SAR), phytoalexins, pathogenesis related (PR) proteins, plantibodies, phenolics, quinones, oxidative bursts.

Unit-V

Basic principles of the disease management –study of important plant diseases with emphasis on its etiological agent, symptoms, epidemiology, life cycle and management: fungal diseases – diseases of phytopathogenic bacteria – phytoplasmas – viruses and viroids.

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Text Books

1. Ravichandra N.G. (2013) Fundamentals of Plant Pathology, PHI Learning Pvt Ltd.
2. Vidyasekharan P. (2010) Principles of Plant Pathology. CBS Publishers & Distributor's.

Reference Books

1. Vidhyasekaran P. (2004) Concise Encyclopedia of Plant Pathology. CRC Press.
2. Sharma J.N., Karthikeyan G. and Sh. Mohinder Singh (2007) Fundamentals of Plant pathology. ICAR E-course.
3. Agrios G.N. (2005) Plant Pathology, 5th Edn. Elsevier Academic Press.

Course Outcome:

Upon successful completion of the course the candidate will

- *understand the concept of plant diseases.*
- *have gained understanding on disease triangle and disease pyramid.*
- *have become acquainted with the virulence factors of pathogens and effects of pathogens on host physiological processes.*
- *understand the concept of resistance and avirulence gene.*
- *gain an in-depth knowledge on basic principles of disease management.*

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DSC – 6D

APMB243P **Practicals – XII: PLANT PATHOLOGY (1 credit)**
(Allied -IV)

1. Preparing a plant pathology herbarium
2. Study of important diseases of crop plants by preparing cross sections and microscopic examination fungal conspicuous structures from infected plant materials – (a) *Albugo* and *Puccinia.*
3. Study of important diseases of crop plants by preparing cross sections and microscopic examination fungal conspicuous structures from infected plant materials – (a) *Ustilago* and *Colletotrichum*.
4. Study of important diseases of crop plants by preparing cross sections and microscopic examination fungal conspicuous structures from infected plant materials – (a) *Fusarium* (b) *Verticillium* (c) *Rhizoctonia*
5. Critical examination of citrus canker symptoms from infected samples.
6. Examining diseased cereal crops for various disease symptoms, identification and microscopic examination.
7. Examining diseased pulse crops for different disease symptoms identification and microscopic examination.
8. Examining diseased cash crops for different disease symptoms identification and microscopic examination.

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SEMESTER – IV

SEC– 2

APMB244 MUSHROOM AND SPIRULINA CULTIVATION (2 credits)

Course Objectives:

The course imparts entrepreneurial skills with objectives (i) to learn about the types of edible mushrooms and their uses to human kind (ii) to gain knowledge on cultivation methods for mushroom and the diseases that commonly affect them (iii) to appreciate the importance of Spirulina to human kind, understanding their cultivation methods and processing techniques.

Unit - I

Edible and non-edible mushroom –historical account, most commonly cultivated mushrooms in the world, distribution and production in various countries.

Unit - II

Cultivation of button, oyster and paddy straw mushroom –raising a pure culture – spawn preparation and mass cultivation – harvest pests and diseases in mushroom

Unit – III

Economics of mushroom cultivation – precautions in mushroom cultivation –precaution to be taken while selecting the area, spawn preparation, spawn run, during cropping harvesting etc. Mushroom recipes (western and Indian recipes, pickles, powders, jams etc.

Unit – IV

Introduction to SCP production –historical use and rediscovery of *Spirulina* importance– morphology, taxonomy and habitat of *Spirulina*– biochemical composition including proximate composition – amino acids – unsaturated fatty acids – minerals and vitamins. Human health benefits of *Spirulina*.

Unit - V

Natural production –laboratory cultivation – small scale commercial production – commercial and mass cultivation (tank construction, culture medium, strain selection, scaling up of the process) – importance of light and pH in *Spirulina* cultivation – harvesting, drying and packing.

Text Books

1. Changs T. and Hayanes W.A. (Ed.) (1978) Biology and Cultivation of Edible Mushrooms. Academic Press. N.Y.
2. Habib M.A.B., Parvin M., Huntington T.C. and Hasan M.R. (2008) A review on culture, production and use of *Spirulina* as food for humans and feeds for domestic animals and fish. FAO Fishers and Aquaculture Circular No. 1034, FAO, Rome, Italy.

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Reference books

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1. Biswas S., Datta M. and Ngachan S.V. (2012) Mushrooms: A Manual for Cultivation, PHI.
2. Selvendran D. (2015) Large Scale Algal Biomass (*Spirulina*) Production in India. In: D. Das (Ed.) Algal Biorefinery: An Integrated Approach, Springer.
3. Zadrazil F. and Grabbe K. (1983) Edible Mushroom, Biotechnology Vol. 3, Weinheim: Verlag Chemie, Berlin.

Course Outcome:

Upon successful completion of the course the candidate will

- *gain understanding on the edible mushrooms, its distribution and production in various countries.*
- *gain insight on the cultivation of various mushrooms.*
- *gain knowledge on economics of mushroom cultivation and preparation of various mushroom recipes.*
- *understand the importance of Spirulina and their cultivation methods.*

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SEMESTER – V

SEC– 3

APMB351 MANAGEMENT OF MICROBIOLOGY LABORATORY
(Basic credit seminar) (2 credits)

Course Objectives:

A skill based learning course with objectives (i) to understand the rules and regulations of microbiological laboratory maintenance (ii) to familiarize with the instruments and quality control measures commonly adopted in microbiology laboratory (iii) to know about the procedures involved in strain maintenance and laboratory waste disposal.

Unit - I

Rules and regulations to be followed in a microbiology laboratory – maintenance of records –familiarizing with common chemicals, instruments and equipments of microbiology laboratory.

Unit - II

Laboratory management: human resources – logistics and supply – test performance – data management – resource tapping – instruments – water and sources of light and electricity – room– table and benches and space in the laboratory.

Unit - III

Laboratory quality control assessment: Internal quality control and external quality control.

Unit - IV

Maintenance of type strains or reference strain of microbes: culture collection centres – preservation and maintenance of cultures.

Unit - V

Laboratory waste disposal system: national and international guidelines for the disposal of waste. Basic concepts of bio-safety and its universal precautions.

Text books

1. Cappuccino J.G. and Sherman N. (2014) Microbiology a laboratory manual. 10thEdn. Pearson.
2. Gile, T.J. and Scungio D. (2014) Complete guide to Laboratory safety, 4th Edn. HCPro a division of BLR.

Reference books

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1. Emmert E. (2013). Biosafety guidelines for handling microorganisms in the teaching laboratory: development and rationale. Journal of Microbiology & Biology Education14: 78–83.

Course Outcome:

Upon successful completion of the course the candidate will

- *become familiar with the rules and regulations to be followed in Microbiology laboratory.*
- *become acquainted with management of laboratory.*
- *gain knowledge on laboratory quality control assessment.*
- *have an understanding on maintenance of type strains.*
- *have an idea on laboratory waste disposal system and biosafety.*
- *develop experience in public speaking, that may foster development of oral communication.*

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SEMESTER – V

DSE – 1A

APMB352 MICROBIAL DIVERSITY AND BACTERIAL PHYLOGENY (4 credits)

Course Objectives:

This paper exposes the students to appreciate the world of bacteria, the students will be able (i) to understand about the Big Tree of Life (ii) to provide an overview on bacterial taxonomy and Bergey's Manual (iii) to study the role played by candidate phyla.

Unit -I

Microbial Big Tree of Life – The domain Archaea – Bacteria –Eukaryotes – Eukaryotic tree of life – Endosymbiosis theory and the role of horizontal gene transfer in shaping of domains – Different types of microbial diversity – Importance of microbial diversity – Methods of examining microbial diversity.

Unit-II

Eukaryotic diversity and Bacterial phylogeny –Fungal diversity – Protist (algae and protozoa) diversity – Viral diversity – their importance and role in shaping human community. History of bacterial classification – Concept of bacterial phylogeny – Phylogenetic markers – Polyphasic taxonomy – Overall view of bacterial phyla – Bergey's Manual of Systematic Bacteriology (2^{nd} Edn.).

Unit-III

Archaea and Gram negatives:– An overview of their ecological occurrence, morphological diversity, structural, metabolic and genetic diversity, their importance and classification of Archaeal phyla – Gram negative bacteria including cyanobacteria – Deeply branching phyla – Proteobacteria – their classes.

Unit-IV

Gram Positives and heterogeneous members**:** Overall view of– ecological occurrence, morphological diversity, structural, metabolic and genetic diversity, their importance and classification of phyla Firmicutes – Actinobacteria – Bacteroidetes – Spirochetes – Tenericutes (Mollicutes) – Acidobacteria – Planctomycetes – Verrucomicrobia – Chlamydia.

Unit-V

Uncultivated majorities: The Great Plate count anomaly – novel bacterial cultivation strategies – cultivation independent methods of assessing bacterial diversity – Candidatus status of the bacteria – Candidate phyla radiation – their importance.

Text Books

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1. Brown J.W. (2015) Principles of Microbial Diversity, ASM Press.
2. Madigan M.T., Bender K.S., Buckley D.H., Sattley W.M. and Stahl D.A. (2017) Brock Biology of Microorganisms, 15th Edn. (Global Edn.) Pearson Education.

Reference Books

1. Epstein S.S. (2009) Uncultivated microorganisms, Springer-Verlag Publishers.
2. Rosenberg E., DeLong E., Lory S., Stackebrandt E. and Thompson F.(Ed.) (2013) The Prokaryotes (Total of eleven reference book series), Springer-Verlag publishers.
3. Bertrand J.C., Caumette P., Lebaron P., Matheron R., Normand P. and Sime-Ngando T. (Eds.) (2015) Environmental Microbiology: Fundamentals and Applications, Springer Publishers.
4. List of Prokaryotic Names with Standing in Nomenclature (LPSN)- Prokaryotic Nomenclature Up-to-date (PNU) merged site-https://lpsn.dsmz.de/

Course Outcome:

Upon successful completion of the course the candidate will

- *understand the Microbial Big Tree of Life*
- *have an in-depth knowledge on different types of microbial diversity and its importance.*
- *understand bacterial taxonomy - Bergey's manual.*
- *have an understanding on uncultivated majorities and their importance.*

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DSE – 6A

APMB352P Practicals– XIII: MICROBIAL DIVERSITY AND BACTERIAL PHYLOGENY (1 credit)

1. Microscopic observation of bacteria, fungi, algae, protozoa.
2. Isolation and observation on a Gram positive bacteria.
3. Isolation and observation of a Gram negative bacteria.
4. Observation of morphologically distinct cyanobacteria.
5. Observation of morphologically distinct algal populations.
6. Observation of fungi and their types – spores.
7. Comparative observation of fungi and actinobacteria.
8. Isolation and observation of an Archaea.
9. Demonstrating the great plate count anomaly.
10. Visit to microbial rich environments like solar saltern, lakes and demonstrate the presence of distinct and conspicuous microorganisms.

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SEMESTER – V

DSE – 2A

APMB353 MEDICAL MYCOLOGY AND PARASITOLOGY (4 credits)

Course Objectives:

It is an applied microbiology related paper included with the objectives (i) to provide an overview of fungal classification. (ii) to develop an understanding over the collection, transport and detection of fungal pathogens (iii) to understand the role of medical parasitology to human kind.

Unit - I

General properties of fungi – morphology, taxonomy, nomenclature and classification of medically important fungi – virulence factors of fungi causing infection.

Unit -II

Collection, transport and processing of clinical specimens for detection of superficial, subcutaneous and systemic mycoses. Dermatophytes – *Trichophyton –Microsporum* – epidermophyton – dermatophytosis, superficial mycoses – Tinea versicolor, Tinea nigra, Black piedra , White piedra**.**

Unit -III

Subcutaneous mycoses – mycetoma, dimorphic fungi causing systemic mycoses – *Histoplasma capsulatum – Blastomyces dermatitidis – Coccidioides immitis – Paracoccidioides brasiliensis*. Opportunistic mycoses – Candidiasis, Cryptococcosis, Aspergillosis, Zygomycosis.

Unit –IV

Introduction to medical parasitology– morphology, classification, characteristics, pathogenesis, laboratory diagnosis, prevention and control of the following agents. *Entamoeba histolytica, Giardia lamblia, Trichomonas vaginalis, Trypanosoma brucei.*

Unit –V

Morphology, classification, characteristics, pathogenesis, laboratory diagnosis, prevention and control of the following agents. *Leishmania donovani, Leishmania tropica, Plasmodium falciparum, Balantidium coli, Taenia saginata, Taenia solium, Ascaris lumbricoides.*

Text Books

1. Chander J. (2009) Text Book of Medical Mycology, 3rd Edn. Mehta Publishers.
2. Ananthanarayan R. and Kapil A. (2013) Ananthanarayan & Panicker's Text book of Microbiology, 9th Edn. Paperback, Orient Black Swan.
3. Parija S. C. (2013) Text Book of Medical Parasitology – Protozoology and Helminthology, 4th Edn. All India Publishers and Distributors, New Delhi.

Reference Books

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1. Reiss E. Shadomy H.J. and Lyon G.M. (2011) Fundamental Medical Mycology, Wiley-Blackwell.
2. Brooks G., Carrol K.C., Butel J. and Morse S. (2012) Jawetz Melnick and Adelberg Medical Microbiology, 26th Edn. Lange Medical Publications.
3. Chatterjee K.D. (2009) Parasitology: Protozoology and Helminthology, 13th Edn. CBS Publishers & Distributors Pvt. Limited.

Course Outcome:

Upon successful completion of the course the candidate will

- *gain understanding on the general properties of fungi and classification of medically important fungi.*
- *gain insight on collection, transport and processing of clinical specimens for detection of fungal pathogens.*
- *have an understanding on superficial, subcutaneous, systemic and opportunistic mycosis.*
- *have a knowledge on different parasites affecting man and their control.*

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DSE – 7A

APMB353P Practicals – XIV: MEDICAL MYCOLOGY AND PARASITOLOGY (1 credit)

1. KOH preparation for skin scrapings for fungi.
2. Lactophenol preparation for fungi – *Aspergillus*, *Rhizopus* and *Mucor*.
3. Germ tube test for *Candida albicans*.
4. Wet mount preparation for *Candida* and *Cryptococcus*.
5. Sugar fermentation and sugar assimilation test for yeasts.
6. Cultivation of fungi and yeast on SDA or corn meal agar.
7. Slide culture technique.
8. Saline wet mount examinations of stool for parasites.
9. Iodine mount examinations of stool for parasites.
10. LPCB mount examinations of stool for parasites.
11. Stool culture for amoeba and hookworm.
12. Floatation sedimentation techniques for stool examination.
13. Staining of peripheral blood smear for malarial parasite.

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SEMESTER – V

DSE – 3A

APMB354 PHARMACEUTICAL MICROBIOLOGY (4 credits)

Course Objectives:

This paper focusses on the objectives (i) to understand the basics of pharmaceutical microbiology and microbial roles in pharmaceuticals (ii) to appraise the different products of microbial origin and their role in pharmacology. (iii) to appreciate the role of secondary metabolites in pharmaceutical industry.

Unit - I

Introduction – Overview of products, classification of pharmacologic agents based on chemistry and source. Phytopharmaceuticals: screening tests for phytoconstituents – alkaloids and terpenoids. Three examples of commercial natural products from marine and terrestrial organisms.

Unit - II

Drug development: Biology guided fractionation methods: *in vitro* assay systems based on enzymes, tissue, and organ or growth inhibition. Animal models: transgenic animals, cell lines. Antimicrobial activity studies (antibacterial, antiviral, antifungal and antiparasitic activities).

Unit - III

Gene therapy: general introduction, *ex vivo* and *in vivo* gene therapy, potential targets for gene therapy, inherited disorders. Vaccine design and production, classification, genetically recombinant vaccines, advantages and disadvantages – examples – hepatitis B vaccines, cholera vaccines, edible vaccines, DNA vaccines – principles and mechanism.

Unit - IV

Immunological products: Antisera – hyper immune gamma globulin – monoclonal antibodies – uses. Recombinant proteins: strategies and genetic manipulations for overproduction of biomolecules – insulin production, production of interferons.

Unit - V

Other biomolecules: probiotics and neutraceuticals–economic and legal considerations in pharmaceutical biotechnology: FDA guidelines – preclinical trials, acute, sub-acute, chronic and teratogenic studies. Clinical trials – Phases I, II, III and IV. ICMR guidelines for design and conduct of clinical trials, licensing and drug control.

Text Books

1. Denyer S.P., Hodges N.A. and Gorman S.P. (2004) Hugo and Russell's Pharmaceutical Microbiology, 7th Edn. Blackwell Publishers.
2. Mehra P.S. (2011) A text book of Pharmaceutical Microbiology, IK International Publishing House.

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Reference Books

1. Baird R.M., Hodges N.A. and Denyer S.P. (2005) Handbook of Microbiological Quality control in Pharmaceutical and Medical Devices, Taylor and Francis Inc.
2. Saghee M.R., Sandle T. and Tidswell E.C. (2011) Microbiology and Sterility Assurance in Pharmaceuticals and Medical devices, Business Horizons publishers.
3. Hanlon G. and Sandle T. (2015) Industrial Pharmaceutical Microbiology: Standards and Controls, Euromed Communications.

Course Outcome:

Upon successful completion of the course the candidate will

- *understand the classification of pharmacological agents.*
- *gain an insight on drug development.*
- *understand the importance of gene therapy and different types of vaccines.*
- *become familiar with immunological products, probiotics and neutraceuticals*

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DSE – 8A

APMB354P **Practicals –XV: PHARMACEUTICAL MICROBIOLOGY** **(1 credit)**

1. Preparation of medicinal plant extracts.
2. Sterility testing of vaccines and injections.
3. Antibacterial activity of antibiotic preparations.
4. Antifungal tests.
5. Estimation of thiamine, riboflavin, ascorbic acid content of multivitamin formulations.
6. MIC- by broth and agar dilution method.
7. Phenol co-efficient test.
8. Proteolytic digestion of antibodies.
9. Analysis of digested fragments.
10. Visit to a vaccine production unit and observe the unit operation procedures.

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SEMESTER – V

DSE – 4A

APMB355 INDUSTRIAL MICROBIOLOGY (4 credits)

Course Objectives:

An application oriented paper of microbiology with objectives (i) to impart theoretical knowledge on microbial roles in industrial biomolecules production. (ii) to obtain a fundamental knowledge on the fermentation equipments and types of fermentation (iii) to learn about the industrial level production of food products and proteins.

Unit - I

General concepts of industrial microbiology, principles of exploitation of microorganisms of their products, screening, strain development, immobilization methods, fermentation media, raw materials used in media production, antifoaming agents, industrial sterilization.

Unit - II

Fermentation equipment and its uses, types of fermentation – single, batch, continuous, multiple, surface, submerged, and solid state fermentation.

Unit - III

Food fermentations and food produced by microbes: bread, cheese, malt beverages, vinegar, fermented dairy products and oriental fermented foods. Microbial cells as food – single cell proteins.

Unit - IV

Industrial products derived from microbes: industrial enzymes – amylase, protease, cellulase. Aminoacids production: glutamic acid and lysine. Production of antibiotics: penicillin, streptomycin.

Unit - V

Industrial products derived from microbes: Vitamins – riboflavin, cyanocobalamin. Vaccines: genetic recombinant vaccines. Organic acids: citric acid, acetic acid. Steroid conversion. Production of alcoholic beverages: beer and wine, biofuels: ethanol, methane, biogas. Disposal of industrial waste.

Text Books

1. Waites M.J. Morgan N.L., Rockey J.S. and Higton G. (2011) Industrial Microbiology. An Introduction, Paperback, WB Publishers.
2. Patel A.H. (2016) Industrial Microbiology, 2nd Edn. Laxmi Publications.

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Reference Books

1. Baltz R.H., Demain A.L. and Davies J.E. (2010) Manual of Industrial Microbiology and Biotechnology, ASM Press.
2. Flickinger M.C. and Drew S.W. (1999) Encyclopedia of Bioprocess Technology: Fermentation, Biocatalysis and Bioseparation, (Vol 1-5), Wiley publishers.
3. Stanbury P.T., Whitaker A. and Hall S. (2016) Principles of Fermentation Technology, Butterworth-Heinemann.

Course Outcome:

Upon successful completion of the course the candidate will

- *have got an overview of the versatile role of microbes in industrial microbiology.*
- *have an in-depth knowledge on fermentation equipment and types of fermentation.*
- *have a knowledge on food fermentations and single cell proteins.*
- *have an understanding on the industrial products derived from microbes*

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DSE – 9A

APMB355P **Practicals– XVI: INDUSTRIAL MICROBIOLOGY**

(1 Credit)

1. Wine production.
2. Isolation of lactic acid bacteria from curd.
3. Isolation of lipolytic organisms from butter or cheese.
4. Immobilized bacterial cells for production of hydrolytic enzymes.
5. Enzyme production and assay – cellulase, protease and amylase.
6. Alcohol production.
7. Immobilization of yeast.
8. Visit and observe an industry unit pertaining to microbiological products manufacturing.

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SEMESTER – V

DSE – 5A

APMB356 BIOSTATISTICS AND COMPUTER APPLICATIONS (4 credits)

Course Objectives:

A general statistics and computer applications paper which has the objectives (i) to impart basic knowledge of statistics and tools used for several quantitative analysis in microbiology. (ii) to appreciate the role of MS office related programmes and their applications (iii) to provide knowledge on networking fundamentals, database concept and data retrieval.

Unit - I

Biostatistics : definition – nature and scope of statistics and limitations – collection of data – sampling and sampling design – classification and tabulation – frequency distribution for discrete and continuous data – diagrammatic representation (bar diagram and pie chart – graphical representations (histogram, frequency polygon and ogives).

Unit - II

Measures of central tendency: mean, median, mode, geometric mean, harmonic mean, measures of dispersion, range, mean deviation, quartile deviation and standard deviation, standard error.

Unit - III

Introduction to computers: computer application, basics, organization, PC, mainframes and super-computers, concept of hardware and software, concept of file, folders and directories, commonly used commands, flow charts and programming techniques.

Unit - IV

Introduction in MS Office software concerning word processing, spreadsheets for biostatistics and presentation software. New technologies in IT– electronic commerce – hypermedia – data warehouses and marts – data mining online analytical processing – geographic information systems. Application of IT – computer in business and industry – computers in home – computers in education and training – computer in entertaining science, medicine and engineering.

Unit - V

Networking fundamentals, client, server, LAN, WAN, TelNET, INTERNET, NICNET, WWW, html, e mail, introduction to MEDLINE, CCOD and PUBMED, for accessing biological information.

Text Books

1. Balakrishnan N. (2003) Statistical Methods and Practice – Recent Advances, Narosa Publishing House Private Limited.
2. Preston Gralla (2000) How the Internet Work, Tech. Media.

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Reference Books

1. Wardlaw A.C. (2000) Practical Statistics for experimental biologists, 2nd Edn. Wiley publishers
2. Gupta S.P. (2009) Statistical Methods, 28th Edn. Sultan Chand and Sons.
3. Gurumani N. (2005) An introduction to Biostatistics, MJP Publishers, Chennai.

Course Outcome:

Upon successful completion of the course the candidate will

- *be familiar with the basics of biostatistics.*
- *understand the measures of central tendency.*
- *have a basic knowledge on computer applications, new technologies used in information technology and its applications.*
- *have a good understanding on networking tools to access biological information.*

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DSE – 10A

APMB356P Practicals – XVII: BIOSTATISTICS AND COMPUTER APPLICATIONS (1 credit)

1. Representation of Statistical data by
   a) Histograms b) Ogive Curves c) Pie diagrams.
2. Determination of Statistical averages/ central tendencies.
   a) Arithmetic mean b) Median c) Mode.
3. Determination of measures of Dispersion
   a) Mean deviation
   b) Standard deviation
   c) Quartile deviation.
4. Computer operations-getting acquainted with different parts of Computers. [DOS] and basics of operating a computer.
5. Creating files, folders and directories.
6. Applications of computers in biology using MS-Office.
   A] MS-Word B] Excel C] Power Point.
7. Creating an e-mail account, sending and receiving e mails.
8. An introduction to INTERNET, search engines, websites, browsing and downloading.

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SEMESTER – V

GE – 1

APMB357 BIOINFORMATICS (3 credits)

Course Objectives:

An important associated subject of microbiology with objectives (i) to provide an overview of various bioinformatics tools, databases available and sequence analysis methods. (ii) to provide knowledge on database concept, management, retrieval along with utilization in gene and protein analysis (iii) to understand the sequence alignments, genome sequence assembly and gene finding methods.

Unit - I

Analysis of DNA and protein sequences – codon distributions, frequency statistics, pattern and motif searches – randomization.

Unit - II

Sequence alignments: Scoring matrices – PAM and BLOSUM – local and global alignment concepts – dynamic programming methodology – Needleman and Wunsch algorithm, Smith – Waterman algorithm – statistics of alignment score – multiple sequence alignment – progressive alignment – database searches for homologous sequences – FASTA and BLAST versions.

Unit - III

Evolutionary analysis: distances – clustering methods – rooted and unrooted tree representations – bootstrapping strategies.

Unit - IV

Fragment assembly – genome sequence assembly. Gene finding methods: content and signal methods, gene prediction – analysis and prediction of regulatory regions.

Unit - V

Neural network – concepts and secondary structure prediction – probabilistic models: Markov chain – random walk – hidden Markov models – gene identification and other applications.

Text Books

1. Lesk M.A. (2008) Introduction to Bioinformatics, 3rd International Student Edition, Oxford Publication.
2. Claverie J.M. and Notredame C. (2007) Bioinformatics for Dummies, 2nd Edn. Wiley Publishers.

Reference Books

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1. Rastogi S.C., Mendiratta, N. and Rastogi P. (2007) Bioinformatics – Concepts, Skills, Applications, 2nd Edn. Prentice Hall India Publication.
2. Hodgman T.C., French A. and Westhead D.R. (2010) Bios Instant Notes Bioinformatics, Taylor & Francis.
3. Mount D.W. (2005) Bioinformatics: Sequence and Genome analysis, 2nd Edn. Paperback, CBS Publishers.

Course Outcome:

Upon successful completion of the course the candidate will

- *develop better understanding on analysis of DNA and protein sequences.*
- *gain knowledge on sequence alignments.*
- *have understanding on evolutionary analysis, fragment assembly and neural network.*

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SEMESTER – VI

SEC-4

APMB361 MICROBES AND THEIR APPLICATIONS (Advanced Credit Seminar) (2 credits)

This course is a credit seminar paper included with the objectives (i) to understand about the importance of seminar preparation (ii) to develop the art of presenting the microbiology topics with a logic insight and discussion with their peers.

Unit – I

Identifying suitable topic in fundamentals of microbiology or applications of microbiology to human kind and society.

Unit – II

Literature survey and collection.

Unit – III

Preparation of a report – abstract preparation for seminar presentation.

Unit – IV

Presentation of the seminar in Powerpoint format.

Unit – V

Discussion on the topic and evaluation of the seminar report.

Reference

Microbiology Undergraduate credit seminar (MBI 490), a component of Capstone Experience in Microbiology taken up as a part of Undergraduate Microbiology programme of University of Miami https://miamioh.edu/cas/academics/departments/microbiology/academics/capstones/index.html#seminar

Course Outcome:

Upon successful completion of the course the candidate will

- *understand the advanced study topics related to microbiology.*
- *able to document scientific content critically and present the same with better understanding*
- *individually render oral presentation with discussion among peers*

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SEMESTER – VI

DSE – 1B

APMB362 FOOD AND DAIRY MICROBIOLOGY (4 credits)

Course Objectives:

An application oriented paper of microbiology, main objectives are (i) to apprise the biology and epidemiology of food borne organisms (ii) to understand about the various principles behind the preservation of food (iii) to appreciate the role of microbes in fermented foods.

Unit - I

Food as a substrate for microorganisms – microorganisms important in food microbiology: molds, yeasts and bacteria – factors affecting the growth of microorganisms in food, feed and fodder.

Unit - II

Principles of food preservation: general principles and application methods – asepsis, removal of microorganisms, anaerobic conditions, high temperature, low temperature, drying and food additives.

Unit - III

Spoilage of food: vegetables, eggs, milk and milk products, meat and meat products, fish and sea foods and canned foods.

Unit - IV

Fermented foods: pickled cucumber, sauerkraut, bread, cheese, vinegar, fermented dairy products – spoilage of fermented dairy products.

Unit - V

Food borne infections and intoxications: bacterial and non-bacterial – microbiology in food sanitation – sewage and waste treatment and disposal – good manufacturing practices – hazard analysis – quality control– employee health standards.

Text Books

1. Frazier W.C. and Westhoff D.C. (2008) Food Microbiology, 4th Edn. Tata McGraw Hill Publishing Co., New Delhi.
2. Bamforth C.W. (2005) Food, Fermentation and Microorganisms, Blackwell Science.

Reference Books

1. Doyle M.P. and Buchanan R.L. (Ed.) (2013) Food Microbiology: Fundamentals and Frontiers, 4th Edn. ASM press.
2. Jay J.M., Loessner M.J. and Golden D.A. (2005) Modern Food Microbiology, 7th Edn. Springer Publishers.
3. Robinson R.K. (2002) Dairy Microbiology: Milk and Milk Products, 3rd Edn. Wiley Publishers.

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Course Outcome:

Upon successful completion of the course the candidate will

- *understand the factors affecting the growth of microorganisms in food.*
- *gain knowledge on the principles of food preservation.*
- *gain understanding on the spoilage of various foods.*
- *have knowledge on fermented foods and fermented dairy products.*
- *understand food borne infections, intoxications, microbiology in food sanitation, sewage and waste treatment, disposal and hazard analysis.*

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DSE – 6B

APMB362P Practicals– XVIII: FOOD AND DAIRY MICROBIOLOGY (1 credit)

1. Bacterial counts of food samples.
2. Quantitative analysis of milk by standard plate count method.
3. Isolation and counting of fecal bacteria in water.
4. Test of quality of milk by methylene blue dye reduction test.
5. Detection of mastitis through milk test.
6. Isolation of microorganisms from curd.
7. Isolation of bacteria and fungi from spoiled food.
8. Microbial populations in fruit juices, soft drinks and ice cream.
9. Isolation of lipolytic organisms from butter.
10. Visit to a microbiology based Food industry and observe the unit operation procedures.

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SEMESTER – VI

DSE – 2B

APMB363 MICROBIAL ECOLOGY AND ENVIRONMENTAL MICROBIOLOGY

(4 credits)

Course Objectives:

This paper was added with the objectives (i) to enlighten students about the microbes in several ecosystems (ii) to understand varied interactions that occur within microbial communities (iii) to expose students to environmental awareness related to treatment of wastewater and importance of water quality and indicator organisms

Unit - I

Environment ecosystems, food chain – niche, soil, water and air environment. Microbial interactions – symbiosis, neutralism, commensalism, synergism, mutualism, ammensalism, competition, parasitism and predation.

Unit - II

Aerobiology – microbes in aerosol. Allergens – assessment of quality of air – air borne diseases caused by bacteria, fungi and viruses – symptoms and preventive measures.

Unit - III

Microbiology of water – determination of water quality – bacteriological examination of water – indicator organisms – water borne pathogens. Microbiology of sewage – chemical and biochemical characteristics of sewage – sewage treatment and disposal of wastes.

Unit - IV

Biodegradation of oil, biodeterioration of materials – paint, paper, wood, leather and metal – mode of deterioration– organism involved – disadvantage and mode of prevention.

Unit - V

Water pollution – BOD – COD. Bioremediation, composting, bioamelioration – biofilm formation – impact on the environment. Environmental protection laws.

Text Books

1. Atlas R.N. and Bartha R.(1992). Microbial Ecology: Fundamentals and Applications, 3rd Edn. Redwood City, CA Benjamin/Cummings.
2. Pepper I.L. and Gerba C.P. (2004) Environmental Microbiology: A Laboratory manual, 2nd Edn. Academic Press.

Reference Books

1. Pepper I., Gerba C. and Gentry T. (Ed.) (2014) Environmental Microbiology, Academic Press.
2. Madsen E.L. (2008) Environmental Microbiology: From Genomes to Biogeochemistry,

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Blackwell publishers.
3. Barton L.E. and Northup D.E. (2011) Microbial Ecology, Wiley-Blackwell.

Course Outcome:

Upon successful completion of the course the candidate will

- *understand the environmental ecosystem and microbial interactions.*
- *understand the microbiology of air and assessment of quality of air.*
- *have an in-depth knowledge on microbiology of water and sewage.*
- *be familiar with biodeterioration of different materials, bioremediation and environmental protection laws.*

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DSE – 7B

APMB363P Practicals–XIX: MICROBIAL ECOLOGY AND ENVIRONMENTAL MICROBIOLOGY (1 credit)

1. Bacteriological examination of water by multiple tube fermentation tests.
2. Water analysis for total bacterial population by standard plate count method.
3. Isolation of cellulolytic organism for various soil.
4. Determination of salinity of water.
5. Estimation of oxygen by Winkler's method.
6. Estimation of BOD of water.
7. Estimation of COD of water.
8. Isolation of bacteriophage from the sewage.
9. Isolation of microorganism from air by open plate method.
10. Determination of total bacterial population in water by standard plate count method.
11. Visit and observe unique ecosystems and understanding the role of microorganisms.

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SEMESTER – VI

DSE – 3B

APMB364 SOIL AND AGRICULTURAL MICROBIOLOGY (4 credits)

Course Objectives:

A microbiological application oriented paper added with objectives (i) to appreciate the wealth of soil microbiota (ii) to appreciate the role of biochemical cycling of nutrients (iii) to know about the importance of biofertilizers and biopesticides.

Unit-I

Introduction to soil microorganisms – bacteria (cyanobacteria and actinobacteria), algae, fungi, protozoans, nematodes and viruses – Role of microbes in soil fertility.

Unit-II

Microbial associations in phytosphere: rhizosphere – phyllosphere – spermosphere. Mycorrhiza – types and importance to agriculture – organic matter decomposition – humus formation.

Unit-III

Biogeochemical cycles – carbon, nitrogen, phosphorus, sulphur cycles; nitrogen fixers – root nodule formation –nitrogenase, hydrogenase – biochemistry of nitrogen fixation.

Unit-IV

Biofertilizers – definition, importance – types and their application methods – Steps in mass production of bacterial biofertilizers – quality guidelines for biofertilizers. Mass production of blue green algae, *Azolla* and mycorrhiza. Plant response to biofertilizers application.

Unit -V

Plant growth promoting rhizobacteria – Biological control of phytopathogens – Mechanism of control – *Trichoderma* sp. and *Pseudomonas fluorescens* as biocontrol agents – Disease suppressive soils –Biopesticide and their importance: Bacterial, fungal and viral.

Text Books

1. Sylvia D.M., Fuhrmann, J.J., Hartel P.J. and Zuberer D.A. (2005) Principles and Applications of Soil Microbiology, 2nd Edn. Pearson, Prentice Hall.
2. Subba Rao N.S. (2001) Soil Microorganisms and plant growth, Oxford and IBH Publishing Co.Pvt. Ltd.

Reference Books

1. Glick B.R. (2015) Beneficial Plant Bacterial Interactions, Springer.

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2. Paul E.A. (Ed.) (2015) Soil Microbiology, Ecology and Biochemistry, 4thEdn, Academic Press.
3. Madigan M.T., Bender K.S., Buckley D.H., Sattley W.M. and Stahl D.A. (2017) Brock Biology of Microorganisms, 15thEdn. (Global Edn.) Pearson Education.

Course Outcome:

Upon successful completion of the course the candidate will

- *understand the diverse groups of microorganisms in soil and its role in soil fertility.*
- *gain knowledge on the microbial association and biogeochemical cycles.*
- *understand the role of biofertilizers and biopesticides and their importance.*

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DSE – 8B

APMB364P **Practicals–XX: SOIL AND AGRICULTURAL MICROBIOLOGY** **(1 credit)**

1. Isolation of bacteria, fungi and actinobacteria from soils.
2. Isolation of nitrogen fixing bacteria from root nodules of legumes.
3. Enumeration of rhizosphere to non rhizosphere population of bacteria.
4. Isolation of antagonistic *Pseudomonas* from soil.
5. Microscopic observations of root colonization by VAM fungi.
6. Isolation of *Azospirillum* sp. from the roots of grasses.
7. Isolation of phyllosphere microflora.
8. Isolation of P solubilizing microorganisms.
9. Observation of *Anabaena* from *Azolla* plants.
10. Demonstration on different biofertilizers types, formulation and application methods.
11. Visit to biofertilizers and biopesticides unit to understand about the Unit operation procedures.

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SEMESTER – VI

DSE – 4B

APMB365 HAEMATOLOGY AND BLOOD BANKING (4 credits)

Course Objectives:

A medical microbiology application oriented paper added with objectives (i) to appreciate the importance of blood and its examination (ii) to appreciate the role of biochemical cycling of nutrients (iii) to know about the importance of biofertilizers and biopesticides.

Unit - I

Blood: definition, characters, composition. Collection of blood – capillary blood: from adults and infants, examinations employed. Venous blood: from adults and infants, examinations employed – Anticoagulants: definition – type: Wintrobes, EDTA, heparin, citrate, concentration, examinations, advantages and disadvantages.

Unit - II

Counting of blood cells: Neubauer counting chamber – total RBC count: diluting fluids, normal values – total WBC count: diluting fluids, normal values differential leucocyte count: granulocyte and agranulocytes, morphology and function, staining technique – Platelet count: morphological characters and functions, haemoglobin: composition and normal values, haemoglobin estimation.

Unit - III

Coagulation mechanism: factors, bleeding time, clotting time. Haematological indices: packed cell volume. Erythrocyte sedimentation: principle – determination: introbes, Westergren method – advantages and disadvantages – factors affecting the process.

Unit - IV

Preparation of stains and staining techniques: Wright stain, Leishman's stain, Giemsa's stain, Fields stain, peroxidase stain. Examination of blood smear – peripheral smear report – size, colour and shape. Blood parasites: malarial parasite and microfilaria.

Unit - V

ABO Grouping: History, slide and tube technique, Rh typing: slide and tube technique, Coombs test: direct and indirect method, donor screening – cross matching, collection of blood, preservation and storage.

Text Books

1. Maheswari N. (2008) Clinical Pathology, Haematology and Blood Banking (for DMLT students), 2nd Edn. Jaypee Brothers Medical Publishers.
2. Hoffbrand A.V. and Moss P.A.H. (2015) Hoffbrand's Essential Haematology, 7th Edn. Wiley.

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Reference books

1. Greer J.P., Foerster J., Lukens J.N., Rodgers G.M., Paraskevas F. and Glader B.E. (Ed.) (2013). Wintrobe's Clinical Hematology, 13th Edn. Wolters Kluwer.
2. HIllyer C., Silberstein L., Ness P., Anderson K. and Roback J. (2006) Blood banking and Transfusion medicine, 2nd Edn. Elsevier Press.
3. Godkar P.B. and Godkar D.P. (2013) Textbook Medical Laboratory Technology Vol-I and II, Bhalani Publishing House.

Course Outcome:

Upon successful completion of the course the candidate will

- *understand the composition of blood and collection of blood.*
- *gain an insight on the various methods involved in counting of different blood cells.*
- *have a better understanding on the coagulation mechanism and erythrocyte sedimentation.*
- *become acquainted with the preparation of stains and staining techniques of examination of blood smear.*
- *understand ABO grouping, Rh typing, donor screening, preservation and storage of blood.*

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DSE – 9B

APMB365P **Practicals – XXI: HAEMATOLOGY AND BLOOD BANKING** **(1 credit)**

1. Collection of blood – finger prick, venous blood.
2. Hb estimation, RBC count, estimation of packed cell volume, total WBC count and absolute eosinophil count.
3. Staining of blood smears and differential count of WBC.
4. Platelet count by various methods.
5. Erythrocyte sedimentation rate by various methods.
6. Preparation of reagents for coagulant studies.
7. Preparation of anticoagulant fluids.
8. Coomb's test.
9. Screening of HbS Ag.

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SEMESTER – VI

DSE – 5B

APMB366 MICROBIAL PRODUCTION OF PIGMENTS, FLAVOUR AND AROMA COMPOUNDS (4 credits)

Course Objectives:

A paper with focus on exposing industrial importance of the microbiology to students with objectives (i) to understand the role of microbes in pigment production (ii) to appreciate the role of microbes in aroma and flavour compound synthesis

Unit –I

Scope of the subject – Importance of microbial products over chemically synthesized products – ill effects of chemicals – overall view of microbes involved in pigment, flavour and aroma production.

Unit -II

Biochemical and physiological basis of pigment, flavour and aroma compounds production – compound synthesis and biocatalysis – Culture dependent and culture independent methods to identify the organisms – Techniques used to identify novel potential organisms.

Unit - III

Bacterial pigments – prodigiosin – violacein and deoxyviolacein – fungal monascin – bacterial and algal carotenoids – astaxanthin – occurrence, isolation, chemistry and biological properties – catalysis – its applications and importance.

Unit - IV

Terpenes – pyrazines – lactones – esters – jasmonic acid – high bulk flavour – vanillin – Occurrence – chemical – biological significance – synthesis – biotransformation – biotechnological applications of natural and nature identical flavour and aroma compounds.

Unit - V

Genetic engineering in pigment, flavour and aroma production – Mass multiplication – up scaling – product recovery – purification of pigments, flavour and aroma compounds – future strategies and innovative areas of research – ethical, biosafety and legal aspects of production.

Text books

1. Margalith P.Z. (1992) Pigment Microbiology, Chapman and Hall.
2. Berger R.G. (Ed.) (2007) Flavours and Fragrances: Chemistry, Bioprocessing and Sustainability, Springer-Verlag.

Reference books

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1. Berger R.G. (1995) Aroma Biotechnology, Springer-Verlag.
2. Gabelman A. (Ed.) (1994) Bioprocess production of flavour, fragrance and colour ingredients, John Wiley and Sons.
3. Lauro G.J. and Francis F.J. (2000) Natural food colourants – Science and Technology, Marcel and Dekker.

Course Outcome:

Upon successful completion of the course the candidate will

- *understand the importance of microbial products over chemically synthesized products.*
- *understand the biochemical and physiological basis of pigment, flavor and aroma compound.*
- *understand the genetic engineering in pigment, flavor and aroma production.*
- *gain understanding on ethical, biosafety and legal aspects of production.*

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DSE – 10B

APMB366P Practicals –XXII: MICROBIAL PRODUCTION OF PIGMENTS, FLAVOUR AND AROMA COMPOUNDS (1 credit)

1. Observation of *Dunaliella* sp.– a beta carotene producing algae.
2. Isolation of *Monascus* sp. from soil.
3. Mass production of pigment using *Monascus* fungal culture.
4. Isolation of pigment producing bacteria/actinobacteria.
5. Mass multiplication of the pigment producer and pigment extraction
6. Production and estimation (HPLC) of vanillin from precursor using microbial cultures.
7. Microbial production of xylitol from xylose and their estimation using HPLC
8. Microbial biocatalysis of precursor to vitamin C and their estimation using HPLC
9. Usage of yeast for the biocatalysis of flavour and aroma compounds

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SEMESTER – VI

GE -2

APMB367 MICROBIAL GENOMICS (3 credits)

Course Objectives:

A modern microbiology course which focuses on the genomic background and emphasizes the following objectives (i) to know about the basics of genome sequencing (ii) to critically analyze the several types of gene sequencing methods with their pros and cons (iii) to enlighten about the importance of metagenomic studies in microbiology

Unit-I

Introduction to microbial genomics – sequencing genomes – first generation DNA sequencing – shot gun sequencing – second generation DNA sequencing – third and fourth generation DNA sequencing

Unit-II

Biological sequences as information – DNA, RNA and protein as informative molecules – general characteristics of microbial genomes – genome assembly – genome annotation – identification of an open reading frame in a genome.

Unit-III

Microbial genomes size and content – small genomes and large genomes – genomes of organelles – symbionts and organelles – eukaryotic microbial genomes an introduction: genomes of microbial parasites – the yeast genome.

Unit-IV

Functional genomics: microarrays and transcriptomes – gene chips and gene expression and its applications – RNA sequence analysis – methods in proteomics – comparative genomics and proteomics – the interactome.

Unit-V

Culture independent studies of microorganisms – metagenomics: principles and applications – steps in construction of a metagenomes – examples of metagenomic studies – metagenomics as a tool to reveal the vast microbial diversity.

Text Books

1. Madigan M.T., Bender K.S., Buckley D.H., Sattley W.M. and Stahl D.A. (2017) Brock Biology of Microorganisms, 15th Edn. (Global Edn.) Pearson Education.
2. Sanders E.R. and Miller J.H. (2010) I Microbiologist: A discovery based course in Microbial Ecology and Molecular Evolution, ASM press.

Reference Books

1. Fraser C.M., Read T. and Nelson K.E. (2004) Microbial Genomes, Springer.

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2. Highlander S.K., Rodriguez-Valera F. and White B.A. (2015) Encyclopedia of Metagenomics: Environmental Metagenomics, Springer Science.
3. Dale J.W. and von Schantz M. (2007) From Genes to Genomes: Concepts and Applications of DNA Technology, 2nd Edn. Wiley publishers.

Course Outcome:

Upon successful completion of the course the candidate will

- *understand the basics of Microbial Genomics.*
- *gain knowledge on biological sequences as information.*
- *understand the content of microbial genomes.*
- *develop knowledge on functional genomics and metagenomics*