Bachelor of Sciences : Microbiology (Third/DegreeYear)

Course Learning Outcomes & Contents of the Courses
(Paper wise)

- The total Notional Learning Hours for assignment of credits across school education, higher education and vocational education /skilling have been agreed to be 1200 Hrs per year for which the students/ learners shall be awarded 40 Credits. For the purpose of credit calculations under National Credit Framework (NCrF), 30 notional learning hours will be counted as one Credit.

- A Credit is a unit by which the coursework is measured. It determines the number of hoursof instruction required per week over the duration of a semester (Minimum 15 weeks).
- 1 Credit of class room **theory = 15 hours** of engagement in a semester
- 1 Credit of **Practical/Internship/workshop**-based activity/theory under ODL (Open and Distance Learning) = **30 hours** of engagement in a semester
- 1 Credit of field visit/industry visit/Assignments = 40-45 hours of engagement in a semester
- Research Project/Dissertation: Entire Eighth Semester
- The weightage of the credits of a course may differ (4-6 credits) based on level of the courses.

Bachelor of Sciences : Microbiology (Third/DegreeYear)

Course Learning Outcomes & Contents of the Courses
(Paper wise)

Semester	Paper code	Paper name	Credit points	Hours
FIVE	BS23MJ5MB1	Microbial Molecular Biology and Genetics	4	60
	BS23MJ5MB2	Microbial Metabolism	4	60
	BS23MJ5MB3	Basic techniques of genetics and metabolism	4	60+
	BS23MN5MB1	Industrial Microbiology	4	60
	BS23MN5MB2	Basic techniques of Industrial Microbiology	4	60+ (120)
	BSC23SE505	Instrumentation and Biotechniques	2	30
SIX	BS23MJ6MB1	Biotechnology	4	60
	BS23MJ6MB2	Mycology and Virology	4	60
	BS23MJ6MB3	Basic techniques in virology, medical and plant pathology	4	60+ (120)
	BSC23MN6MB1	Intellectual Property Rights	2	30
	BSC23MN6MB2	Filling of patents and Case study	2	30
	BSC23SE605	Dissertation related to the subject and its allied branches	4	60+ (120)

Bachelor of Sciences : Microbiology Semester Five

BS23MJ5MB1 Microbial Molecular Biology and Genetics Credit 4

Course learning outcomes: By the conclusion of this course, the students have -
Outcome 1. Understood genome organization of model organisms namely *E.coli*and *Saccharomyces,* and the molecular mechanisms that underlie mutations.
Outcome 2. Developed a fairly good knowledge about the three well known mechanisms by which genetic material is transferred among the microorganisms namely transformation, transduction and conjugation.
Outcome 3.Are able to describe different types of the extrachromosomal elements or the plasmids; the nature of the transposable elements in the prokaryotic and the eukaryotic cells.

Unit 1. DNA Structure, Replication Lecture 15 hours

1. DNA as Genetic Material
2. The Flow of Genetic Information: central dogma
3. Structure of DNA: A, B, Z.,
4. Patterns of DNA synthesis/replication , experimental proof
5. DNA replication: Replication machinery, proof reading, termination of replication,
6. Replication of linear chromosome

Unit 2. Gene Structure and function Lecture 15 hours

1. Gene Structure : protein coding genes, tRNA and rRNA genes
2. Transcription in prokaryotes
3. Difference of transcription in eubacteria, archeaand eucaryotes
4. The Genetic Code, experimental proof
5. Translation : initiation, elongation and termination
6. Introduction to chaperones

Unit 3 Microbial Genetics: Regulation of Gene Expression Lecture 15 hours

1. Levels of Regulation of Gene Expression
2. The Discovery of Gene Regulation
3. Regulation of Transcription Initiation: induction and repression of enzyme synthesis, Lactose operon and tryptophan operon
4. Regulation of Transcription Elongation : Attenuation of *trp* operon
5. Regulation at the Level of Translation : riboswitch, antisense RNA
6. Global Regulatory Systems, Quorum sensing in *V.fisheri*

Unit 4. Mechanisms of Genetic Variation Lecture 15 hours

1. Types of mutation
2. Principle and causes of spontaneous mutation
3. Induced mutation: physical, chemical and biological agents

4. Detection and Isolation of Mutants :Ames test.
5. DNA Repair
6. Transposable Elements
7. Bacterial Plasmids
8. HGT VGT
9. DNA Transformation
10. Bacterial Conjugation
11. Transduction : Generalized and specialized

BS23MJ5MB2 Microbial Metabolism Credit 4

Course learning outcomes: By the conclusion of this course, the students are capable of -
Outcome 1. Describing the growth characteristics of the microorganisms capable of growing under unusual environmental condition of temperature, oxygen, and solute and water activity.
Outcome 2. Describing the growth characteristics of the microorganisms which require different nutrient for growth and the associated mechanisms of energy generation for their survival like autotrophs, heterotrophs, chemolithoautotrophs etc.
Outcome 3.Differentiating concepts of aerobic and anaerobic respiration and how these are manifested in the form of different metabolic pathways in microorganisms.

Unit 1. Basic concepts of enzymes: 15 lectures

a) Physicochemical properties of enzymes, vitamins
b) Nomenclature, classification of enzymes
c) Mechanism of action of enzymes
d) Factors affecting enzyme activity
e) Isoenzymes, abzymes and allosteric enzymes.
f) Enzyme inhibition
g) Enzyme kinetic: M-M equation, double reciprocal and regulation

Unit 2. Catabolism: Concept of aerobic respiration, anaerobic respiration and fermentation 15 lectures

a) Carbohydrates: classification, properties, functions and importance
b) Free energy, reducing power, Energy rich molecules
c) Sugar degradation pathways : EMP, ED, Pentose phosphate pathway TCA cycle.
d) Electron transport chain: components of respiratory chain, electron transport phosphorylation, uncouplers and inhibitors.
e) Fermentation - Alcohol fermentation and Pasteur effect; Lactate fermentation (homofermentative and heterofermentative pathways)
f) Concept of linear and branched metabolic pathways

Unit 3. Catabolism: Introduction to aerobic and anaerobic chemolithotrophy 15 lectures

a) Amino acid and proteins: chemistry, properties and functions
b) Hydrogen oxidation (definition and reaction)
c) Methanogenesis (definition and reaction).

d) Introduction to phototrophic metabolism - groups of phototrophic microorganisms, anoxygenic vs. oxygenic photosynthesis with reference to photosynthesis in green bacteria, purple bacteria and Cyanobacteria
e) Anaerobic respiration dissimulator nitrate reduction (Denitrification; nitrate/nitrite and nitrate/ammonia respiration; fermentative nitrate reduction).

Unit 4 Anabolism: The Use of Energy in Biosynthesis **15 lectures**

a. Lipids and fats: chemistry, properties and functions and importance
b. The Precursor Metabolites
c. The Fixation Of CO_2 By Autotrophs: Calvin Cycle, Reductive TCA Cycle
d. Synthesis Of Sugars : Gluconeogenesis, Disaccharides
e. Introduction to Biological Nitrogen Fixation (Only Pathway) Ammonia Assimilation. Assimilatory Nitrate Reduction
f. Anaplerotic Reactions : Glyoxylate Cycle
g. Synthesis Of Amino Acids and sulphur assimilation (Only Pathway)
h. Fatty Acid, Triacylglycerol And Phospholipid Synthesis (Only Pathway)

References :

1) Principles Of Microbiology , Atlas R.M.
2) Microbiology Marjorie Kelly Cowan
3) Microbiology Gerard J. Tortora
4) Foundations In Microbiology Kathleen Park Talaro
5) General Microbiology ,Roger Y. Stanier Macmillan, 1987
6) Michael J. Pelczar Jr. Chan EcsAnd Krieg Nr (2004) Microbiology , 5th Edition. Tata Mcgraw Hill.
7) Prescott's Microbiology, Eighth Edition Reviewed By Joanne J. DobbinsJoanne M. Willey , Linda M. Sherwood ,And Christopher J. Woolverton . 2011. Mcgraw-Hill Higher Education, New York, NY.
8) Black JG (2008), Microbiology : Principles And Explorations 7th Edition, Prentice Hall.
9) Medigan M T And Martinko JM (2014), Brock Biology Of Microorganisms, 14th Edition. Parker J. Prentice Hall International
10) https://onlinecourses.swayam2.ac.in/cec21_bt17/preview

BS23MJ5MB3 Basic techniques of genetics and metabolism Credit 4

A. Microbial Genetics

1. Preparation of Master and Replica Plates: auxotrophic mutants (**Spontaneous mutants)**
2. Study physical (UV) mutagens on bacterial cells: lac mutants, pigmentless mutants
3. Study survival curve of bacteria after exposure to ultraviolet (UV) light (turbidometric)

4. Gradient plate technique for isolation of streptomycin resistant mutants
Study of χ max

B. Microbial Metabolism

1. Estimation of sugars by Cole's method
2. Estimation of sugar by Nelson's Somogy's method
3. Estimation of protein by Lowery's method
4. Qualitative analysis of carbohydrates, amino acid and protein : paper chromatography, thin layer chromatography
5. Detection of enzyme by biochemical tests:
    a) Utilization of sugars (Oxidative reduction test, sugar utilization test [glucose, lactose, maltose, sucrose, xylose, fructose], utilization of starch, methyl red test, vogus praskaurs test, citrate utilization test
    b) Utilization of proteins: H_2S production test, urea utilization test, nitrate reduction test, casein utilization test, gelatine utilization test, indole production test
    c) Lipid utilization test, miscellaneous test : catalase test, oxidase test, dehydrogenase test

BS23MN5MB1 Industrial Microbiology Credit 4

Course learning outcomes: By the conclusion of this course, the students -
Outcome 1. Are capable of describing a large number of substrate that are used for the industrial fermentation processes.
Outcome 2.Have developed an understanding of different types of reactors or fermenters which are used for laboratory, pilot and industrial scale fermentations and their processes parameters.
Outcome 3.Have acquired a detailed knowledge of number of products which are produced by industrial fermentation processes

Unit 1. Introduction to fermentation 15 lectures

a) Concept of fermentation and types of fermentation processes :Open and closed fermentation, surface culture fermentation, submerged fermentation (batch, fed-batch & continuous), solid substrate fermentation, Laboratory, pilot- scale fermentation, constantly stirred tank ,Stirred tank Bioreactor
b) Stages in development of fermentation process and component parts of fermentation process
c) Range of fermentation products.
d) Characteristics of an industrially important ideal organism
e) Primary Screening of industrially important organisms: amylase, organic acid, antibiotics and amino acid producers; Introduction to secondary screening

Unit 2. Fermentation media, sterilization and inoculums development 15 lectures

a) Principles of media formulation
b) Outline of Fermentation media ingredients: Water, nutritive: carbon, nitrogen sources, growth factors and non nutritive ingredients (minerals, buffers, precursors, inducers, inhibitors, antifoam agents)
c) Criteria of selection and various carbon sources and nitrogen sources

d) Sterilization of media: Use of high-pressure steam: Principle, batch and continuous sterilization process
e) Sterilization by use of filtration: Principle, types of filters, sterilization of animal cell media and air
f) Inoculum development: General principles for development of seed culture of yeast mold and bacteria

Unit 3. Bioreactor Design **15 lectures**

a) Basic functions of a bioreactor and fermenters
b) Types of enzyme bioreactors
c) Body construction of fermenter
d) Devices used for aeration and agitation: sparger, impellers, baffels, KLa value
e) Devices used for pH, temperature, foam and dissolved oxygen
f) Bioreactors for special fermentation: Airlift, types of tower fermenters

Unit 4. Down-stream processing **15 lectures**

a) Cell disruption: Types and principle
b) Filtration: Types and principle
c) Centrifugation: Types and principle
d) Solvent extraction: Types and principle
e) Precipitation: Types and principle
f) Flocculation: Types and principle
g) Lyophilisation and spray drying: Types and principle

BS23MN5MB2 Basic techniques of Industrial Microbiology Credit 4

1. Study of types of enzyme/cell immobilization .
2. Immobilization of enzymes (amylase) by calcium alginate and its efficiency by starch hydrolysis using iodine reagent.
3. Primary screening of amylase producing bacteria
4. Primary screening of antibiotic producing bacteria (crowded plate technique)
5. Primary screening of organic acid producing bacteria.
6. Production of amylase by fermentation and detection of its activity by iodometric/DNSA/Nelson Somogy's technique
7. Study of lambda max

Reference Books

1. Richard H. Baltz. Julian E Davies and Arnold L.Demain Manual of Industrial Microbiology and Biotechnology. 3rd edition, ASM Press (2010).
2. Daniel Forciniti. Industrial Bioseperation: Principles and practice. 1st edition, Wiley-Blackwell (2008).
3. Reed. G. Prescott and Dunn's Industrial Microbiology. CBS Publishers. (1999).
4. Demain, A. L. Industrial Microbiology and Biotechnology. 2nd Edition. (2001).
5. EL Mansi. E.M.T. FermentationMicrobiologyand Biotechnology. 2ndEdition,CRC Taylor&Francis (2007).
6. Waites,M.J.,Morgan, N.L.,Rockey, J.S.andHigton,G.Industrial Microbiology: Anlntroduction. Blackwell SciencePublishers(2002).
7. Casida LE, Industrial Microbiology, J. Wiley, (1968).

8. Pelczar, MJ Chan ECS and Krieg NR, Microbiology McGraw-Hill.
9. Willey,Sherwood,Woolverton. Prescott,Harley, and Klein's Microbiology McGraw-Hill publication
10. Tortora,Funke,Case. Microbiology.Pearson Benjamin Cummings.
11. Jacquelyn G. Black. Microbiology Principles and explorations. JOHN WILEY & SONS, INC
12..Madigan,Martinko, Bender,Buckley,Stahl.Brock Biology of Microorganisms. Pearson
13. Tom Besty,D.C Jim Koegh.Microbiology Demystified McGRAW-HILL.
14. Wulf Crueger.Cruegers Biotechnology: A Textbook of Industrial Microbiology 2017
15. Stanbury P F, Whitaker A, And Hall S J, (1995). Principles Of Fermentation technology, 2nd Edn, Pergamon Press, London, Uk

BSC23SE505 . Instrumentation and Biotechniques Credit 2

Course learning outcomes: By the conclusion of this course, the students have -
Outcome 1. Developed an understanding which basic analytical equipments could be used
Outcome 2.Developed an understanding as to where and how the basic analytical equipments can be used.

Unit1A.Chromatography 8h lectures
Principles and applications of: paper chromatography (including Descending and 2-D), Thin layer chromatography. Column packing and fraction collection. Gel filtration chromatography, ion exchange chromatography and affinity chromatography, GLC, HPLC.

Unit1B.Centrifugation 7h lectures
Preparative and analytical centrifugation, fixed angle and swinging bucket rotors. RCF and sedimentation coefficient, differential centrifugation, density gradient centrifugation and ultracentrifugation.

Unit 2 A. Electrophoresis 8h lectures
Principle and applications of : native polyacrylamide gel electrophoresis, SDS- polyacrylamide gel electrophoresis, 2D gel electrophoresis, Isoelectric focusing

Unit.2B.Spectrophotometry 7h lectures
a) Principle and use of study of absorption spectra of biomolecules.
b) Analysis of biomolecules using UV and visible range. Colorimetry and turbidometry.

Suggested readings
1. Wilson K and Walker J. (2010). Principles and Techniques of Biochemistry and Molecular Biology. 7th Ed., Cambridge University Press.
2. Nelson DL and Cox MM. (2008). Lehninger Principles of Biochemistry, 5th Ed., W.H. Freeman and Company.
3. Willey MJ, Sherwood LM & Woolverton C J. (2013). Prescott, Harley and Klein's Microbiology. 9thEd., McGraw Hill.
4. Karp G. (2010) Cell and Molecular Biology: Concepts and Experiments. 6th edition. John Wiley & Sons. Inc.

5. De Robertis EDP and De Robertis EMF. (2006). Cell and Molecular Biology. 8th edition. Lipincott Williams and Wilkins, Philadelphia.
6. Cooper G.M. and Hausman R.E. (2009). The Cell: A Molecular Approach. 5th Edition. ASM Press & Sunderland, Washington D.C., Sinauer Associates, MA.
7. Nigam A and Ayyagari A. 2007. Lab Manual in Biochemistry, Immunology and Biotechnology. Tata McGraw Hill.

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Bachelor of Sciences : Microbiology Semester SIX

BS23MJ6MB1 Biotechnology Credit 4

Course learning outcomes: By the conclusion of this course, the students have -
Outcome 1. Developed an understanding how microbiology is relevant to technological developments for agriculture and environment.
Outcome 2.Developed an understanding how microbiology is relevant to technological developments for industries related to fermentations and marine.
Outcome 3. Developed an understanding of roles of microbes in bioremediation
Outcome 4. Developed an understanding of tissue culture

Unit 1. Commercial production of cells and primary metabolite 15 lectures

a) Production of single cell protein
b) Production bacterial biofertilizers
c) Production of bacterial pesticides
d) Production of primary metabolite: amylase
e) Production of primary metabolite: vitamins, citric acid, lysine
f) Production of primary metabolite: citric acid (organic acid)
g) Production of primary metabolite: lysine (amino acid)

Unit 2. Commercial production secondary metabolite, microbial polymers, biofuel 15 lectures .

a) Production of secondary metabolite - antibiotics: penicillin
b) Steroid biotransformation
c) Production of bioethanol
d) Production of bioplastics
e) Production of biogas
f) Production of xanthan gum

Unit 3. Microorganisms in pollution control 15 lectures

a) Introduction to biobenification, biosorption, bioremediation, bioaugmentation
b) Degradation of xenobiotics and recalcitrant
c) Bioleaching of mineral and its recovery
d) Removal of heavy metals from waste
e) Biosensors and their application
f) Acid mine drainage

Unit 4. Tissue culture **15 lectures**

A. **Plant tissue culture:**
a) Culture vessels and their washing
b) Nutrient media
c) Callus and its culture methods
d) Cell viability test
e) Regeneration
f) Anther culture
g) Ovary culture
h) Meristem culture

B. **Animal tissue culture:**
a) Types of Cell cultures
b) Culture vessels
c) Culture Nutrient media
d) Preparation of Explant
e) Organ culture
f) Hybridoma technology

C. Introduction to marine biotechnology and aquaculture

References:

1. Wiley JM, Sherwood LM and Woolverton CJ. (2008). Prescott, Harley and Klein's Microbiology. McGraw Hill Higher Education
2. Stanbury P F, Whitaker A, and Hall S J, (1995). ***Principles of FermentationTechnology***, 2nd edn, Pergamon Press, London, UK
3. Waites M J, and Morgam N L,(2002). ***Industrial Microbiology: An Introduction*** Blackwell Science
4. Crueger W and Crueger A, (2000), ***Biotechnology: A Text Book of Industrial Microbiology***, 2nd edn, Panima Publishing Corporation, New Delhi, India
5. Trevan M D, Boffey S, Goulding K H, and Standury S, (eds), (1987), ***Biotechnology: The Biological Principles***, Tata McGraw-Hill, New Delhi, India
6. Casida L E, Jr. (1968). ***Industrial Microbiology***, Wiley Eastern Ltd, New Delhi,India
Alexander M, (1977), ***Introduction to Soil Microbiology***, 2nd edn, WileyEastern Ltd.
7. Biotechnology. An introduction ,Susan R Barnum, Vikas Publishing House.
8. Biotechnology Expanding Horizons, B D Singh, Kalyani Publishers.

BS23MJ6MB2 **Mycology and Virology** **Credit 4**

Course learning outcomes: By the completion of this course the students able to-
Outcome 1. Describe useful and harmful activities of fungi.
Outcome 2. Identify commonly available fungi and algae and their characteristics.
Outcome 3. Discuss how fungi and algae are used as biofertilizers in agriculture and as biopesticides.
Outcome 4. Grow mushroom in the laboratory.

Unit 1 Characteristics and classification **15 hours lectures**

a) Structure of yeast, mold, Lichen and Mycorhizza
b) Nutrition and Metabolism , Modes of reproduction of fungi
c) Culture media used for fungal cultivation
d) Classification of fungi
e) Mycotoxins

Unit 2. Fungal genetics **15 hours lectures**

a) Reproduction in Phycomycetes, Ascomycetes, Basidiomycetes and Deuteromycetes
b) Heterothallism
c) Para-sexuality
d) Tetrad analysis

Unit 3. **15 hours lectures**

a) General properties of virus, viroid's, virusoid's, satellite viruses and Prions.
b) Basic structure of virus
c) Modes and stages of reproduction of viruses, one step growth curve
d) Classification and nomenclature of different groups of viruses
e) Baltimore system of classification

Unit 4. **15 hours lectures**

a) Purification of viruses
b) Isolation and cultivation of viruses
c) Microscopic examination of virus
d) Study of one step growth curve of bacterial viruses.
e) Uses of virus: vaccine, cloning vectors, gene therapy, phage typing

Reference for mycology:

1. Alexopoulus, C.J., Mims,C.W. and Blackwel, M, Introductory Mycology. John Wiley, New York.
2. Mehrotra, R.S. and K.R.Aneja An Introduction to Mycology. New Age International Press, New Delhi.
3. Webster, J. Introduction to fungi. Cambridge University Press. Cambridge, U.K. (1985).
4. Bessey E.A. Morphology and Taxonomy of fungi. Vikas Publishing House Pvt. Ltd., New Delhi.
5. Jhon Webster and R W S Weber. Introduction to Fungi. Cambridge University Press 2007.

References for virology:

1. Pelczar M., Chan E.C.S. and Krieg, N.R. Microbiology. Tata Mc Grew Hill Publishing Co. Ltd., New Delhi.
2. Stainier R.V., Ingraham, J.L., Wheelis, M.L. and Painter P.R. The Microbial World. Printice-Hall of India (Pvt.) Ltd., New Delhi
3. Ellen Strauss, James Strauss.Viruses and Human Disease 2nd Edition. Academic Press
4. Christopher Burrell Colin Howard Frederick Murphy. Fenner and White's Medical Virology 5th Edition.Academic Press
5. Bernard N. Fields.Fields Virology Lippincott Williams & Wilkins
6. S. Jane Flint..Principles of Virology.American Society for Microbiology

BS23MJ6MB3: Basic techniques in virology, medical and plant pathology Credit 4

1. Study of the structure of important animal viruses :rhabdo, influenza, paramyxo, hepatitis, HIV, polio virus, Vaccinia virus using electron micrographs.
2. Study of the structure of important plant viruses (caulimo, gemini, tobacco ringspot, cucumber mosaic and alpha-alpha mosaic viruses) using electron micrographs.
3. Study of the structure of important bacterial viruses :T plages, lambda phage filamentous phage, ϕX174,MS13 using electron micrograph.
4. Isolation and enumeration of bacteriophages (PFU) from water/sewage sample using double agar layer technique.
5. Studying isolation and propagation of animal viruses by chick embryo technique (demo)
6. Study of cytopathic effects of viruses using photographs.

Medical Microbiology:

1) Isolation and Identification of Gram negative bacteria: *E. coli, Salmonella, Shigella, Pseudomonas, Enterobacter*
2) Slide and tube test for typhoid diagnosis
3) Study of skin flora by swab method
4) Perform antibacterial sensitivity by Kirby-Bauer method (Antibiogram)

Plant Pathology:

a) Study of important diseases of crop plants (specimen)
b) Isolation of pathogen causing leaf canker disease
c) Isolation of fungal pathogen from infected plant
d) Microscopic observation of cutting sections of infected plant material (oozing)

BSC23MN6MB1 Intellectual Property Rights Credit 2

Course learning outcomes: By the conclusion of this course, the students have -
Outcome 1. Full knowledge of working in a microbiology laboratory taking all safety measures, handing of live bacteria, disposal of infectious waste, care of the equipment requiring safety audit
Outcome 2. Developed knowledge of basic concepts related to IPR.
Outcome 3. Developed knowledge of patent filing, and some well-known/well-publicized case studies related to IPR

Unit 1. Introduction to Intellectual Property Rights 7 hours lectures

a) Patents and Types
b) Trademarks
c) Copyright &Related Rights
d) Industrial Design and Rights
e) Importance of IPR – patentable and non patentables and Patenting life
f) Legal protection of biotechnological inventions
g) World Intellectual Property Rights Organization (WIPO)

Unit 2. Agreements and Treaties 7 hours lectures

a) GATT
b) TRIPS Agreements
c) Madrid Agreement
d) Hague Agreement
e) WIPO Treaties
f) Budapest Treaty on international recognition of the deposit ofmicroorganisms
g) Patent Co-operation Treaty (PCT)
h) Indian Patent Act 1970 & recent amendments.

BSC23MN6MB2. Filling of patents and Case study **Credits 2**

a) Filing primary applications for patents
b) Study of steps of a patenting process
c) A case study

Reference books

1. Private Power, Public Law: The Globalization of Intellectual Property Rights By Susan K. Sell Cambridge University Press, 2000
2. Essentials of Intellectual Property: Law, Economics, and Strategy By Alexander I. Poltorak; Paul J. Lerner Wiley, 2011 (2nd edition)

BSC23SE605: Dissertation Related To The Subject And Its Allied Branches Credit 4

Teaching learning processes:

The teaching learning processes incorporate a variety of modes and a regular use of ICT. These are listed below:

1. **Classroom Teaching** for topics which are intensely information-based. This a very regular feature of all the courses in Microbiology

2. **Power Point slides** for topics which involve information related to intricate biological pathways such as metabolic pathways in bacteria and other microorganisms.

Use of Power Point presentations are also made whenever the lectures are to be summarized in a crisp and pointwise manner to highlight salient / important conclusions from the topics.
3. **Classroom Discussions** are a regular feature while teaching. The students are drawn into impromptu discussions by the teacher during the process of teaching.

4. **Video Displaying**, both real-time and animations, are used for topics which require 3D dimensional viewing of the biological mechanisms to drive the point home. These have proved to be very helpful while teaching concepts of molecular biology like DNA replication, transcription and translation. These are also used to convey complexities of antigen-antibody interactions and generation of antibody diversity during the teaching of Immunology.

5. **Model Making** is also used especially for understanding and building a perception of the students for the structures of viruses which cannot be seen by a light microscope and can be seen only under expensive equipment like electron microscopes.

6. **Laboratory Practical** are an integral part of every course included in UG programme in Microbiology. The is also a daily affair for UG students of Microbiology.

7. **Problem Solving** is encouraged during the laboratory work.

8. **Group Activity** as well as discussions with the laboratory supervisor/ among the students themselves/ Mentor is also encouraged during laboratory work.
9. **Project Work** is included in the programme where students work individually or in groups to design experiments to solve/answer a problem suggested by the Mentor or identified by the students in consultation with the Mentor. The students are mentored regularly during the duration the project is in progress.

10. **Presentations by the Students** are regularly done. The students are mentored in presentation of data, interpretation of data and articulation with the students/teachers/Research Scholars during their presentation.

11. **Presentation by Experts** in different specialties of Microbiology are arranged to broaden the horizons of the students.

12. **Interaction with Experts** is also encouraged during/after presentations to satisfy/ignite curiosities of the students related to developments in the different ares of Microbiology.

13. **Visit to Industries/Laboratories** related to Microbiology like fermentation, food, diagnostics etc. are organized to acquaint the students with real-life working environments of the professional microbiologists with a view to broaden their perspective of the subject of Microbiology