

Punyashlok Ahilyadevi Holkar Solapur University, Solapur



Name of the Faculty – Science and Technology

Choice Based Credit System

Syllabus – Microbiology

Name of the Course – B. Sc. III (Sem. V & VI)

(Syllabus to be implemented June 2024)

Punyashlok Ahilyadevi Holkar Solapur University, Solapur
Faculty of Science & Technology
Choice Based Credit System (CBCS) (w.e.f. 2024-25)
Revised Structure for B. Sc-III

Subject/ Core Course	Name and Type of the Paper		No. of papers/ Practical	Hrs/week			Total Marks Per Paper	UA	CA	Credits
	Type	Name		L	T	P				
Class :	B.Sc.- III Semester - V									
Ability Enhancement Course(AECC)	English (Business English)		Paper II Part A	4	--	--	50	40	10	2.0
Core Courses: (Students can opt any one subjects among the three Subjects excluding Interdisciplinary/Additional Subject offered at B. Sc-II.)	DSC 1 E		Paper IX	4	--	--	100	80	20	4.0
	Virology		Paper X	4	--	--	100	80	20	4.0
	DSC 1 F Agricultural									
	DSC 1 G Immunology		Paper XI	4	--	--	100	80	20	4.0
DSE 1 A – Industrial or DSE 1B or DSE 1C		Paper XII	4	--	--	100	80	20	4.0	
Total Theory Sem-V				20	--	--	450	360	90	18
	\$ SEC-2			4	--	--	100	80	20	4.0
Class :	B.Sc.- III Semester –VI									
Ability Enhancement Course(AECC)	English (Business English)		Paper II Part B	4	--	--	50	40	10	2.0
Core Coursest: (Students can opt any one subjects among the three Subjects excluding interdisciplinary / Additional subject offered at B.Sc. II.	DSC 1 H Molecular Biology and Bioinformatics		Paper XIII	4	--	--	100	80	20	4.0
	DSC 1 I Microbial Biochemistry		Paper XIV	4	--	--	100	80	20	4.0
	DSC 1 J Environmental Microbiology		Paper XV	4	--	--	100	80	20	4.0
	DSE 2 A – Medical Microbiology Or DSE 2 B – Clinical Microbiology Or DSE 2 C Health Microbiology		Paper XVI	4	--	--	100	80	20	4.0

Total Theory Sem-VI			20	--	--	450	360	90	18
Core	DSC 1E & 1H	Practical IV	--	--	5	100	80	20	4.0
	DSC 1F & 1 I	Practical V	--	--	5	100	80	20	4.0
	DSC 1G & 1 J	Practical VI	--	--	5	100	80	20	4.0
	DSE 1A/B/C & 2 A/B/C	Practical VII	--	--	5	100	80	20	4.0
Total (Practicals)					20	400	320	80	16
Grand Total			40		20	1300	1040	260	52
	\$ SEC- 2		4			100	80	20	4

\$The students can choose MOOCs/ NPTEL/SWAYAM/Pathshala/Add-on / Skill based courses of university/college initiated courses of same credits.

\$ These courses are not compulsory, but after completion of these courses students get additional credits on their Mark lists. \$SEC Courses initiated by colleges should be communicated to university for information and necessary action.

Summary of the Structure of B.Sc. Program as per CBCS pattern

Class	Semester	Marks-Theory	Credits-Theory	Marks-Practical	Credits-Practical's	Total - credits
B.Sc.-I	I	450	18	--	--	18
	II	450	18	400	16	34
B.Sc.-II	III	300	12	--	--	12
	IV	300	12	600	24	36
B.Sc.-III	V	450	18	--	--	18
	VI	450	18	400	16	34
Total		2400	96	1400	56	152
	SEC sem.- III & V	200	8			8

B.Sc. Program:

Total Marks: Theory + Practicals = 2400(+200) +1400 =3800+200

Credits: Theory + Practicals = 96(08) + 56 = 152+08

Numbers of Papers Theory: Ability Enhancement Compulsory Course (AECC) 04
Theory: Discipline Specific Core Paper (DSC) 20
Theory: Discipline Specific Elective paper (DSE) 02
Skill Enhancement Course (SEC) 04

Total: Theory Papers (Core paper- 30
22)
: Practical Papers 11

Abbreviations:

L: Lectures T: Tutorials P: Practical UA: University Assessment CA : College Assessment CC: Core Course AEC : Ability Enhancement Course DSE : Discipline Specific Elective Paper SEC : Skill Enhancement Course, AIC: Additional Interdisciplinary Courses

Note: Each theory papers of 50 Marks should be of two Units. Each theory papers of 100 Marks should be of four Units. Each theory paper Unit is of 15 Lectures. Practical paper of 100 Marks is of at least 20 practical.

P.A.H. Solapur University, Solapur,
Faculty of Science Choice Based Credit System (CBCS)
B.Sc.-III Microbiology
(2024-2025: w.e.f. June 2024)

Introduction:

The Curriculum development plays a very vital role in the development of quality of education. The education system should be such that students will be able to compete locally, regionally, nationally as well as globally. The present situation demands developing “learner-centric approach while redesigning of curriculum. There is also need to allow the flexibility in education system. The choice based credit system (CBCS) allows students to choose interdisciplinary, intra-disciplinary courses, skill oriented papers and thus offers more flexibility for student. The courses can be evaluated following the grading system, which is considered to be better than the conventional marks system. In view of this, PAH Solapur University, Solapur has implemented Choice Based Credit System of Evaluation at Undergraduate level. While designing the syllabi of microbiology for undergraduate course for semester V and VI, an attempt has been made to follow the pattern given in the UGCs Undergraduate Template. This will help to bring a match across all the Indian universities.

Microbiology deals with the study of microorganisms. This branch of life science has immensely grown up widening its horizons and opening new frontiers of knowledge. The scope of microbiology as a subject is immense due to its ability to control all critical points of many fields like medical, dairy, pharmaceutical, industrial, clinical, research, water industry, agriculture, nanotechnology, etc. A career in microbiology is lucrative option. There is demand of trained microbiologists in a vast range of industries and institutes like research and development laboratories of government and private hospitals, research organizations, pharmaceutical, food, beverage and chemical industries.

To cater the needs, discipline specific papers on industrial, agricultural, environmental, medical microbiology, microbial biochemistry, virology, immunology have been included in the curriculum for semester V and VI. At the same time, the framework is so designed as to maintain and copeup the need of microbiology degree and the learning outcomes.

Learning Outcomes based approach to Curriculum Planning:

The Learning Outcomes-based Curriculum Framework (LOCF) for the B.Sc. (Honours) degree in Microbiology is designed to suit the need of the hour, in keeping with the emergence of new areas of microbiology. The framework is architected to allow for flexibility in programme design and course content development, while at the same time maintaining a basic uniformity in structure in comparison with other universities across the country. The programme is designed to build a strong microbiology knowledge base in the student and furthermore, acquaints the students with the applied aspects of this fascinating discipline as well. The student is thus equipped to pursue higher studies in an institution of her/his choice, and to apply the skills learnt in the programme to solving practical societal problems. The programme offers an elective course to the student for skill enhancement courses that prepares the student for an eventual job in academia or industry.

Graduate Attributes in Microbiology:

Some of the characteristic attributes of an Honors graduate in Microbiology include:

- **Disciplinary Knowledge acquisition:** gathers in-depth knowledge of basic and applied areas of microbiology.
- **Core microbiology laboratory skills:** understands various methods of safe handling, culturing and storage of microorganisms in the laboratory.
- **Interdisciplinary approach:** becomes aware of the role of microbiology in interdisciplinary research as well as in daily life.
- **Environmental literacy:** develops a basic understanding of the microbiological principles that have environmental implications, and gains an awareness of regulatory requirements and their compliance in biotechnology and microbiological research.
- **Thinking ability:** inculcates independent thinking and apply knowledge acquired.
- **Spirit of Teamwork:** Reveals the importance of interacting with and working alongside people from diverse backgrounds.
- **Global perspective:** becomes acquainted with standard international practices and emerging technologies used to study microbes.
- **Skills for Communication:** acquires oral as well as written skills through oral presentations of ongoing developments in the field and compiling of information in brief in written format.
- **Ethical awareness:** develops attitude of conducting their work with honesty
- **Self-motivation:** develops planning, organization and time management skills.
- **Digitally literatracy:** acquires Skills of using computers for Bioinformatics and computation and appropriate software for analysis of genomics and proteomics data, and employing modern bioinformatics search tools to locate, retrieve, and evaluate location and biological annotation

genes of different species.

Outline of Choice Based Credit System:

1. **Core Course:** A course, which should compulsorily be studied by a candidate as a core requirement is termed as a Core course.

2. **Elective Course:** Generally a course which can be chosen from a pool of courses and which may be very specific or specialized or advanced or supportive to the discipline/ subject of study or which provides an extended scope or which enables an exposure to some other discipline/subject/domain or nurtures the candidate's proficiency/skill is called an Elective Course.

Discipline Specific Elective (DSE) Course: Elective courses maybe offered by the main discipline/subject of study is referred to as Discipline Specific Elective.

3. **Ability Enhancement Courses (AEC):** The Ability Enhancement (AE) Courses may be of two kinds: Ability Enhancement Compulsory Courses (AECC) and Skill Enhancement Courses (SEC). "AECC" courses are the courses based upon the content that leads to Knowledge enhancement; (i) Environmental Science and (ii) English/MIL Communication. These are mandatory for all disciplines. SEC courses are value-based and/or skill-based and are aimed at providing hands-on-training, competencies, skills, etc.

• **Credit:** Credit is a numerical value that indicates students work load (Lectures, Lab work, Seminar, Tutorials, Field work etc.) to complete a course unit. In most of the universities 15 contact hours constitute one credit. The contact hours are transformed into credits. Moreover, the grading system of evaluation is introduced for B.Sc. course wherein process of Continuous Internal Evaluation is ensured. The candidate has to appear for Internal Evaluation of 20 marks and University Evaluation for 80 marks.

• **Scheme of Evaluation:** As per the norms of the grading system of evaluation, out of 100 marks, the candidate has to appear for college internal assessment of 20 marks and external evaluation (University assessment) of 80 marks..

Semester–V: Theory:(100marks): Comprising DSE-

- a) University Examination (UA)(80 marks):No. of theory papers: 4 (paper IX to paper XII)
- b) Internal Continuous Assessment (CA) (20 marks) No. of theory papers: 4 (paper IX to paper XII)
- c) Compulsory paper on“Ability Enhancement Compulsory Course (AECC)”on English
- d) One Add-on-self learning course MOOC/SWAYAM COURSE/INTERNSHIP

Internal test- Home assignment /tutorials/ seminars/viva/ group discussion/outreach programs.

Semester–VI: Theory: (100marks): Comprising DSE-

- a) University Examination (UA)(80 marks): No. of theor ypapers: 4 (paper XIII to paper XVI)
- b) Internal Continuous Assessment (CA) (20 marks) No. of theory papers: 4 (paper XIII to paper

XVI)

Internal test-Home assignment /tutorials/ seminars/viva/ group discussion/outreach programs.

Practical Examination:(400marks)

University Examination (320 marks): Number of practicals : 04

Practical-I: Based on Papers- IX & XIII (80UA+20CA)

Practical-II: Based on Papers- X &XIV:(80 UA +20 CA)

Practical-III: Based on papers -XI& XV:(80 UA +20 CA)

Practical-IV: Based on papers-XII&XVI:(80UA+ 20CA)

Internal Continuous Assessment: Total 80

(a) Internal practical test and

(b) Viva/group discussion/model or chart/attitude/attendance/overall behavior

(c) University practical examination of 320marks (Practical I to IV for Four separate days) will be conducted at the end of semester VI

Passing Standard:

The student has to secure a minimum of 4.0 grade points (Grade C) in each paper.

A student who secure less than 4.0 grade point (39% or less marks, Grade FC/FR) will be declared fail in that paper and shall be required to reappear for respective paper. A student who failed in University Examination (theory) and passed in internal assessment of a same paper shall be given FC Grade. Such student will have to reappear for University Examination only. A student who fails in internal assessment and passed in University examination (theory) shall be given FR Grade. Such student will have to reappear for both University examination as well as internal assessment. In case of Annual pattern/old semester pattern students/candidates from the mark scheme the candidates shall appear for the same stipulated marks of external examination and his/her performance shall be scaled to 100 marks.

• **ATKT:**

Passed in all papers except 6 (six) papers combined together of semester III and IV of B.Sc.Part-II Microbiology examination and clearly passed in B.Sc.Part-I- Microbiology shall be permitted to enter upon the course of Semester V of B.Sc. III Microbiology.

Abbreviations: L : Lectures, T: Tutorials, P : Practical's, CA: College Assessment, UA : University Assessment.

PAH SOLAPUR UNIVERSITY SOLAPUR
Theory Syllabus (CBCS)
B.Sc. III – Microbiology (Semester V)
(w.e.f. June 2024)
Credits – 04 Total Lectures – 60
DSC 1 E: Paper – IX – Virology

Unit I: Introduction and Classification of Viruses (15)

- A. General properties and structure of virus.
- B. Concept and replication of Viroids and Prions
- C. Viral classification on the basis of LHT system, Baltimore Classification scheme and as per International committee (ICTV)
- D. Isolation, Cultivation, Purification and Enumeration of Viruses

Unit II: Reproduction of Bacterial Viruses (15)

- A. One Step Growth Experiment
- B. T₄ Bacteriophage – Lytic Cycle
- C. Temperate Phages and lysogeny of Lambda Phages
- D. ØX 174 – Replication

Unit III: Animal Viruses and Oncogenesis (15)

- A. Characters of etiological agent, mode of transmission, pathogenesis, symptoms, laboratory diagnosis and treatment and Reproduction genetic material of following animal viruses: a) Adeno viruses, b) Influenza viruses, c) Rabies, d) HIV, e) Swine Flu, f) Ebola.
- B. Oncogenic Virus: Types – DNA, RNA virus
- C. Types of Cancer, Characteristics of cancerous cell.
- D. Hypothesis of Cancer: Somatic Mutation, Viral Gene and Defective Immunity

Unit IV: Plant Virus (15)

- A. Viral Plant Disease – Tobacco mosaic virus (TMV), Cauliflower Mosaic Virus (CaMV).
- B. Prevention and Control of plant viral diseases.
- C. Virus as biopesticides – Concept, production and application.

References:

1. General Microbiology – Stanier
2. General Microbiology – Pawar and Daginawala Vol I & II
3. Genetics of bacteria and their viruses – William Hays
4. Virology – Biswas
5. Virology – Luria

6. Microbiology – Prescott, Harley and Klein, Willey Sherwood
7. Plant Viruses – Mathews
8. Microbiology by Davi

PAH SOLAPUR UNIVERSITY, SOLAPUR (CBCS)

Theory Syllabus B.Sc. III-Microbiology (Semester-V)

w. e. f. June 2024 [Credits -4, Total Lectures-60]

DSC 1F : Paper - X: Agricultural Microbiology

Unit I- Soil Microbiology and elemental cycles (15)

- A. Introduction to soil– Definition of soil, Soil formation, types, structure and properties
- B. Soil as an ecosystem, rhizosphere and phyllosphere
- C. Soil microorganisms, types and their role in soil fertility, humus.
- D. Interactions in soil.
- E. Role of microorganisms in elemental cycle – Carbon, Nitrogen, Sulphur and Phosphorous

Unit II- Composting and Biodegradation (15)

- A. Compost production with reference to organic waste, types of microorganisms, and factors affecting - aeration, C:N:P ratio, moisture content, temperature, pH, and period of composting.
 1. Green manure
 2. Farm yard manure
 3. Town compost
 4. Vermi compost
- B. Biodegradation of Cellulose, hemicelluloses, Lignin, Pectin, and Pesticides - DDT

Unit III- Plant pathology (15)

- A. Common symptoms produced by plant pathogens
- B. Modes of transmission of Plant diseases: Oily spots on pomegranate – *Xanthomonas axonopodis*, Whip smut of Sugarcane
- C. Control measures of plant diseases

Unit IV- Applications of Biotechnology in Agriculture (15)

- A. Biofertilisers (Azo and Rhizo and PSB) production and applications.
- B. Bioinsecticides – *Bacillus thuriengensis* and *Trichoderma viridae*,
- C. Genetically Modified Crops: Concept with examples

References

1. Soil Microbiology – Subbarao,N.S.
2. Microbial dynamics and diversity – DesyStaley
3. Biology of Microorganisms – Brock, Parker, Madigen, 9thedition
4. Agricultural Microbiology- Bagyaraj andGhosh
5. Plant Diseases- SinghR.S.

6. Soil Microbiology –Alexander.
7. Industrial Microbiology – PatelA.H.
8. Textbook of Biotechnology – R.C.Dubey,

**PAH SOLAPUR UNIVERSITY, SOLAPUR (CBCS) Theory Syllabus
B.Sc. III-Microbiology (Semester-V) w. e. f. June 2021**

[Credits -4, Total Lectures-60]

DSC 1G: Paper - XI: Immunology

Unit I. Immune cells and organs (15)

A] Immune organ

a] structure &function of lymphoid organs:

- 1] Primary and organs - Thymus, bone marrow,
- 2] Secondary lymphoid organs-- spleen, lymph node and Mucosa associated lymphoid tissue(MALT)

b] Immune Cells (Hematopoiesis)

i]. Classification , Structure and functions of Lymphoid cells- T cells and T cell subsets, NK cells, B cells and APC

ii]. Classification, Structure and functions of myeloid cells – Granulocytes, Monocytes and macrophages

Unit II. Adaptive Immunity and Immuno-hematology (15)

A. Immune Response

- a) Humoral (antibody) mediated response –Cells involved and mechanism
- b) Cell mediated – cells involved, mechanism (endogenous and exogenous pathways); cytokines and their role
- c) Primary and secondary immune response

B. Immuno-hematology

- a. ABO blood group system
- b. Rh blood group system
- c. Blood transfusion reaction and its complications

Unit III: Complement system and Hyper Sensitivity (15)

A. Components of complement and their properties,

1. Activation of complement –classical and alternate pathway
2. Biological effects of complement

B. Hypersensitivity – Classification - based on

1. Time: Immediate and delayed type hypersensitivity

2. Mechanism of Pathogenesis

- a) Type I : Anaphylaxis, Atopy
- b) Type II : Autohaemolytic anemia
- c) Type III : Arthus reaction, Serum sickness
- d) Type IV: contact dermatitis, Allergy of infection

Unit IV: Transplantation and Autoimmunity

(15)

A. Types of grafts and mechanism of graft rejection – Graft vs. Host rejection

B. Autoimmunity:

a. Mechanism of Autoimmunity

b. Types of Autoimmune diseases

a) Hemocytolytic

b) Organ Specific(Graves disease, Myasthenia gravis, pernicious anemia)

c) Non organ specific (S.L.E., R.A.)

References

1. Essentials of Immunology Roitt Evan, Brostoff J. Male D. (1993) 6th Edition.
2. Immunology - Kuby J. (1996) - W.H. Freeman and Co.
3. Immunology – Fudenberg
4. Medical Microbiology - Davis and Dulbecco
5. Medical laboratory technology – RamnaikSood
6. Diagnostic Microbiology – Bailey's and Scotts
7. Immunology – a problem approach by Wood, Hood and Weison
8. Medical Bacteriology – Dey and Dey
9. Handbook of Immunology- G.P. Talwar (1983) Vikas Publishing Pvt. Ltd
10. Textbooks of medical microbiology-Anant Narayan
11. Immunology & Serology-Carpenter.

PAH Solapur University, Solapur (CBCS)

Theory Syllabus

B.Sc III Microbiology (semester V)

w.e.f June 2024

(Credit -4, Total lecture -60)

DSE-1A : Paper XII : Industrial Microbiology

Unit I Food and Dairy Microbiology (15)

A. Food Microbiology

- a) Food as a substrate for microorganisms.
- b) Food Spoilage (Meat and Poultry, Fruits and Vegetables)
Food borne diseases - food infection (Salmonella) and food poisoning (Clostridium)
- c) Principle and methods of food preservation

B. Dairy Microbiology.

- a) Composition of milk, Sources of microorganisms and spoilage of milk
- b) Qualitative examination of milk - Dye Reduction Test - MBRT
- c) Pasteurization of milk- Types of Pasteurization, Efficiency of Pasteurization - Phosphatase test

Unit II. Downstream processing and quality control (15)

A. Downstream processing:

Filtration, Centrifugation, Flocculation, Precipitation, Solvent extraction, Distillation, Whole broth processing, Crystallization, and Chromatography

B) Quality Control in Fermentation Industry Test for Bioassay (Penicillin) Sterility, Pyrogenicity, Allergy, Carcinogenicity, Toxicity for Pharmaceutical and health care and food products .

Unit III Industrial Production and applications (15)

- A. Streptomycin
- B. Lysine
- C. rDNA products -- Insulin
- D. Vitamin B12
- E. Monoclonal antibody

Unit IV Production of alcoholic beverages. (15)

A Grape wine - Definition, types, production of wine and spoilage of wine

B. Production of Champaign and California Sherry Wine

C. Beer - Definition, types and production of beer

References

1. Principles of fermentation technology – Whitkar and Stanbury
2. Pharmaceutical Microbiology – Huggo
3. Biochemistry – Fox and Nelson
4. Industrial Microbiology – Prescott and Dunn
5. Microbial technology – Pepler
6. Advances in Biotechnology – S.W. Jogdand.
7. Textbook of Biotechnology – R.C. Dubey,
8. Biotechnology – B.D. Singh
9. Industrial Microbiology – Casida
10. Industrial Microbiology by A.H. Patel.
11. Food Microbiology: an Introduction by Adam and Dick
12. Food Microbiology by Frazier

PAH Solapur University, Solapur (CBCS)

Theory Syllabus

B.Sc III Microbiology (Semester- V)

w.e.f June 2024

(Credit -4, Total lecture -60)

DSE1B: Paper MIC- XII : Bioprocess Technology

Unit I: Dairy Microbiology (15)

- a) Basics of Dairy Microbiology- microbiology of starter cultures and dairy products
- b) Nutritional and therapeutic importance of fermented dairy products
- c) Probiotics, prebiotics and functional dairy foods
- d) Detail study including definition, process and microbial culture/consortium of Functional Dairy Products: Fermented milk products, functional dairy products, and therapeutic applications.
- e) Health benefits of functional fermented dairy products: such as dahi, lassi, yoghurt, kefir, cheese, fermented whey drinks.

Unit II: Food Microbiology (15)

- A) Food as a substrate for microorganisms.
- B) Food Spoilage (Meat and Poultry, Fruits and Vegetables), Food borne diseases - food infection (Salmonella)and food poisoning (Clostridium)
- C) Principle and methods of food preservation
- D) Food Fermentation - i) Idli ii) Bread

Unit III Industrial Production Of-- (15)

- Vinegar (acetator)
- Mushrooms (Agaricus bisporus)
- Streptomycin production
- Amylase enzyme production

Unit IV: A) Downstream processing (15)

- Fermentation Product Recovery
- Criteria for choice of recovery process
- Biomass separation from fermentation media
- Precipitation Filtration, Cell Disruption for intracellular products, Solvent extraction and recovery, Chromatography, Drying, Crystallization, Whole broth processing

References

1. Principles of fermentation technology – Whitkar and Stanbury
2. Pharmaceutical Microbiology – Huggo
3. Biochemistry – Fox and Nelson
4. Industrial Microbiology – Prescott and Dunn
5. Microbial technology – Pepler
6. Advances in Biotechnology – S.W. Jogdand.
7. Textbook of Biotechnology – R.C. Dubey,
8. Biotechnology – B.D. Singh
9. Industrial Microbiology – Casida
10. Industrial Microbiology by A.H. Patel.
11. Food Microbiology: an Introduction by Adam and Dick
12. Food Microbiology by Frazier

Theory Syllabus
B.Sc III Microbiology (Semester V)
w.e.f June 2024

(Credit -4, Total lecture -60)

DSE1-C: Paper MIC- XII : Fermentation Technology

Unit I: Strain Improvement: **(15)**

- a) Objective of strain improvement
- b) Methods for strain improvement:
 - i. selection of different types of mutants
 - ii. application of rDNA technology

Media optimization:

- a. Classical approach – One factor at a time Full factor design
- b. Placket & Burman design
- c. Response Surface Methodology (RSM)

Sterilization of Media:

- a. Methods of sterilization
- b. Batch sterilization and Continuous sterilization

Unit II: Scale-up and Scale-down: **(15)**

- a. Objective of scale-up
- b. Levels of fermentation (laboratory, pilot-plant and production levels)
- c. Criteria of scale-up for critical parameters (aeration and agitation, broth rheology and sterilization)
- d. Scale-down

Unit III: Principles and methods of downstream processing: **(15)**

Cell disruption, Filtration, Centrifugation, Liquid-liquid extraction
Distillation, Ion exchange chromatography, Drying

Unit IV: Quality assurance (QA) of fermentation product and **(15)**

- A) Detection and Quantification of the product by physicochemical, Biological and enzymatic methods
- Sterility testing, Pyrogen testing – Endotoxin detection, Ames test and modified Ames test, Toxicity testing.

References

1. Principles of fermentation technology – Whitkar and Stanbury
2. Pharmaceutical Microbiology – Huggo
3. Biochemistry – Fox and Nelson
4. Industrial Microbiology – Prescott and Dunn
5. Microbial technology – Pepler
6. Advances in Biotechnology – S.W. Jogdand.
7. Textbook of Biotechnology – R.C. Dubey,
8. Biotechnology – B.D. Singh
9. Industrial Microbiology – Casida
10. Industrial Microbiology by A.H. Patel.
11. Food Microbiology: an Introduction by Adam and Dick
12. Food Microbiology by Frazier

Theory Syllabus

B.Sc. III-Microbiology (Semester-VI)

w. e. f. June 2024

[Credits -4, Total Lectures-60]

DSC 1H: Paper - XIII: Molecular Biology and Bioinformatics

Unit I: Basic concepts of microbial genetics (15)

- A) Structural organization of *Escherichia coli* chromosome, folded fiber model
- B) Transcription: RNA polymerase enzyme, process and post transcriptional modification.
- C) Translation (Activation of amino acids, initiation, elongation, termination)
- D) Operon (concept and types of regulation) – Lac Operon, Catabolite repression, Tryptophan operon (Repressor)

Unit II: Mutation and Genetic Recombination (15)

- A. Effect of Mutation
 - a) Concept of Intragenic and intergenic mutation
 - b) on translation
 - c) on phenotypes
 - d) Time course of phenotypic expression
 - e) Selection, detection and Isolation of mutants
 - f) Genetic Complementation – Cis – Trans Test
- B. Genetic Recombination
 - a) Fate of exogenote
 - b) Transformation
 - c) Conjugation
 - d) Transduction

Unit III: Techniques in molecular biology and Genetic engineering (15)

- A. Techniques in molecular biology
 - a) Extraction of DNA
 - b) PCR (gene amplification)
 - c) Electrophoresis of DNA.
 - d) DNA sequencing – Sanger Dideoxy method
 - e) DNA finger printing- method and applications
- B. Genetic Engineering
 - a) Introduction, Tools and Techniques of Genetic engineering
 - b) Applications of Genetic engineering

A. Bioinformatics

- a. Introduction to Bioinformatics.
- b. Introduction to major bioinformatics resources on Internet: National Centre for Biotechnology Information (NCBI), DDBJ, EMBL.
- c) The Basic Local Alignment Search Tool (BLAST)
- d) Protein data bank (PDB) and Nucleic acid sequence database (GenBank)

B. Protein Engineering – concept, methods and applications

References

1. General microbiology – Stanier
2. General microbiology – Pawar and Daginawala Vol I and II
3. Biochemistry – Lehninger
4. Molecular Biology of Gene – J.D. Watson
5. Recombinant DNA – J.D. Watson
6. Microbiology - Davis
7. Biochemistry - Purohit
8. Genetics of bacteria and their viruses – William Hays
9. <http://www.ncbi.nlm.nih.gov/>

Theory Syllabus (CBCS)
B. Sc. III – Microbiology (Semester VI)
(w.e.f. June 2024)
Credits – 04 Total Lectures – 60
DSC 1I: Paper XV – Environmental Microbiology

Unit I: Air Microbiology and Biosafety (15)

- A) Microorganisms in air – Launching, transport and deposition of aerosols, survival of microorganisms in air
- B) Significance of microorganisms in air (Extramural and intramural)
- C) Methods to study air borne microorganisms, sampling, qualitative and quantitative methods.
- D) Concept and definition of biosafety, objectives of biosafety, NIH guidelines
- E) Bioaerosol control (ventilation, filtration, biocidal control, UV gaseous (quarantine))
- F) Regulatory framework of biosafety in India-
 - a) Recombinant DNA advisory committee (RDAC)
 - b) Institutional biosafety committee (ISBC)
 - c) State biosafety coordination committee (SBCC)
 - d) District level biosafety committee (DLBC)

Unit II: Marine microbiology and fresh water ecosystem (15)

- A. Microorganisms in marine water, methods to study aquatic microorganisms, Characteristics of marine environment, types of organisms and their role.
- B. Fresh water ecosystem: Eutrophication, types of fresh water bodies a) classification of lakes b) Sources c) Consequences d) Control

Unit III: Extremophiles and Geo Microbiology (15)

- A. Extremophiles: General characteristics of extremophiles and their role-Acidophile, Alkalophiles, Thermophile, Psychrophiles, Barophiles and Osmophiles
- B. Geo-microbiology: Introduction, Microorganisms involved, biochemistry of microbial leaching, commercial leaching – slope, heap, in situ, leaching of iron, copper and uranium
- C. Oil recovery: Methods – Primary, Secondary and microbially enhanced oil recovery.

Unit IV: Environmental Impact Assessment and Industrial Waste Management (15)

- A) Types of wastes, waste water assessment BOD, COD, TS, TDS, TSS and treatment.
- B) Industrial waste treatment: Characteristics and treatment of wastes from different industries – Sugar and Dairy industry.
- C) Bioremediation: Lead and Mercury
- D) Concept of carbon sequestration and carbon credit.

References:

1. Physiology and Biochemistry of extremophiles – Charles Gerday and Nicolas Glansdroff.
2. Environmental Microbiology – Maier
3. Microbial ecology – Fundamentals and applications – Atlas and Bartha
4. Microbial dynamics and Diversity – Desy Staley
5. Biology of Microorganisms – Brock, Parker, Medigen, 9th Edition
6. Microbiology – Prescott and Harley, 5th Edition

PAH SOLAPUR UNIVERSITY, SOLAPUR (CBCS)

Theory Syllabus

B. Sc. III- Microbiology(Semester-VI)

w. e. f. June 2024 [Credits-4,Total Lectures-60]

DSC 1J Paper-XIV: Microbial Biochemistry

Unit I Enzyme, Enzyme kinetics and regulation

(15)

A) Enzymes:

(i) Definition, properties, structure, specificity, mechanism of action (Lock and key model, induced fit hypothesis)

(ii) Allosteric enzymes – Definition, Two models explaining mechanism of action (Sequential and Concerted)

(iii) Ribozymes and Isozymes

iv) Factors affecting on catalytic efficiency of enzymes

i) Proximity and orientation ii) Strain and distortion iii) Acid base catalysis iv) Covalent catalysis

B) Enzyme kinetics – Derivation of Michaelis Menten equation, Significance of K_m and V_{max}

C) Regulation of enzyme synthesis

i) Positive control – Arabinose Operon ii) Feed Back Inhibition

Unit II Extraction, purification and assay of enzymes

(15)

A) Cell disruption, Extraction and homogenization of membrane bound enzymes

B) Purification of enzymes on the basis of -i) Molecular size ii) Solubility differences

iii) Electric charge iv) Adsorption characteristics v) Biological affinity

C) Immobilization of enzymes – Methods and applications

D) Assay of enzymes (enzyme unit, enzyme activity, Specific activity)

Unit III Assimilation and Metabolic pathways:

(15)

A. Assimilation of:

a. Carbon

b. Nitrogen – N_2 and NH_3 (GOGAT)

c. Sulphur

B. Metabolic Pathways

1, Pyruvate as key metabolite in Carbohydrate metabolism

- a. TCA Cycle
- b. Pentose Phosphate Pathway
- c. Phosphoketolase pathway

Unit IV Metabolism of Macromolecules:

(15)

- A) Nucleotides-Purines and pyrimidines B) Peptidoglycan C) Beta Oxidation of lipids D)
Bioluminescence

References:

1. Molecular Biology of Gene– J.D.Watson
2. Principles and techniques of Practical Biochemistry–K.Wilson and J.Walker.
3. Analytical Chemistry– Robert B.Dilts
4. Chromatographic methods by Braithwaite and White
5. Outline of Biochemistry– Cohn and Stump
6. Biochemistry– West and Todd Russel
7. Biochemistry– Lehninger
8. Enzymes– Dixon and Web
9. Biological chemistry– Mahler and Cordes
10. Nature of Enzymology–R.L. Foster
11. Microbial technology– Pepler
12. Biochemistry– A problem approach by Wood, Hood and Weison

Theory Syllabus B.Sc. III-Microbiology (Semester-VI)

w. e. f. June 2024[Credits -4 Total Lectures- 60

DSE 2A: Paper XVI: Medical Microbiology

Unit I Mechanism of Pathogenicity – (15)

1. Definition & Concept
2. Basic principles of Microbial adhesion
3. Mechanism of Bacterial invasion
4. Bacterial toxins – Types & mechanism of action
5. Mechanism of pathogenicity of viral & fungal infections

Unit II: Microbial diseases (15)

(characters of etiological agent, , modes of transmission, pathogenesis, symptoms, laboratory diagnosis, prophylaxis and treatment of following diseases)

1. Bacterial: 1. *Pseudomonas aeruginosa* 2. *Mycobacterium tuberculosis*, 3. *Clostridium perfringens* 4. *Vibrio cholerae* 5. Staphylococcal wound Infections
2. Rickettsial: Rocky Mountain spotted fever/ Yellow Fever
2. Fungal: 1. Dermatophycoses [Tinea], 2.. Mucormycosis
4. Protozoan: 1. Malaria

Unit III: Vaccinology & bioweapons (15)

1. Basic concept
2. Types: A] traditional-live attenuated, killed, toxoids
B] New generation vaccines: subunit, Recombinant , conjugated, DNA
3. Definition, Characteristics of bioweapons , Advantages & disadvantages of bioweapons, Examples

Unit-IV : Chemotherapy (15)

1. Ideal characteristics of chemotherapeutic agents
2. Mechanism of action of different chemotherapeutic agents:
 - A] Antibiotics
 - i. Acting on Cell Wall: Penicillin, Bacitracin,
 - ii. Acting on Protein Synthesis: Streptomycin, Chloramphenicol, Tetracycline
 - iii. Acting on nucleic acid synthesis: quinolones, rifampicin
 - iv. Drugs Acting on folic acid synthesis: Sulphonamide, Trimethoprim,
 - B] Antiviral agents: AZT, Remdesivir.
 - C] Antifungal agents: Amphotericin B, Griseofulvin, Nystatin.

D] Antiprotozoal agents: Chloroquine, Tinidazole

3. Mechanism of antibiotic resistance

4. Tests to guide chemotherapy: diffusion and broth dilution methods

References:

1. Pharmaceutical Microbiology – Huggo
2. Text book of Medical Microbiology – Ananthnarayan
3. Review of Medical Microbiology – Jawetz et al
4. Microbiology – Zinsser
5. Medical Microbiology – Cruickshank
6. Medical Microbiology - Davis and Dulbecco
7. Parasitology – Chattergii
8. Medical laboratory technology – RamnaikSood
9. Diagnostic Microbiology – Bailey's and Scotts
10. Medical Bacteriology – Dey and Dey

Theory Syllabus B.Sc. III-Microbiology (Semester-VI)

w. e. f. June 2024[Credits -4 Total Lectures- 60

DSE 2B: Paper XVI: Clinical Microbiology

Unit I :Clinical Microbiology: (15)

Types of Clinical Specimen.

Diagnostic methods: 1. Morphological 2. Cultural 3.Biochemical and 4. Serological

Laboratory disposal of biomedical waste: Types and categorisation and methods used in disposal.

Unit II Pathogenesis – (15)

1. Definition & Concept
2. Basic principles of Microbial adhesion
3. Mechanism of Bacterial invasion
4. Bacterial toxins – Types & mechanism of action
- 5.Mechanism of pathogenicity of viral & fungal infections

Unit III: Study of Common diseases (15)

(15) (characters of etiological agent, , modes of transmission, pathogenesis, symptoms, laboratory diagnosis, prophylaxis and treatment of following diseases)

- 1.Bacterial: 1. *Pseudomonas aeruginosa* 2.*Mycobacterium leprae* 3. *Mycobacterium tuberculosis*, 4.*Clostridium perfringens* 5.*Vibrio cholerae* 6. Staphylococcal wound Infections
2. Rickettsial: Yellow Fever
- 2.Fungal: 1. Mucormycosis
- 4.Protozoal: 1.Malaria

Unit-IV : Chemotherapy (15)

1. Ideal characteristics of chemotherapeutic agents
2. Mechanism of action of different chemotherapeutic agents: A]Antibiotics
 - i. Acting on Cell Wall: Penicillin, Bacitracin.
 - ii. Acting on Protein Synthesis: Streptomycin, Chloramphenicol, Tetracycline
 - iii. Acting on nucleic acid synthesis: quinolones, rifampicin
 - iv. Drugs Acting on folic acid synthesis: Sulphonamide, Trimethoprim,
3. Mechanism of antibiotic resistance
4. Tests to guide chemotherapy : diffusion and broth dilution methods

PAH SOLAPUR UNIVERSITY, SOLAPUR (CBCS)
Theory Syllabus B.Sc. III-Microbiology (Semester-VI)
w. e. f. June 2024[Credits -4 Total Lectures- 60]
DSE 2C: Paper XVI: Health Microbiology

Unit I: Vaccinology & bioweapons (15)

1. Basic concept
2. Types: A] traditional-live attenuated, killed, toxoids B] New generation vaccines: subunit, Recombinant, conjugated, DNA 3. Definition, Characteristics of bioweapons Advantages & disadvantages of bioweapons, Examples

Unit II Pathogenicity – (15)

1. Definition & Concept
2. Basic principles of Microbial adhesion
3. Mechanism of Bacterial invasion
4. Bacterial toxins – Types & mechanism of action
5. Mechanism of pathogenicity of viral & fungal infections

Unit III: Common Human diseases (15)

Etiological agent, , modes of transmission, pathogenesis, symptoms, laboratory diagnosis, prophylaxis and treatment of following diseases)

1. Bacterial: 1. *Pseudomonas aeruginosa* 2. *Mycobacterium leprae* 3. *Mycobacterium tuberculosis*, 4. *Clostridium perfringens* 5. *Vibrio cholerae* 6. Staphylococcal wound Infections
2. Rickettsial: Yellow Fever
2. Fungal: 1. Mucor mycosis
4. Protozoal: 1. Malaria

Unit-IV : Antimicrobial agents (15)

1. Ideal characteristics of chemotherapeutic agents
2. Mechanism of action of different chemotherapeutic agents: A] Antibiotics
 - i. Acting on Cell Wall: Penicillin, Bacitracin.
 - ii. Acting on Protein Synthesis: Streptomycin, Chloramphenicol, Tetracycline
 - iii. Acting on nucleic acid synthesis: quinolones, rifampicin
 - iv. Drugs Acting on folic acid synthesis: Sulphonamide, Trimethoprim,B] Antiviral agents: , Remdesivir.
C] Antifungal agents : Amphotericin B, Griseofulvin, Nystatin.
D] Antiprotozoal agents: Chloroquine, Tinidazole
3. Mechanism of antibiotic resistance
4. Tests to guide chemotherapy : diffusion and broth dilution methods

PAH SOLAPUR UNIVERSITY, SOLAPUR
B. Sc. III- Microbiology
w.e.f. June2024 Practical Syllabus (Credits-4)

PRACTICAL COURSE

DSC 1 E & DSC 1 H: Practical IV

1. Isolation of DNA from bacteria by J.Marmur's method
2. Electrophoretic separation of DNA
3. Isolation of coliphages from sewage
4. One step growth curve
5. Determination of dose of U.V. by UV survival curve
6. Isolation of Lac negative mutants of *E.coli* by visual detection method.
7. Isolation of Streptomycin resistant mutants by gradient plate technique.
8. Isolation of Vitamin B12 requiring(auxotrophic) mutants by replica plate technique.
9. Cultivation of Viruses in Embryonated chicken egg
10. Study of Virally infected lesions of Plant materials
11. Browsing of National Centre for Biotechnology Information (NCBI), DDBJ and EMBL websites.
12. Exploring protein sequence database (PDB) and Gene Bank and BLAST.

DSC 1 F & DSC 1 I: Practical V

1. Isolation of **Azotobacter** from soil.(Identification upto genus level)
2. Isolation of **Rhizobium** from root nodules.
3. Isolation of **Xanthomonas** from infected plant material
4. SPC of market **Biofertilizers**.
5. Estimation of available phosphorous from soil(Stannous chloride method)
6. Estimation of Calcium and Magnesium from soil (EDTA method)
7. Determination of organic carbon contents of soil (Walkley and Black method)
8. Diauxic growth curve of Escherichia coli (glucose and lactose).
9. Immobilization of enzyme by using Sodium alginate
10. Thin layer chromatography-aminoacid
11. Study of Substrate concentration on enzyme activity.
12. Purification of enzyme and study of its activity
13. Amylase assay (Iodometric method)

DSC 1 G & DSC 1 J: Practical VI:

1. Haematology–
2. Estimation of Hb by Sahlis method
3. Total blood cell count: RBC count, WBC count,
4. differential WBC count
5. Determination of Erythrocyte sedimentation Rate
6. Separation and Preservation of Serum and Plasma
7. Widal test (quantitative test), RA test, Pregnancy test
8. Microbiological analysis Drinking water: Presumptive, Confirmed and Completed test
9. Determination of potability of water by MPN.
- 10. Wastewater analysis: Chemical Oxygen Demand (COD)**
11. Biological Oxygen Demand (BOD)

DSE 1 A Practical VII:

1. Examination of milk
 - i) DMC
 - ii) Quantitative analysis of milk by SPC (using nutrient agar)
2. Phosphatase Test(qualitative)
3. Isolation and identification of microorganisms from spoiled food
4. Bioassay of Streptomycin
5. Sterility testing of media and pharmaceutical products
6. Isolation of Lactic acid Bacteria (MRS Medium)
7. Estimation of alcohol by using $K_2Cr_2O_7$
8. Estimation of Citric acid by titration method
9. Bioassay of Vitamin B12

DSE-2A

1. Isolation of pathogen from clinical sample *Pseudomonas aeruginosa* /*S.aureus*
2. Study of determination of effectiveness of antiseptic agents (–tincture iodine, 3% H_2O_2 , 70% alcohol, 5% chlorine bleach) against selected organisms (*Escherichia coli*, *Staphylococcus aureus*, *Bacillus*) by disc diffusion method
3. Antimicrobial susceptibility testing by disc diffusion
4. Urine analysis: Microscopic examination
5. Urine analysis Chemical examination –
Glucose (benedict's method. Protein
(acetic acid),
Bile salt (sulphur method),
Ketone bodies (Rothera's test)

DSE 1 B Practical VII:

- 1.Examination of milk
 - i) DMC
 - ii) Quantitative analysis of milk by SPC (using nutrient agar)
- 2.Phosphatase Test(qualitative)
- 3.Isolation and identification of microorganisms from spoiled food
- 4.Bioassay of Streptomycin
- 5.Sterility testing of media and pharmaceutical products
- 6.Isolation of Lactic acid Bacteria (MRS Medium)
- 7.Estimation of alcohol by using $K_2Cr_2O_7$
- 8.Estimation of Citric acid by titration method
- 9Bioassay of Vitamin B12

DSE-2B

1. Isolation of pathogen from clinical sample *Pseudomonas aeruginosa* /*S.aureus*
2. Study of determination of effectiveness of antiseptic agents (–tincture iodine, 3% H_2O_2 , 70% alcohol, 5% chlorine bleach) against selected organisms (*Escherichia coli*, *Staphylococcus aureus*,*Bacillus*)by disc diffusion method
- 3.Antimicrobial susceptibility testing by disc diffusion
4. Urine analysis:Microscopic examination
- 5 Urine analysis Chemical examination –
Glucose(benedict'smethod.Protein
(acetic acid),
Bilesalt (sulphur method),
ketonebodies(Rothera'stest)

DSE 1 C Practical VII:

- 1.Examination of milk
 - i) DMC
 - ii) Quantitative analysis of milk by SPC (using nutrient agar)
- 2.Phosphatase Test(qualitative)
- 3.Isolation and identification of microorganisms from spoiled food
- 4.Bioassay of Streptomycin
- 5.Sterility testing of media and pharmaceutical products
- 6.Isolation of Lactic acid Bacteria (MRS Medium)
- 7.Estimation of alcohol by using $K_2Cr_2O_7$
- 8.Estimation of Citric acid by titration method
- 9Bioassay of Vitamin B12

DSE-2C

1. Isolation of pathogen from clinical sample *Pseudomonas aeruginosa* /*S.aureus*
2. Study of determination of effectiveness of antiseptic agents (–tincture iodine, 3% H_2O_2 , 70% alcohol, 5% chlorine bleach) against selected organisms (*Escherichia coli*, *Staphylococcus aureus*,*Bacillus*)by disc diffusion method
- 3.Antimicrobial susceptibility testing by disc diffusion
4. Urine analysis:Microscopic examination
- 5 Urine analysis Chemical examination –
Glucose(benedict'smethod.Protein
(acetic acid),
Bilesalt (sulphur method),
ketonebodies(Rothera'stest)

Practical Examination

- iii) The university practical examination will be conducted on four (4) consecutive days for not less than 6 hours on each day of the practical examination. The practical examination shall be conducted by the two external examiners appointed by the University.
- iv) Each candidate must produce a certificate from the Head of the Department in his/her college stating that he/she has completed in a satisfactory manner the practical course on the guidelines laid down from time to time by Academic council on the recommendation of Board of studies and has recorded his/her observations in the laboratory journal and written a report on each exercise performed. Every journal is to be checked and signed periodically by a member teaching staff and certified by the Head of the Department at the end of the year. Candidates are to produce their journal at the time of practical examination. Candidate has to visit two places of Microbiological interest (Pharmaceutical industry, Dairy, Research institutes etc) and submit the report of their visit at the time of examination. The report should be duly certified by the Head of the Department.

Distribution of Marks for practical examination

- One major experiment: 30 marks
- Two minor experiment: 15 marks each
- Journal: 5 marks
- Viva: 10

Total marks:

Practical V:	75
Practical VI:	75
Practical VII:	75
Practical VIII:	75
Tour Report :	20
Total Marks:	320

Major Experiments

Isolation of DNA from bacteria by J.Marmur's method

Isolation of coliphages from sewage

Determination of dose of U.V. by UV survival curve

Isolation of Vitamin B12 requiring (auxotrophic) mutants by replica plate technique.

Minor Experiments

One step growth curve

Cultivation of Viruses in Embryonated chicken egg

Study of Virally infected lesions of Plant material

Browsing of National Centre for Biotechnology Information (NCBI),DDBJ and EMBL

Isolation of Lac negative mutants of *E.coli* by visual detection method.

Isolation of Streptomycin resistant mutants by gradient plate technique.

Exploring protein sequence database (PDB) and Gene Bank and BLAST.

Practical V

Major Experiment

Diauxic growth curve of *Escherichia coli* (glucose and lactose).

Study of Substrate concentration on enzyme activity.

SPC of market Bio-fertilizers.

Isolation of *Azotobacter* / *Rhizobium* / *Xanthomonas*

Minor Experiment

Amylase assay (Iodometric method)

.Immobilization of enzyme by using Sodium alginate

Estimation of available phosphorous from soil(Stannous chloride method)

Estimation of Calcium and Magnesium from soil(EDTA method)

Thin layer chromatography-amino acid

Determination of organic carbon contents of soil (Walkley and Black method)

Practical VI

Major Experiment

Microbiological analysis Drinking water: Presumptive, Confirmed and Completed test

.Determination of potability of water by MPN.

Waste water analysis:Chemical Oxygen Demand (COD)

. Biological OxygenDemand (BOD)

Minor Experiment

Widal test (quantitative test)

RA test,

Pregnancy test

Estimation of Hb

RBC count WBC count

Erythrocyte sedimentation Rate

Study of determination of effectiveness of antiseptic agents.

Practical VII

Major Expt

Isolation of pathogen from clinical sample *Pseudomonas aeruginosa/S.aureus*

Bioassay of Streptomycin

Differential WBC count

Bioassay of Vitamin B12

Isolation of microorganisms from spoiled food

SPC of Milk

Isolation of Lactic acid Bacteria (MRS Medium)

Minor Experiment

Phosphatase Test (qualitative)

Estimation of alcohol by using $K_2Cr_2O_7$

Sterility testing of media and pharmaceutical products

Estimation of Citric acid by titration method

Microscopic examination of urine

Chemical examination of urine

Antimicrobial susceptibility testing by disc diffusion method

List of the Minimum equipments and related requirements for B.Sc–III

- 1) Replicating units for genetics experiments: Two
- 2) Rotary shaker for fermentation experiments: One
- 3) Centrifuge (High speed): One
- 4) Hotplate: One
- 5) Hot air oven: One
- 6) Bacteriological incubator: One
- 7) Spectrophotometer: One
- 8) Research Microscope: one for each student
- 9) Haemocytometer: Two
- 10) Haemoglobinometer: Two
- 11) ESR stands and tubes: Two
- 12) Separate room for fine instruments of size 10' × 15' feet dimension
- 13) A separate culture room of at least 10' × 10' feet dimension
- 14) Electrophoresis assembly: One
- 15) Laminar air flow cabinet: One
- 16) Distillation assembly: One (Glass)
- 17) Reflux assembly: Four
- 18) Serological water bath: One
- 19) Colony counter: One
- 20) Refrigerator: One
- 21) TLC UNIT: One
- 22) Hand Refractometer
- 23) Computer with Internet facilities and printer: One
- 24) Micropipette: One
- 25) Anaerobic Jar: One
- 26) Heating Mantle: One
- 27) UV Chamber