Savitribai Phule Pune University
B. Sc. Biotechnology (CBCS Semester Pattern)

S. Y. B. Sc. Biotechnology

Revised Syllabus w.e.f. June 2020
Semester III

Theory

Subject code	Name of Subject	Credits	Total No. of Lectures	Marks Distribution
BBt-301	Cell Biology I	2 Credits	30	50 (35 External +15 Internal
BBt-302	Molecular Biology I	2 Credits	30	50 (35 External +15 Internal
BBt-303	Genetics	2 Credits	30	50 (35 External +15 Internal
BBt-304	Metabolism	2 Credits	30	50 (35 External +15 Internal
BBt-305	Environmental Biotechnology	2 Credits	30	50 (35 External +15 Internal
BBt-306	Bio analytical Techniques	2 Credits	30	50 (35 External +15 Internal
BBt-307	AECC-I (Environment)	2 Credits	30	50 (35 External +15 Internal
BBt-308	AECC-II (Language Communication)	2 Credits	30	50 (35 External +15 Internal

PRACTICALS

BBt-309	Practical in Cell Biology and Genetics	2 Credits	15 P	50 (35 External +15 Internal
BBt-310	Practical in Bio analytical Techniques	2 Credits	15 P	50 (35 External +15 Internal
BBt-311	Practical in Molecular Biology and Environmental Biotechnology	2 Credits	15 P	50 (35 External +15 Internal
Total Credits (Theory + Practical)		**22**		

Semester IV

Theory

Subject code	Name of Subject	Credits	Total no. of Lectures	Marks
BBt-401	Cell Biology II	2 Credits	30	50 (35 External +15 Internal
BBt-402	Molecular Biology II	2 Credits	30	50 (35 External +15 Internal
BBt-403	Immunology	2 Credits	30	50 (35 External +15 Internal
BBt-404	Animal Development	2 Credits	30	50 (35 External +15 Internal
BBt-405	Plant Development	2 Credits	30	50 (35 External +15 Internal
BBt-406	Microbial Biotechnology	2 Credits	30	50 (35 External +15 Internal
BBt-407	AECC-III (Environment)	2 Credits	30	50 (35 External +15 Internal
BBt-408	AECC- IV (Language Communication)	2 Credits	30	50 (35 External +15 Internal

PRACTICALS

BBt-409	Practical in Molecular Biology and Microbial Biotechnology	2 Credits	15 P	50 (35 External +15 Internal
BBt-410	Practical in Animal and Plant Development	2 Credits	15 P	50 (35 External +15 Internal
BBt-411	Practical in Cell biology and immunology	2 credit	15 P	50 (35 External +15 Internal
Total Credits (Theory + Practical)		**22**		

Subject Code: BBt- 301 **Subject: Cell Biology I (2 Credit Course)**
Total Lectures=30

Unit	Cell Biology I Topic	No of lecture (30)
I	**Introduction To Cell** • Cell Theory • Types of Cell: i. Prokaryote & Eukaryotic Cell ii. Plant & animal cell iii. Cellular Diversity: Cell structure & related functions	5
II	**Cell Membrane** i Chemical components of biological membranes ii. Organization and Fluid Mosaic Model, membrane as a dynamic entity iii. Functions of cell membrane iv Transport – Active and Passive transport with one example Bulk transport: Exocytosis, endocytosis.	6
III	**Cell Organelle** • Structure, components and function of : i. Nucleus, ii. Mitochondria iii. Chloroplast iv. Lysosomes and Vacuoles v. ER & SER vi. Golgi Bodies	12
IV	• Cell Junctions • Extracellular Matrix • Cytoskeleton & Basal Bodies	7

Reference books:

1. Molecular Cell Biology. 7th Edition, (2012) Lodish H., Berk A, Kaiser C., KReiger M., Bretscher A., Ploegh H., Angelika Amon A., Matthew P. Scott M.P., W.H. Freeman and Co., USA
2. Molecular Biology of the Cell, 5th Edition (2007)BruceAlberts, Alexander Johnson, Julian Lewis, Martin Raff, Keith Roberts, Peter Walter. Garland Science, USA
3. Cell Biology, 6th edition, (2010) Gerald Karp. John Wiley & Sons., USA
4. The Cell: A Molecular Approach, 6th edition (2013), Geoffrey M. Cooper, Robert E. Hausman, Sinauer Associates, Inc. USA
5. Karp, G. 2010. Cell and Molecular Biology: Concepts and Experiments. 6th Edition. John Wiley & Sons. Inc.
6. De Robertis, E.D.P. and De Robertis, E.M.F. 2006. Cell and Molecular Biology. 8th edition.Lippincott Williams and Wilkins, Philadelphia.
7. Cooper, G.M. and Hausman, R.E. 2009. The Cell: A Molecular Approach. 5th edition. ASMPress& Sunderland, Washington, D.C.; Sinauer Associates, MA.
8. Becker, W.M., Kleinsmith, L.J., Hardin. J. and Bertoni, G. P. 2009. The World of the Cell. 7th edition. Pearson Benjamin Cummings Publishing, San Francisco.

Subject Code: BBt- 302 **Subject : Molecular Biology I (2 Credit)**
Total Lectures=30

Unit	Molecular Biology I Topic	No of lectures (30)
1	**Historical and conceptual Background-** • Molecular basis of heredity & Central dogma of Molecular Biology • Discovery of DNA as genetic material: Griffith's experiment, Hershy and Chase warring blender experiment, Miescher to Watson and Crick- historic perspective • Nucleic acids- structure, properties and function, Nucleoside and nucleotide • Structure of DNA: DNA forms; A, B & Z • Salient features of double helix, Chargaff's rule • Types and structure of RNA : tRNA, rRNA , mRNA and non-coding RNA (miRNA, SiRNA)	**8**
II	**Concept and Organization of Genome** • Chromosomal organization and structure. • Chromatin structure: Euchromatin, heterochromatin (nucleosomes)- histone, non-histone proteins • Organization of DNA: Prokaryotes, Viruses • Organelle DNA – mitochondria and chloroplast DNA • Definition of gene – introns/exons, Regulatory sequences, promoters, enhancers and suppressors	**8**
III	**Genetic Code** • Concept of codon, reading frame, frame shift, Major scientific contributions to decipher genetic code • Properties of genetic code	**4**
IV	**Replication of DNA** • DNA synthesis: general principles, bidirectional replication, Semiconservative nature of DNA replication, Rolling circle replication • The replication complex: Enzymes involved in DNA replication, Unique aspects of eukaryotic & prokaryotic DNA replication, Fidelity of replication.	**10**

Reference Books :

1. Genes X, 10th edition (2009), Benjamin Lewin, Publisher - Jones and Barlett Publishers Inc. USA
2. Molecular Biology of the Gene, 6th Edition (2008), James D. Watson, Tania Baker,
3. Stephen P. Bell, Alexander Gann, Michael Levine, Richard Lodwick, Pearson Education, Inc. and Dorling Kindersley Publishing, Inc. USA

4. Molecular Biology, 5th Edition (2011), Weaver R., Publisher-McGrew Hill Science. USA
5. Fundamentals of Molecular Biology, (2009), Pal J.K. and Saroj Ghaskadbi, Oxford University Press. India
6. Karp, G. (2010). Cell and Molecular Biology: Concepts and Experiments. VI Edition. JohnWiley & Sons. Inc.
7. De Robertis, E.D.P. and De Robertis, E.M.F. (2006). Cell and Molecular Biology.VIII Edition. Lippincott Williams and Wilkins, Philadelphia.
8. Molecular Biology of the Gene (VI Edition.). Cold Spring Harbour Lab. Press, Pearson Pub.
9. . Principles of Gene manipulation and Genomics. - S.B. Primrose and R.M. Twyman. Blackwell Publication
10. Biotechnology - Fundamentals and applications. - S.S. Purohit and S.K. Mathur. Agrobotanica publications.Gene Cloning and DNA analysis. - T.A. Brown. Blackwell Publication.
11. Recombinant DNA - Genes and Genomes. - James D. Watson, Any A candy, RichardM.M, Jan A Witkowski. W.H. Freeman and Company Publication.
12 Genomes: T A Brown, John Wiley & Sons

Subject Code: BBt- 303 **Subject : Genetics (2 Credit Course)**
Total Lectures=30

Sr. No	Topic	Lectures
I	• **Mendalism and Mendalian Genetics :** Genetic basis of Inheritance: Variations,Heridity, Pre- Mendelian Concept, Importance of Genetics • **Mendelian Genetics:** Mendel Experiments • **Mendel's Law:** Law of Segregation , Mono Hybrid. • **Law Of Independent Assortment**- Di Hybrid and Tri Hybrid • **Deviation From Mendel's Law-** Partial or Incomplete Dominance, Co Dominance, Epistasis • **Penetrance and expressivity-**Pleiotropism • **Gene Interaction-**Modified Di Hybrid Ratio, Multiple Allele	**8**
II	• **Chromosomal aberrations and Mutations. :** i) Variation in chromosome number – types, dosage compensation and barr bodies (Human). ii) Variation in chromosome structure – types, generation of variation, iii) Mutations Classification and types, molecular basis of mutations, iv) Mutagens and their action, hot spot mutations.	**9**
III	• **Sex Determination and Recombination:** • **Linkage and Recombination-** Discovery of Linkage, Complete and incomplete linkage, crossing over, Cytological Proof Of Crossing Over, three point cross ,Recombination Frequency and Map Distance • **Mechanism of Sex Determination-** i) Homo and Heterogametic Theory, ii) Coincidence and interference, iii) X-Linked Inheritance iv) Non Mendelian Inheritance v) Pedigree Analysis	**9**
IV	• **Genetic Disorders** Sickle Cell Anemia, Hemophilia, Colour Blindness, Albinism, Down's and Kleinfelter's Syndrome • Genetic Counseling	**4**

Reference Books :

1. Genetics, by Strickberger M W (2006) (Prentice Hall, India)
2. Fundamentals of Genetics. B.D Singh
3. Genetics: analysis of genes and genomes by Hartl DL, Jones EW (2001) –(Jones and Bartlett, Massachusetts)
4. Introduction to genetic analysis by Griffiths AJ, Wessler SR, Carroll SB, Doebley J (2012) – (Freeman & Co, New York) tenth edition.
5. Molecular genetics of bacteria (ASM Press, Washington) Snyder L, Champness W (2007)
6. Textbook of Cell Biology, Genetics, molecular biology , Ecology and Evolution.: P.S. Verma

and V.KAgarwal (2001)
7. Principals of Genetics: Robert H. Tamarin, 7th Edition.
8. GENES IX (2006): Benjamin Lewin.
9. Concepts of genetics (2011) : Robert Brooker.
10. Genetics: A Mendelian Approach (2006) :Peter J. Russell

Subject Code: BBt- 304 **Subject : Metabolism (2 Credit Course)**
Total Lectures=30

Units	Metabolism Topic	Lectures (30)
1	**Introduction to Metabolism**, • ATP energy cycle, • Chemistry of Metabolism: Oxidation–reduction reaction, Group transfer reactions etc, • Concept of Bioenergetics, ATP & Phosphoanhydride bond.	4
2	**Lipid Metabolism** – • Outline of lipid synthesis, • Catabolism of Fatty acid: beta oxidation, Oxidation of unsaturated fatty acids, Oxidation of odd chain fatty acids, Cholesterol, ketone bodies.	6
3	**Carbohydrate Metabolism** – • Aerobic & Anaerobic glycolysis, sequence of reactions in glycolysis, regulation in glycolysis, • Pyruvate metabolism, citric acid cycle & its regulation, • glycogenesis, glycogenolysis (sequence of reactions & regulation), • Pentose-phosphate pathway (sequence of reactions & regulation),	8
4	**Amino acid Metabolism** – • Essential & non essential amino acids, Brief outline of amino acid synthesis, • Catabolism of Amino acids, Transamination, • Urea Cycle, • Metabolic breakdown of individual amino acids – glucogenic & ketogenic amino acids), amino acids as biosynthetic precursors,	7
5	**Nucleotide Metabolism** – • Biosynthesis of purine & pyrimidine (de novo & salvage pathway); Degradation of purine & pyrimidine.	5

Reference Books :

1. Conn EE and Stump PK. 2010. Outlines of Biochemistry. 5th Ed. John Wiley Publications.
2. Voet D and Voet JG. 2011. Biochemistry. 4th Ed. John Wiley and Sons, Inc. NY, USA
3. Nelson DL and Cox MM. 2012. Lehninger‟s Principles of Biochemisry, 6th Ed . Macmillan Learning, NY, USA.
4. Berg JM, Tymoczko JL, Stryer L and Gatto GJ. 2002. Biochemistry, 7th Ed. W.H. Freeman and Company, NY, USA
5. Stryer, L., “Biochemsitry”, 4th Edition, W.H. Freeman & Co., 2000.
6. Murray, R.K., etal “Harper’s Biochemistry”, 23rd Edition, Prentice Hall International, 1993.

Subject Code: BBt-305 **Subject: Environmental Biotechnology (2 Credit Course)**
Total Lectures=30

Unit	Environmental Biotechnology Topic	No. of lectures
I	• **Foundations of Environment and Ecology** Environment: Definitions, Components - Atmosphere, Hydrosphere, Lithosphere, Biosphere) and Inter-relationships, Ecology and Ecosystems: Interconnections in nature	2
II	• **Ecosystem**: Principles and its concepts- Introduction. Characteristics, Components of ecosystem and Types- Aquatic and terrestrial ecosystems, Homeostasis • **Biotic Community**: Types; Characteristics , Structure • **Ecological succession**: Types, General process of succession. Concept of climax • **Energy flow**: Food chain, food web, Trophic Levels, Energy efficiency, Energy Budget.	7
III	• **Threats to Environment and Ecosystem** Environmental pollution : Types, sources and consequences of : Air, Water, Soil, Radiation Biotechnological approaches for pollution control	5
IV	• **Biotechnology in Protection and Restoration of Ecosystem** i) Bioremediation: Importance of bioremediation, ii) Use of microorganisms for Bioremediation, iii) Phytoremediation. iv) Bioindicators and detectors	4
V	• **Environmental Priorities in India-** i) Environmental Impact Assessment (EIA case study), ii) Red data book iii) TRAFIC	2
VI	• **Waste and Disaster Management:** i) Biomedical waste management ii) Integrated waste management iii) Hazards to the environment	3
VII	• **Microbial Biodegradation of :** i) Plastic ii) Hydrocarbons iii) Dyes, pesticides/ insecticides and herbicides	3
VIII	• **Current global environmental issues** i) Ozone layer depletion (Montreal protocol), El Nino, ii) Acid rain - causes and effects, iii) Green House Effect, iv) Global climate change v) Greenhouse gases and their impact on the environment vii) Global warming – effect on oceans, coastline and marine ecosystem	4

	viii) Impact of global warming on India.	

Reference Books

1. Ecology and environment (2005) Sharma PD Rastogi Publication, New Delhi
2. Ecology and environmental biology (2011) Saha T K Books & Allied (p) Ltd, Kolkata
3. Ecology science and practice (2001) Faurie et al Oxford & IBH Publ. Co. Pvg. Ltd, New Delhi
4. Ecology: Principles and Applications (1998) J. L. Chapman, M. J. Reiss Cambridge University Press, Cambridge
5. Environmental Biology (2000) Varma&Agarwal S. Chand Limited, New Delhi
6. Environmental biology and toxicology (2011) Sharma PD Rajpal And Sons Publishing, Delhi
7. Environmental biotechnology(2010) Rana Rastogi Publications, New Delhi
8. Environmental Science (2011) Santra S.C. New Central Book Agency, Kolkata
9. Fundamentals of Ecology (2005) Eugene Pleasants Odum, Gary W. Barrett Brooks and Coel, USA
10. Fundamentals of Ecology (2009) Dash 3rd edition, Tata McGraw-Hill Education, New Delhi
11. Introduction to Environmental Biotechnology (2007) Chattergy PHI Learning Pvt. Ltd, Delhi
12. Textbook of environmental studies for undergraduate courses (2005) Erach Bahrucha Universities Press, Hyderabad
13. Evans & Furlong. Environmental Biotechnology.Theory& Applications. 2nd ed 2011. Wiley-Blackwell.
14. Scragg A. Environmental Microbiology Oxford Univ Press. 2005.
15. Bhattacharya & Banerjee. Environmental Biotechnology. Oxford Univ Press 2008.

Subject Code: BBt- 306 Subject: Bio analytical Techniques (2 credit course)
Total Lectures=30

Units	Bio analytical Techniques Topic	Lectures
1	**Introduction:** Lab safety, Scientific notation & Units, errors & accuracy in experimentation, Biochemical Calculations, Buffer solutions, Measurement of pH, Calibration of pipettes & balance	2
2	**Spectroscopy:** • The electromagnetic spectrum • Concept &Measurement of transmittance and absorbance • Beers Lamberts law, molar extinction coefficient, limitations of Beers Lamberts law • Types of spectrometers – UV & visible; Principles, Instrumentation and applications	8
3	**Centrifuge:** • General principle- sedimentation velocity, sedimentation equilibrium • Types of centrifuges: preparative and analytical centrifugation, differential centrifugation, density gradient, ultracentrifuge • Applications	6
4	**Chromatographic Techniques:** • Introduction to chromatography, General principles Planar Chromatography Partition chromatography: Thin layer chromatography, paper chromatography • Column chromatography–columns, stationary phases. Packing of columns, application of sample, column development, fraction collection and analysis. • Adsorption chromatography: Ion Exchange Chromatography, Size exclusion chromatography	8
5	**Electrophoresis:** • General principle, factors affecting electrophoresis voltage, current, resistance, buffer, composition, concentration, pH. • Agarose Gel electrophoresis • SDS-PAGE – Native and denaturing gels, • Applications	6

Reference Books:

1. Wilson K and Goulding K.H., A biologist's guide to Principles and Techniques of Practical Biochemistry.

2. Willard and Merrit, Instrumental Methods and Analysis
3. Ewing GW, Instrumental Methods of Chemical analysis.
4. Vogel's, Text Book of Quantitative Chemical Analysis, 6th Edition, 2004.
4. Raymond P. W. Scott, Techniques and Practice of Chromatography –Vol. 70.
6. Sethi P.D, DilipCharegaonkar, Chromatography –2nd Edition.
7. Hanes, Gel Electrophoresis of Proteins- A Practical Approach,
8. Biophysical chemistry by Upadhyay, Upadhyay and Nath, Himalaya publication house.

Subject Code: BBt-309 **Subject: Practical in Cell Biology and Genetics**
(2 Credit Course)
Total Practical= 15 P (15x3hrs.)

Sr.no.	Topic	Practical
Section I : Cell Biology		
1	Study of Prokaryotic and Eukaryotic cell structure. Study of Electron Micrographs of all important cell organelles	1
2	Micrometry- Measurement of cell size taking different types of cells.	2
3	Staining and Observation of human cheek epithelial cells	1
	Isolation and characterization of the following subcellular components, using appropriate samples, by differential centrifugation: i. Nuclei : staining and counting ii. Mitochondria : Succinate Dehydrogenase assay iii. Chloroplast : Microscopic Observation iv. Lysosomes: Acid Phosphatase assay	4
4	Methods of cell lysis and confirmation	1
Section II : Genetics		
7.	**Problem Sets of** – • Mendalian inheritance and Non Mendalian inheritance Monohybrid cross. Dihybrid cross and Trihybrid cross • Incomplete Dominance, Co-dominance. • Epistasis. • Gene interactions	3
8	**Problems set of Linkage and Pedigree analysis** • 2 point cross. 3 point cross and genetic mapping. • Tetrad analysis: Chromosome interference, analysis of ordered and unordered tetrads. • Sex linked inheritance	3
9	Studies on karyotype analysis	1

References:

1. Cell biology and genetics lab manual Boğaziçi University Department of Molecular Biology and Genetics 2007-2008
2. Cell Biology Laboratory The University of Toledo Department of Biological Sciences/Natural Sciences and Mathematics
3. Principals of Genetics: Robert H. Tamarin, 7th Edition.
4. Genetics, (2006) Strickberger MW - (Prentice Hall, India.)

Subject Code:BBt-310 **Subject : Practical in Bio Analytical Technique and Metabolism (2 Credit Course)**
Total Practical = 15 P(15x3hrs)

Sr. No.	Topic	Practical
Section I – Biochemical & Biophysical Techniques		
1	Quantitative determination of free amino acid content from biological sample.	1
2.	The separation of amino acids by ion exchange chromatography	2
3	The separation of dyes by using Gel filtration Chromatography	1
4.	SDS-polyacrylamide Slab gel electrophoresis of proteins	2
5.	Native gel electrophoresis of proteins	1
6	Determine λ max of DNA, protein, bromophenol blue solutions using spectrophotometer	1
Section II – Metabolism		
7.	Estimation of glucose by Benedict's method	1
8	Estimation of amylase activity from given sample.	1
9	Estimation of reducing sugar by DNSA (dinitrosalicylic acid) method	1
10	Estimation of alkaline phosphates activity from given sample.	1
11	Estimation of creatinine in urine or Preparation of lactalbumin from milk or Chlorophyll from plant source	1
12	Estimation of cholesterol by ZAK's method	1

Reference Books :

1. Jayaram T. 1981. Laboratory manual in Biochemistry, Wiley Estern Ltd. New Delhi.
2. Plummer D. 1988. An Introduction to Practical Biochemistry. 3rd ed. Tata McGraw Hill, New Delhi.
3. Nath RL. 1990. Practical Biochemistry in Clinical Medicine. Academic Pub.
4. Sadasivam S and Manickam A. 1996. Biochemical Methods. 2nd ed. New Age International (P) Ltd. Publisher, New Delhi.

Subject Code: BBt-311 **Subject : Practical in Molecular Biology and Environmental Biotechnology**

(2 Credit Course)

Total Practical= 15 P (15x3hrs.)

Sr. No	Topic	Practical
	Molecular Biology	
1	Reagent and buffer preparation	1
1	Estimation of Nucleic acids by UV-Vis spectrophotometry	1
2	Determination of melting temperature of DNA	1
3	Bacterial DNA isolation by alkaline lysis/ lysozyme method and purity check by using A 260/280.	2
4	Bacterial DNA agarose gel electrohporesis	1
5	Estimation of DNA by diphenylamine method	1
6	Isolation of RNA from Yeast or Yeast Tablets	1
	Environmental Biotechnology	
1	Study of pollution indicator plants in terms of morphology and anatomy (any 5-7 plants)	1
2	Community sampling-By Quadrate method for plants : Percentage of frequency, density, abundance . frequency class diagram and comparison with Raunkiaers frequency chart, Simpson's index of dominance.	2
3	Microbial (Bacterial, Algal and Fungal) community estimation	1
4	Study of polluted and unpolluted soil by i) Physical properties : Colour, Texture, Water holding capacity	1
	ii) Chemical properties: pH, Organic content, chlorides and Alkalinity	2
5	Testing genotoxicity of water sample : Polluted and non Polluted	1

Reference Books :

1 Introduction to Environmental Biotechnology (2007) Chattergy PHI Learning Pvt. Ltd, Delhi

2 Textbook of environmental studies for undergraduate courses (2005) Erach Bahrucha Universities Press, Hyderabad

3 Scragg A. Environmental Microbiology Oxford Univ Press. (2005).

4 Evans & Furlong. Environmental Biotechnology.Theory & Applications 2nded 2011. Wiley-Blackwell.

5. Lab manual on molecular biology January 2016 Edition: First Edition, Media Associates Delhi-53Editor: Ruhi Dixit, KartikayBisen, Ashwani Kumar, Ashim Borah, Chetan KeswaniISBN: 978-81-909182-7-5

Savitribai Phule Pune University
B. Sc. Biotechnology (CBCS Semester Pattern)

S. Y. B. Sc. Biotechnology

Revised Syllabus w.e.f. June 2020
Semester IV

Subject Code: BBt-401 **Subject : Cell Biology II (2 Credit Course)**
Total Lectures=30

Unit	Topic	No of lecture
1	**Cell Cycle** • Introduction to cell cycle • Phases and Check points of cell cycle	4
2	**Cell Division in Plant & Animal** • Mitosis • Meiosis	7
3	**Cell Signaling** • Signaling molecules • Signaling receptors: Cell surface receptors • Autocrine, syncrine & paracrine signaling • G-protein signaling (one example) • Calcium Signaling	12
4	**Cell Death** • Aging, Apoptosis and Necrosis • Neoplasia • Autophagy • Ferroptosis • Pyroptosis	7

Reference books:

1. Molecular Cell Biology. 7th Edition, (2012) Lodish H., Berk A, Kaiser C., KReiger M., Bretscher A., Ploegh H., Angelika Amon A., Matthew P. Scott M.P., W.H. Freeman and Co., USA
2. Molecular Biology of the Cell, 5th Edition (2007)BruceAlberts, Alexander Johnson, Julian Lewis, Martin Raff, Keith Roberts, Peter Walter. Garland Science, USA
3. Cell Biology, 6th edition, (2010) Gerald Karp. John Wiley & Sons., USA
4. The Cell: A Molecular Approach, 6th edition (2013), Geoffrey M. Cooper, Robert E. Hausman, Sinauer Associates, Inc. USA
5. Karp, G. 2010. Cell and Molecular Biology: Concepts and Experiments. 6th Edition. John Wiley & Sons. Inc.
6. De Robertis, E.D.P. and De Robertis, E.M.F. 2006. Cell and Molecular Biology. 8th edition.Lippincott Williams and Wilkins, Philadelphia.
7. Cooper, G.M. and Hausman, R.E. 2009. The Cell: A Molecular Approach. 5th edition. ASM Press& Sunderland, Washington, D.C.; Sinauer Associates, MA.

8. Becker, W.M., Kleinsmith, L.J., Hardin. J. and Bertoni, G. P. 2009. The World of the Cell. 7th edition. Pearson Benjamin Cummings Publishing, San Francisco.

Subject Code: BBt-402 Subject: Molecular Biology II (2 Credit Course)
Total Lectures=30

Unit	Topic	No of lectures
I	**Synthesis of RNA: Transcription:** • Transcription in prokaryotes: Prokaryotic RNA polymerase, role of sigma factor, promoter, Initiation, elongation and termination • Transcription in Eukaryotes: Eukaryotic RNA polymerases, transcription factors, promoters, enhancers, mechanism of transcription initiation, promoter clearance and elongation RNA splicing and processing: processing of pre-mRNA: 5' cap formation, polyadenylation, splicing. • Splicing mechanisms, Splicing of tRNA precursors, Splicing of rRNA precursors	**8**
II	**Synthesis of Protein: Translation** • Structure of ribosome and assembly • Protein Synthesis in Prokaryotes: properties of the prokaryotic Initiator tRNA-fMet, Charging of tRNA, amino acyl tRNA synthetases • Protein Synthesis in Eukaryotes: Mechanism of initiation, elongation and termination of polypeptides, • Fidelity of translation, Inhibitors of translation. • Posttranslational modifications of proteins	**10**
III	**DNA damage and repair** • Causes and types of DNA damage • Mechanism of DNA repair: Photo reactivation, base excision repair, nucleotide excision repair, mismatch repair, SOS repair, recombination repair	**5**
IV	**Regulation of activity of Genes and Gene products in Prokaryotes**: a) General aspects of gene Regulation: inducible and repressible system b) The lactose operon : Catabolite repression c) The Arabinose operon: Positive , negative regulation d) The Tryptophan operon : Regulation by attenuation.	**7**

Reference Books :

1. Genes X, 10th edition (2009), Benjamin Lewin, Publisher - Jones and Barlett Publishers Inc. USA
2. Molecular Biology of the Gene, 6th Edition (2008), James D. Watson, Tania Baker, Stephen P. Bell, Alexander Gann, Michael Levine, Richard Lodwick, Pearson Education, Inc. and Dorling Kindersley Publishing, Inc. USA
3. Molecular Biology, 5th Edition (2011), Weaver R., Publisher-McGrew Hill Science.USA
4. Fundamentals of Molecular Biology, (2009), Pal J.K. and SarojGhaskadbi, OxfordUniversity Press. India
5. Karp, G. (2010). Cell and Molecular Biology: Concepts and Experiments. VI Edition. JohnWiley & Sons. Inc.

6. De Robertis, E.D.P. and De Robertis, E.M.F. (2006). Cell and Molecular Biology.VIII Edition. Lippincott Williams and Wilkins, Philadelphia.
7. Molecular Biology of the Gene (VI Edition.). Cold Spring Harbour Lab. Press, Pearson Pub.
8. Principles of Gene manipulation and Genomics. - S.B. Primrose and R.M. Twyman.Blackwell Publication

Subject Code: BBt- 403 **Subject : Immunology (2 Credit Course)**
Total Lectures=30

Unit	Topics	No. of lectures (30)
I	**Immunology: Basic definitions and fundamentals of the immune system** • Definitions - Infection, Invasion, Pathogen, Immunity, Antigen, Antibody • Concept of Host pathogen interaction • Organization of Immune system: a) Structure and function of the cells and tissues of immune system. b) Structure and function of Primary and Secondary lymphoid organs • Types of immunity: a) Innate and Acquired immunity b) Cell mediated and Humoral immunity • Immune Response: Primary and Secondary • Phagocytosis	07
II	**Components of the immune system:** • Antigens: Types and properties of an antigen. Factors affecting immunogenicity. • Immunoglobulin: Structure and their types. Properties and function of different Immunoglobulin classes. • Complement system: Components, function and pathways. • Major Histocompatibility Complex: Types, structure and function • Cytokines: Types, properties and their function	08
III	**Antigen-Antibody Interactions** • General characteristics of Antigen-Antibody reaction • Concept of Lattice hypothesis and Zone phenomenon • Principle and example of different diagnostic tests: i. Precipitation, Agglutination, Immunodiffusion and Complement fixation test ii. Radioimmunoassay, Immunofluorescence, ELISA iii. Western blotting	07
IV	**Clinical Immunology** • Hypersensitivity reactions: Types of Hypersensitivity and clinical manifestation. • Autoimmunity: Mechanisms, Types of autoimmune diseases • Concept of Immunotherapy • Vaccine Technology: • Adjuvant- Properties and role with suitable example • Concept with suitable example of Killed and Live attenuated vaccines, Combined vaccines	8

	• Modern Techniques: Concept of Subunit vaccines, Recombinant DNA Vaccines, Conjugate vaccines, Polyvalent vaccines, Monoclonal antibodies, Chimeric antibodies with suitable example	

Reference Books

1. Ananthanarayan R and Paniker CKJ. Textbook of Microbiology. University Press Publication.
2. Roitt I. Essential Immunology. 10th Ed. Blackwell Science.
3. Kuby. Immunology. 4th edition. W. H. Freeman & company.
4. SudhaGangal and ShubhangiSontakke, Textbook of basic and clinical immunology, 1st edition (2013), University Press, India

Subject Code: BBt- 404 Subject : Animal Development (2 Credit Course)
Total Lectures=30

Unit	Topics	Lectures
I	• History of developmental biology, • Model organisms in study of developmental biology: frog, chick, mouse, Drosophila, Sea urchin, Zebra Fish , *Caenorhabditis elegans*	2
II	**Reproduction and Development**: • Basics of gametogenesis: Oogenesis, spermatogenesis and spermiogenesis • Detailed structure of gametes • Fertilization process in sea urchin and mammals • Types of eggs, types and patterns of cleavage • Morphogenetic movements	9
III	**Gastrulation** • In*Amphioxus*, frog, chick, *Drosophila* up to formation of three germinal layers	8
III	**Basics of neurulation**	2
IV	**Concept of pattern formation** • Maternal effect genes and their role in Drosophila pattern formation	2
V	• Concept of Stem cells, Progenitor cells, cell lineages, determination, commitment and differentiation, re differentiation and trans-differentiation	1
VI	**Different types of regeneration with one example of each type**	2
VII	**Theories of ageing**	1
VIII	• Apoptosis during Embryonic development, intrinsic an extrinsic pathways	2
IX	**Abnormal development and teratogenesis in animals**	1

Reference Books:

1. Development Biology, 9th edition, (2010),Gilbert S.F.(Sinauer Associates, USA)
2. Principles of Development, 5thedition (2018), Wolpert L and Tickle C, Publisher: Oxford University Press, USA.
3. An introduction to embryology, 5th edition, B. I. Balinsky, B.C. Fabian (2012) Cengage Learning India

Subject Code: BBt-405 **Subject : Plant Development (2 Credit Course)**
Total Lectures=30

Unit	Topic	No. of lectures
1	**Plant as a living system** • Principles and Unique features of plant development • Comparison of Plant and animal development,	3
2	**Plant development at:** • Cellular, organ and whole-plant levels • Whole plant as an interacting dynamic system	2
3	**Major phases of plant development** **i) Vegetative development:** • Zygote to seed embryo to seedling till vegetative maturity • Pattern formation in plants- vegetative	3
	ii) Reproductive development: • Shift from vegetative to reproductive phase • Structure of flower • Induction- perception of inductive stimuli and subsequent changes, • Pattern formation in plants- flowering	4
4	• Microsporogenesis, development of male gametophyte and male gamete • Megasprogenesis, development of female gametophyte and female gamete • Double fertilization and triple fusion • Development of endosperm	5
5	**Concept of** • competence, • Determination, • Commitment, • Differentiation, • De-differentiation and • Re-differentiation (partial/ terminal) *in vivo* with one example each	3
6	**Model systems to understand plant development :** • *Arabidopsis* Molecular regulation of development in *Arabidopsis*	6
7	**Parthenogenesis-** • Haploid , Diploid • Parthenocarpy – Natural , Induced • Importance of seed and seed dispersal • Applications of Plant development in Biotechnology	4

Reference Books:

1. Development Biology, 9th edition, (2010), Gilbert S.F.(Sinauer Associates, USA)
2. Principles of Development, 4th edition (2010), Wolpert L and Tickle C, Publisher: Oxford University Press, USA.
3. Bhojwani S.S. and Bhatnagar S.P.(2009) – Embryology of Angiosperms (Vikas Publ House, New Delhi)
4. Burgess J. (1985) An Introduction to Plant Cell Development (Cambridge Univ Press, UK)
5. Taiz L, Zeiger E (2010) – Plant physiology (Sinauer Associates, USA).
6. Sharma HP (2009) – Plant embryology: Classical and experimental (alpha sci)
7. Steeves TA & Sussex IM (2004) – Patterns in plant development. (Cambridge Univ Press, Cambridge, New York)
8 The molecular life of plants by Jones et al Wiley
9. Biochemistry and Molecular Biology of Plants, 2nd Edition - Bob Buchanan et al Wiley
10. Plant Physiology, Taiz and Zeiger Sixth edition Sinaeur

Subject Code: BBt : 406 **Subject : Microbial Biotechnology (2 Credit Course)**

Total Lectures=30

Unit	Topic	No. of Lectures
I	**History and Scope of Microbial Biotechnology**	1
II	**Food and Dairy Microbiology** **A) Food Microbiology** • Role of microorganisms in food spoilage, Factors affecting growth of microbes in food (intrinsic and extrinsic factors), Spoilage of meat and poultry, Fruits and vegetable, Canned food. • Principles of Food Preservation. • Methods of preservation Chemical and Physical methods. **B) Dairy Microbiology** • Milk: Definition, Composition of milk, Normal and abnormal microflora of milk, Sources of contamination of milk, International standards of Milk. • Milk Spoilage- Flavour and colour defects, Stormy fermentation, Sweet curdling, Ropiness. • Grading of milk- Direct and Indirect Tests • Preservation of Milk- Pasteurization and efficiency of pasteurization. • Microbial processing of milk- Curd,Yogurt, Butter, Kefir, Cheese. • Food borne diseases- Food infection and intoxication	7
III	**Medical Microbiology** • Medical Microbiology: Normal flora, • Diseases of various systems Tuberculosis, Leprosy, Typhoid, Polio, Syphilis, Tetanus, causative agent, symptoms, morphology, pathogenesis, diagnosis and treatment.	7
IV	**Microbes in Waste treatment Processes** • Water borne diseases: Indicators of faecal pollution, Routine bacteriological analysis of water for potability: Presumptive, Confirmed, Completed test, Membrane Filter Technique and Eijkman tests. • Bacteriological standards of drinking water.(WHO, BSI) • Sewage and Industrial waste water: Types of wastes, relevance of COD and BOD determination in analysis of waste water • Methods and principles of treatment of sewage (primary, secondary and tertiary treatment methods	8

	• Microbial consortium for effluent treatment.	
V	**Applications of Microbial Biotechnology** • Geomicrobiology-Ore leaching (methods and examples), MEOR. • Bioweapons • Biofertilizers and Biopesticides and Microbial plant growth Promoters(gibberellins and IAA) • GMOs-Norms and applications • Microbial Sweeteners (Thaumatin, Monelin) • Microbial toxins and their applications • Microbial Polysaccharide production: any 2 examples • Concept of Synthetic Biology and Bio metabolite Production	7

References Books :

1. Food Microbiology, Frazier & Westhoff, 4th edition, Tata McGraw Hill Publications
2. Modern Food Microbiology, James Jay, 7th edition, Springer Publications
3. Advances in Biotechnology, S. N. Jogdand, Himalaya Publishing House
4. Milk & Milk Products, C. Eckles, 4th edition, Tata McGraw Hill Publications
5. Prescott, S.C. and Dunn, C.G., (1983) Industrial Microbiology, Reed G. AVI tech books
6. General Microbiology - Stanier R.Y., 5th edition, (1987)Macmillan Publication, UK.
7. Fundamental Principles Of Bacteriology**,** Salle,A.J.,McGraw Hill Company, New York
8. Tortora, G.J., Funke, B.R., Case, C.L, 1992. Microbiology: An introduction 5th Edition, Benjamin Pub. Co. NY
9. Davis B.D., Delbacco, 1990 Microbiology 4th edition, J.B. Lippincott Co. NY
10. Wolfgang K. Joklik, 1992, Zinsser Microbiology 20th Edition, McGraw-Hill Professional Publishers
11. Dey, N.C and Dey, TK. 1988, Medical Bacteriology, Allied Agency, Calcutta, 17thEdition
12. Ananthnarayana, R. and C.E, Jayaram Panikar, 1996 Text book of microbiology, 5th edition, Orient Longman. .Park and Park, Preventive and Social medicine. 2013, Publisher: Banarsidas Bhanot, Jabalpur
13. Ingraham J.L. and Ingraham C.A. (2004) Introduction to Microbiology. 3nd Edition. Thomson Brooks / Cole.
14. Madigan M.T, Martinko J.M. (2006) Brock's Biology of Microorganisms. 11th Edition. Pearson Education Inc.
15. Salle A.J. (1971) Fundamental Principles of Bacteriology. 7th Edition. Tata MacGraw Publishing Co.
16. Standard Methods for the Examination of Water and Wastewater (2005) 21st edition, Publication of the American Public Health Association (APHA), the American Water Works Association (AWWA), and the Water Environment Federation (WEF); edited by Andrew D. Eaton, Mary Ann H. Franson.Satyanarayan, U. Biotechnology(2008), Books and Allied Ltd.Kolkata
17. Sing, B. D. Biotechnology,(2010), Kalyani Publishers, New Delhi

Subject Code:BBt-409 Subject : Practicals in Molecular Biology and Microbial Biotechnology (2 Credit Course)

Total Practical= 15 P (15x3hrs.)

Sr. No.	Title of Experiment	No. of Practical
	Molecular Biology	
1	Preparation of Reagents	1
2	Isolation of Eukaryotic(Plant) DNA and analysis by Agarose gel electrophoresis	2
3	Isolation of Eukaryotic(Animal) DNA and analysis by Agarose gel electrophoresis	2
4	Estmation of RNA by Orcinol method	**1**
5	Estimation of proteins by Bradford method	**1**
	Microbial Biotechnology	
6	Food and Dairy Microbiology: a. Isolation and identification (Genus level) of spoilage causing microorganisms from spoiled foods b. Grading of raw milk (Dye reduction test, DMC) c. Determination of efficiency of Pasteurization by phosphatase test	**3**
7	Study of Normal flora of humans (Skin and oral cavity)	**1**
8	Assessment of potability of water: a. Presumptive b. Confirmed and c. Completed test. d. Eijkman's teste. e. IMViC tests	**3**
9	Visit to Dairy/ Effluent treatment plant / Sewage Treatment /Biofertilizer plant/ any other relevant industry and report writing.	**1**

Reference books :

1 Lab manual on molecular biology January 2016 Edition: First Edition, Media Associates Delhi-53Editor: Ruhi Dixit, KartikayBisen, Ashwani Kumar, Ashim Borah, Chetan KeswaniISBN: 978-81-909182-7-5

2 Modern Food Microbiology, James Jay, 7th edition, Springer Publications

3 Madigan M.T, Martinko J.M. (2006) Brock's Biology of Microorganisms. 11th Edition. Pearson Education Inc

4 Ananthnarayana, R. and C.E, Jayaram Panikar, 1996 Text book of microbiology, 5th edition, Orient Longman. .Park and Park, Preventive and Social medicine. 2013, Publisher: Banarsidas Bhanot, Jabalpur

Subject Code: BBt-410 Subject : Practicals in Animal & Plant development
2 Credit Course (Total Practical= 15 P (15x3hrs.)

Sr. no.	Topic of practical	Practical No
	Animal development	
1	Study of frog development, observation of different development stages (Permanent slides or fixed embryos)	1
2	Study of amphioxus development, observation different development stages (Permanent slides)	1
3	Study of staging & staining of Chick embryos (24 h, 48h, 72 h)	2
4	Effect of teratogen on development of chick embryo by window technique	2
5	Demonstration of any one technique of chick embryo culturing	1
6	Demonstration of regeneration in *Hydra*	1
	Plant Development	
1	Methods of studying plant development (any suitable plant material) a) Dissection b) Sectioning c) Staining d) Mounting	1
2	Study of apices and meristem- RAM, SAM, florally induced meristem	2
3	Microsporogenesis- anther squash technique	1
4	Development of male and female gametophytes	1
5	Developmental stages during plant embryogenesis in dicots and monocots	1
6	Dissection of seed and excision of young embryo and endosperm (Two dicotyledon and Two monocotyledon example)	1

Reference Books:

1. Burgess J. (1985) An Introduction to Plant Cell Development (Cambridge Univ Press, UK)
2. Taiz L, Zeiger E (2010) – Plant physiology (Sinauer Associates, USA).
3. Sharma HP (2009) – Plant embryology: Classical and experimental (alpha sci)
4. Development Biology, 9thedition, (2010), Gilbert S.F.(Sinauer Associates, USA)
5. Principles of Development, 5thedition (2018), Wolpert L and Tickle C, Publisher: Oxford University Press, USA.
6. An introduction to embryology, 5th edition, B. I. Balinsky, B.C. Fabian (2012) Cengage Learning India

Subject Code: BBt-411 Subject :Practical in Cell Biology and Immunology
(2 Credit Course) Total Practical= 15 P (15x3hrs.)

Unit	Topic	Practical
Section I : Cell Biology		
1	Study of different stages of Mitosis	2
2.	Effect of colchicine on mitosis	1
3	Study of different stages of Meiosis in *Tradescantia*	2
4	Study of polytene chromosomes (*Drosophila/Chironomus* larva)	2
Section II – Immunology		
5.	Determination of blood group using slide agglutination Reaction	1
6	To determine total leukocyte of given blood sample	1
7	Determine Differential count of given blood sample	1
8	Immunodiffusuion: a) Single Radial immunodiffusion b) Ouchterlony double diffusion technique (pattern of identity)	2
9	Determination of antibody titer by tube agglutination test (Widal Test)	2
10	Detection of presence of antigen by qualitative ELISA(Dot ELISA)	1

Reference Books :

1 Cell biology and genetics lab manual Boğaziçi University Department of Molecular Biology and Genetics 2007-2008
2 Cell Biology Laboratory The University of Toledo Department of Biological Sciences/Natural Sciences and Mathematics
3 Ananthanarayan R and Paniker CKJ. Textbook of Microbiology. University Press Publication.
4 Roitt I. Essential Immunology. 10th Ed. Blackwell Science.
5 Kuby. Immunology. 4th edition. W. H. Freeman & company.