Syllabus as per NEP 2020 guidelines

Five Year B.Sc. /M.Sc in Biotechnology,
Department of Biotechnology (IBB), Savitribai Phule Pune University
Detailed syllabus for Year I (Sem I and II)

SEMESTER I

Sem I Major Core (2C)

Biology I 2C

General- (4L)
Origin of life: primordial soup, bioelements, biomolecules, importance of water, Cell as the unit of life, development of cell theory, cell types: prokaryotes vs. eukaryotes; from single cell to multi-cellular organism, concept of multi-cellularity, cell-cell interactions- at tissue level, cell organization,

Microbial World – (7L)
Definition, scope, impact and future of microbiology, beneficial and harmful microbes – food industry, agriculture, medical field
History of Microbiology –Major discoveries and contributions of different scientists (Leewenhoek, Joseph Lister, Robert Koch, Louis Pasteur etc.)

Introduction to viruses (bacteriophages, plant, animal), Archea (thermophiles, halophiles, methanogens) Fungi, algae, protozoa

Plant World- (7L)
Plant forms and classification- Algae, Bryophytes, Pteridophytes, Gymnosperms, and Angiosperms

-Plant forms and anatomy

-Plant reproduction: asexual and sexual, life cycles, and alterations of generation

-Plant evolution (Evolutionary trends like –increase in complexity of sporophyte and reductions in gametophytes, seed development, conducting elements etc.)

Animal World- (7L)
Level and organization in animal kingdom: Major animal groups and their salient features: (at Phylum level for non-chordates to chordates at class level).
Animal adaptation and trends in animal evolution.

Sem I Major Core (2C)

Introduction to Biotechnology I - 2C

Introduction to Biotechnology (4L)

1. History & Introduction to Biotechnology
2. What is Biotechnology?
3. Definition of Biotechnology,
4. Traditional and Modern Biotechnology,
5. Branches of Biotechnology- Plant, Animal Biotechnology, Marine Biotechnology, Agriculture, Healthcare, Industrial Biotechnology, Pharmaceutical Biotechnology, Environmental Biotechnology.
6. Biotechnology Research in India.
7. Biotechnology Institutions in India (Public and Private Sector)
8. Biotech Success Stories
9. Biotech Policy Initiatives
10. Biotechnology in context of Developing World
11. Public Perception of Biotechnology

Basics of Microbial biotechnology (7L)

1. Nutritional classification of microorganisms on the basis of carbon, light: (Photoautotrops, Photoorganotrops, Chemolithotrops (sulfur, hydrogen, iron oxidizers), chemoorganotrophs, nitrogen: (nitrifying, nitrogen fixing, denitrifying microorganisms), oxygen (aerobes, facultative anaerobes, microaerophiles, aerotolerant anaerobes, anaerobes)
2. Physical factors influencing growth –Temperature (hyperthermophiles, thermophiles, mesophiles, psychotrophs, psychrophiles), pH (acidophiles, neutrophiles, alkaliphiles) Osmotic pressure (extreme, moderate, mild halophiles, osmophiles, xerophiles)
3. Techniques in microbiology: staining (monochrome, negative, Gram, capsule, endospore, acid fast), media preparation, cultivation, isolation, preservation

Basics of Plant biotechnology (7L)

1. Plant Biotech and the advance of agriculture, Global Food
2. Omics- Genome to Proteome to Metabolome- The underlying biology of life to implement
3. biotechnology
4. Plant Tissue Culture Methods and Application to produce clonal plants and bioactive substances
5. Plant Transformation Crown Gall to Agro Insertion sites, stability, Biolistics

6. Vectors, Directed modification of genomes, gene expression, suppression, RNAi,
7. Gene Editing. Constructs and regulation/ test
8. Applications of Biotechnology in Agriculture : GM Food, GM Papaya, GM Tomato,
9. Modifications in Plant Quality - Golden Rice,
10. Fungal and Insect Resistant Plants - BT Crops, BT Cotton and BT Brinjal
11. Pros and Cons of transgenics, Ethics
12. Molecular Pharming, Plant Based Vaccines

Basics of Animal biotechnology (7L)

Applications of animal biotechnology:

1. Improvement of Livestock management: Disease diagnosis, Hormones, Animal vaccines, Manipulation of reproduction in animals (Artificial insemination, multiple ovulations, *in vitro* fertilization, Embryo transfer technology)
2. Application of Biotechnology in Medicine- Production of monoclonal antibodies, Production of vaccines and Production of Growth Hormone
3. Application of biotechnology in Aquaculture: Production of mono sex populations. Aquaculture and fish seed production: Hypophysiation, hCG injections, Pearl culture technology,
4. Potential application of transgenic animals: Models for various diseases/disorders, production of peptides and proteins of biopharmaceutical interest (molecular farming)
5. Gene therapy in human: Adenosine deaminase deficiency disease, Duchenne Muscular dystrophy disease and Cystic fibrosis)

Sem I Major Core (2P)

Laboratory exercises in Biology and Biotechnology I P (2C)

Microbiology (3P)

1. Concept of sterility, existence of microorganisms and their control
2. Media preparation: Liquid, semi-solid, slants, butts, plates, dehydrated, selective, differential
3. Simple staining: Monochrome, negative
4. Differential staining: Gram, Capsule and Endospore staining

Plants (3P)

Plant morphology and anatomy of major plant groups namely - Algae, Bryophytes, Pteridophytes, Gymnosperms, and Angiosperms

Animals (3P)

Animal morphology and anatomy of major groups namely – Invertebrates and Vertebrates

Sem I VSC 2C

Physics Theory (2C) **(to be detailed for 2C)**

DC and AC Circuits – DC circuits: voltage divider, current divider arrangements, effective resistance of network, Maximum power transfer theorem, examples, AC Circuits: concept of ac signal, terms related to ac circuits (1)
Electronic components – Active, passive, resistors,thermistor, LDR, capacitor, Inductor, transformer, symbols, applications, working of each. (2)
Semiconductor devices and Amplifiers – applications of photodiodes, Zener diodes as photo, temperature sensors, Transistor, biasing, bipolar transistor as amplifier, amplification, phase inversion, transistor as switch (3)
Oscillators: concept, discussion of two oscillators (1)
Number systems and Logic gates- decimal number system, binary no system, hexadecimal, octal, inter-conversions, binary codes, binary addition, subtraction. Logic gates revision, De Morgan's theorem, Boolean algebra, logical equations to logic circuits and vice versa, examples, Half adder, Full adder (2)
Combinational and Sequential logic- Multiplexers, Demultiplexers, RS flip-flop(latch) as memory unit (2)
Transducers(sensors) - primary & secondary transducers, types, applications (2)

Reference Books:

1. Electronic Principles by Malvino, Bates
2. Digital principles and Applications by Leach, Malvino, Saha
3. Digital Electronics by R. P. Jain

Sem I GE/OG (2T+2P)

Mathematics and Statistics I (major elective 4 credits)

Theory
Mathematics (15 lectures or 1 credit)
Refreshing course on Sets & symbolic logic, Power functions & polynomials, integration & differentiation, periodic functions and conversion of different co-ordinate system.
Matrices and determinants: addition of matrices, multiplication of scalars, transpose of a matrix, system of linear equations, inverse of a matrix. Eigen values and eigen vectors.

Vector differential calculus: curves, arc length, tangent, curvature, velocity & deceleration, directional derivative, transformation of coordinate systems and vector components, divergence and curl of vector field.
Relations & Functions: Linear, periodic, logarithmic, exponential, Quadratic functions. Mapping & Cartesian product. Their application in Biology.
Partial differential equations: Introduction to partial derivatives & Ordinary Differential Equation of the first order.
Graphical representations: Linear scales, nonlinear scales, Semilogarithmic, triangular, nomography, pictorial presentations

Statistics (15 lectures or 1 credit)
Frequency distribution and associated measures
Probability Theory, Sample mean, Sample variance, mean and variance of a distribution, random numbers, random sampling.
Probability Distributions: Applications of probability and standard distributions, estimation, standard error and confidence interval, t-tests, F-test, single tail & double tail.
Confidence intervals, goodness of fit, pairs of measurements, fitting straight lines, curves, polynomials etc.
Test of hypothesis associated with correlation and regression.

Mathematics and Statistics I practical (2 credits)

Mathematics (**15 lectures or 1 credit**)
Problem solving and tutorials session for the mathematics part above

Statistics (**15 lectures or 1 credit**)
Sampling technique (simple random sampling, stratified sampling, probability proportional sampling, sampling procedures).
Model sampling from continuous distribution (such as uniform, exponential and normal)
Test of significance.
T test,
F test,
Pair T test,
Test of proportionality
Fitting of straight lines, curves (growth curve models, polynomials).
Test of significance associated with correlation and regression
Goodness of fit test. (Distribution fitting and model validation)

Sem I SEC (2T/P)

Physics Practical (to be detailed)

Sem I AEC (2C)

English (to be detailed)

Sem I VEC (2T+P)

Introduction to Computers (2C T+P)

Computer operation: keyboard, mouse, screen, printer, and other I/O devices 2L

Operating systems: introduction e.g., Linux, Windows 2L

File formats and directory structure

Word Processing (Microsoft Word): Creating, Saving & Opening a document, Editing, Inserting, Deleting, Formatting, Moving & Copying Text, Find & Replace, Spell Checker & Grammar Checker (Thesaurus), Document Enhancement (Borders, Shading, Header, Footer), Printing document (Page layout, Margins), Introduction to the use of Wizards & Templates, Working with Graphics (Word Art) 1P

Working with Tables & Charts, Inserting Files (Pictures, Databases, Spreadsheets)

Spreadsheet Applications (Microsoft Excel): Worksheet Basics (Entering information in a worksheet, Saving & Opening a worksheet, Editing, Copying & Moving data, Inserting, Deleting & Moving Columns & Rows, Clearing Cells & Formatting cells), Working with workbooks, Working with formulae and functions, Printing worksheets, An introduction to the use of advanced spreadsheet concepts, Database Management (Sorting records, Finding records, Adding & Deleting records, Filtering records in a worksheet), Working with Macros, Creating and using multiple worksheets 1P

Creation of Computer Presentations with graphics (Microsoft Power Point): Creation of slides, Rapid Presentation design using wizards, inserting graphs & charts Action buttons, Transitions, Build and Animation effects

Internet, Search Engines, using E-Mail/Web mail, ftp

System handling, system commands, introduction to computer languages and utilities 6L

References:

1. Introduction to Computers by A. Leon and M. Leon, Vikas Publishing House.
2. Fundamentals of Computers by Rajaraman V., PHI.

3. Computers Today by Sanders D. H., McGraw Hill.
4. Computer Architecture and Organizations by J. P. Hayes, Mc Graw Hill.
5. Modern Digital Electronics by R. P. Jain, Tata Mc Graw Hill.
6. Computer Network by Andrew S. Tanenbaum, PHI.
7. Inter Networking With TCP/IP: Principles, Protocol And Architecture by D.E. CornerVol1

Sem I CC

Yoga (to be detailed)

Sem I IKS

To be detailed

SEMESTER II

Sem II Major Core (2T)

Biology II - 2C 25L

(I) Cellular structure of microbes (9L)

Ultrastructure of prokaryotes, flagella, pili, capsules, cell wall, cell membrane, genomes, plasmids, cytoplasmic inclusions, endospores, magnetosomes, carboxysomes, chlorosomes, gas vesicles, Volutin granules.

Nutritional classification of microorganisms on the basis of carbon, light: (Photoautotrops, Photoorganotrops, Chemolithotrops (sulfur, hydrogen, iron oxidizers), chemoorganotrophs, nitrogen: (nitrifying, nitrogen fixing, denitrifying microorganisms), oxygen (aerobes, facultative anaerobes, microaerophiles, aerotolerant anaerobes, anaerobes)
Physical factors influencing growth –Temperature (hyperthermophiles, thermophiles, mesophiles, psychotrophs, psychrophiles), pH (acidophiles, neutrophiles, alkaliphiles) Osmotic pressure (extreme, moderate, mild halophiles, osmophiles, xerophiles)

Prokaryotic cell cycle: Binary fission, multi-fork replication, role of FtsZ, MreB, Z ring divisome, addiction modules for plasmid transfer to progeny 4L
Population growth: Growth phases-Generation time, Kinetics of growth 2L
Growth patterns: Synchronous, Batch, Continuous, Diauxic 3L

(II) Plant tissue organization and systems (8L)

Plant tissues- parenchyma, collenchyma, chlorenchyma, sclerenchyma
Apical meristems, Epidermis, secretory cells and structures, trichomes,
Vasculature – Organization, Xylem, Phloem, Cambium and associated cells, Stelar evolution
Root – types and associated tissues, leaf – types, variations and structure, tissues
Stem organization- primary and secondary growth, cork, periderm
Plant forms and structural adaptations to various climatic regimes, and stresses
Specialized plant cells, sensory cells, tendrils, thorns, spines

(III) Animal tissue organization and systems (8L) to be detailed

Sem II Major Core (2T)

Biotechnology II - 2C

(I) Microbial growth and control (9L)

Techniques in microbiology: staining (monochrome, negative, Gram, capsule, endospore, acid fast), media preparation, cultivation, isolation, preservation

Control of Microorganisms: Sterilization, disinfection, cidal, static agents 1L
Control of microbial growth by physical methods: Dry heat, moist heat, filtration, radiation (mode of action, applications) 2L
Chemical control –dyes, alcohol, acid, alkali, halogen, heavy metals, phenol, phenol derivatives, formaldehyde, ethylene oxide, detergents (mode of action, applications) 2L
Control of Pathogens and chemotherapy: History and development of chemotherapy, principal groups of antibacterial agents, and mechanism of action, drug resistance: origin, mechanisms, and transmission, antiviral and antifungal agents 2L
Genetic exchange in bacteria 2L

(II) Plant propagation and cell culture (8L)

Plant Propagation
Introduction to plant propagation, Opportunities in the industry
Biology, Principles and Techniques of Propagation (sexual, asexual and vegetative)
Methods: Seed, Cutting, Layering, Grafting

Greenhouse – structural details, types

Modern soil free cultivation methods - Hydroponics, aeroponics, aquaponics
Associated structural requirements, Media, fertilization consideration, Growth stimulants, Pest and pathogen control

Tissue culture and micropropagation

Resource Potential of Algae
Algae as food, feed, fuel

Application of algae in agriculture, pharmaceuticals and environment, bioremediation, carbon sequestration, indicators
Introduction to Commercially important Algae: Diatoms, *Volvox, Anabaena, Oedogonium, Caulerpa, Sargassum, Gracilaria, Chara, Ulva,*
Algal Cultivation methods: Indoor and large scale, harvesting and processing of algal biomass

Resource Potential of Fungi
Fungal taxonomy and diversity, Mycorrhizae, fungal biopesticides
Edible mushrooms and mushroom cultivation
Fungal Biotechnology- Enzymes and Metabolities (Penicillin, Citric Acid and Alcohol)

(III) Animal models and cell culture (8L)

Techniques of Animal biotechnology:

- Components of Cloning of genes in animal systems: Enzymes, Vectors (plasmids, Phages, cosmids, yeast Shuttle vector, viral vectors), Expression platforms (insect cell, animal cell, animals)
- Confirmation of cloning: antibiotic selection, blue-white screening, colony, hybridization, Fluorescence in-Situ Hybridization (FISH) and Western blotting.
- Preparation of cell lines, types of cell lines (insect and animal cell lines)
- Methods of gene transfer–Microinjection, electroporation, lipofection and viral mediated gene transfer techniques
- Generation of chimeric, transgenic and knockout mice and other animals and their characterization. Gene editing- Gene silencing-CRISPR-associated protein-9 nuclease (Cas9) technology

Sem II Major Core (2P)

Laboratory exercises in Biology and Biotechnology I P (2C)

Microbiology (3P)
Simple staining: Monochrome, negative
Differential staining: Gram, Capsule and Endospore staining
Motility Demonstration: Hanging drop preparation, wet mount, dark field microscopy
Cultivation of fungi: on Saborauds, Czapek Dox, Potato Dextrose agar
Determination of antimicrobial activity and MIC, paper disc and well diffusion method

1. Growth curve of *Escherichia coli* by turbidimetric method, calculation of specific growth rate and generation time 1P
2. Isolation of bacteria by streaking, spread plate technique, Pour plate 1P

3. Determination of thermal death rate and thermal death time of *Escherichia coli* and *Bacillus* 1P
4. Determination of antimicrobial activity by paper disc and well diffusion method 1P
5. Determination of Minimal inhibitory concentration (MIC) by microtitre plate assay 1

Plants (3P)
Cell types and tissue systems of plants staining
Maceration of various tissue explants, Identification of xylem vessels, trachieds, stomata, root hairs etc.
Plant propagation
Algal growth and recovery of biomass/bioactive
Mushroom cultivation

Animals (3P)
Animal tissues
Blood grouping
Cell counting using hemocytometer

Sem II VSC (2T)

Biochemistry & Biogenesis T (2C)

Biochemistry (13 Lectures)

1. Water and Intermolecular Forces
2. Thermodynamics in Biochemistry
3. pH, acids bases and Buffers
4. Amino Acids
5. Introduction to Protein structure
6. Glycoproteins and Proteoglycans
7. Sugars and Polysaccharides
8. Basic aspects of lipid structure
9. Nucleosides and Nucleotides
10. Structure of Nucleic Acids
11. Vitamins and Coenzymes

Biogenesis (12 Lectures)

1. Terpenes: sesquiterpenes, triterpenes and cholesterol,
2. Ornithine based(pyrrolizidine), Lysine based (quinolizidine and indolizidine),
3. Pyridine based, Tyrosine and modified tetrahydroisoquinoline

4. Polyketides – saturated and unsaturated fatty acids, Arachidonic acid cascades – prostaglandins, Thromboxane, Leukotriene in nature and lab
5. Selectivity of enzyme mediated reaction mechanism and its comparison with synthetic reactions involving vit. B_1, B_2, B_6, Biotin, NAD/NADP – NADH/NADPH, Folic acid, Riboflavin

Sem II SEC (2P)

Biomolecules and Biogenesis: (2 Credit/ Practical)

Biochemistry (6 expt.)

1. Benedict's test for monosaccharides
2. Phenol-Sulfuric acid method for total carbohydrates
3. Estimation of carbohydrate by the Anthrone method
4. Ninhydrin test for Amino acids
5. Estimation of proteins by Bradford's method
6. Estimation of proteins by Lowry's method
7. Detection of fatty acids by TLC
8. Fats and oils detection by Acrolein Test / Sudan III test/ Dichromate Test/
9. Determination of degree of unsaturation by Huble's Test for the given sample
10. Quantification of DNA using UV -Visible spectrophotometer

Biogenesis (3-4 expt.)

1. Synthesis of coumarins/flavonoids from chalcones
2. Metabolic degradation of cholesterol using LS-MS quantification
3. Fluorometric/Spectrophotometric detection of Riboflavin (Vit B2)
4. Reduction reaction using NADH and Sodium borohydride and comparing reaction rate and product yield.

References

1. Garrett & Grisham, Biochemistry, Saunders Publishing,
2. Voet and Voet. Biochemistry, second edition, Prentice-Hall,
3. Lehninger, Nelson and Cox. Principles of Biochemistry
4. Practical Biochemistry, Gupta and Bhargava
5. Practical Biochemistry: Principles and Techniques Wilson and Walker

Sem II Minor (2T+P)

Introduction to Laboratory Instrumentation and Safety (T+P) 2C

Theory

Laboratory facilities in biotechnology 1L
Handling and Use of Physics laboratory
Handling and Use of Chemistry laboratory
Microbiology laboratory 2L
Molecular biology laboratory 2L
Animal and plant cell culture laboratory 2L
High end instrumentation 1L
Laboratory operations and SOP 1L
Hazards in laboratories 1L
Laboratory safety measures and safe disposal of laboratory wastes 1L
How to handle emergency conditions in the laboratory? 1L
Personal and protective equipment and measures 1L

Practicals

1. Handling of glass and digital Pipettes
2. Handling of weighing machine
3. pH measurement through litmus paper and pH machine
4. Handling of tabletop centrifugal devices
5. Use of laminar flow and bio safety cabinet
6. Use of autoclaves
7. Using small laboratory equipments like stirrer, vortex, sonicator, nanodrop, waterbath, incubators, shakers
8. Operations and Maintenance of deep freezers
9. Storage and handling of general chemicals/acids, solvents
10. Safe disposal of laboratory wastes
11. Use of fume hood and personal safety measures
12. Laboratory safety demonstrations, fire extinguishers and first aid

Sem II VEC (2 T+P)

Computer Language Python (2C) to be detailed

Sem II GE/OE (2T+2P)

Mathematics and Statistics II

Mathematics (15 lectures or 1 credit)

Exactness and integrating factors, variation of parameters. Ordinary linear differential equations of n-th order, solution of homogeneous and non-homogeneous equations, operator method, method of undetermined coefficients and variation of parameters

Eigen vectors systems of linear differential equations
Sequence of series, power series methods for linear ordinary differential equations
Laplace transform and its applications, Fourier series and Fourier transform and their applications
Partial differential equations: models in chemical kinetics and physiology
Introduction to solution techniques such as variable separation, product method and Laplace Transform method

Statistics (15 lectures or 1 credit)
Frequency distributions and associated statistical measures
Multivariate analysis. Multiple linear regressions, Factor analysis. Partial Least Square, Principle Component analysis
Cluster Analysis (a) Nearest neighbor search (b)Search using stem numbers (c)Search using text signatures

Mathematics and Statistics II practical (2 credits)

Problem solving and tutorials session for the mathematics and statistics part above

Sem II AEC (2T)
To be detailed

Sem II CC (2)
From the basket (to be detailed)