Department of Biotechnology

Syllabus
For
Integrated M. Sc. Biotechnology
To be effective from academic session 2019-2020

Central University of Rajasthan
NH-8, Bandarsindri,
Kishangarh-305817
Distt Ajmer

Integrated M.Sc. Biotechnology (5 years program)

Program Objectives

In depth knowledge and understanding

1. In depth knowledge and understanding in multi. Disciplinary environment

- About the basic and advanced biotechnology field.
- into current research and development in the field.

2. Skills and Abilities

- For evaluating information relevant to concepts and issues of contemporary biotechnology.
- For analyzing and solving both theoretical and applied biotechnological problems.

3. Critical Judgement and Evaluation

- About legal, ethical, social and business aspects of biotechnology-based products and services.
- To perform biotechnological research or assessments independently and/or in collaborations with other person(s) or team.

4. Professional Development

- Ability to work independently in R&D of both public and private sectors or other employment in biotechnology-based organizations,
- higher studies at the Doctoral level.

Semester Wise Course details:

Semester I

Course Code	Course Name	Credits
BIO-101	Biology-I Diversity of Life	3
BIO-102	Biology Practical _I	1
	Chemistry*	4
	Mathematics*	4
	Physics*	4
	English*	2

*Content for Paper will be designed and given by respective Department

Semester II

Course Code	Course Name	Credit
BIO-103	Biology-II Techniques for Biology	4
	Chemistry*	4
	Mathematics*	4
	Physics*	4
	English/ICT*	2

*Content for Paper will be designed and given by respective Department

Semester III

Course Code	Course Name	Credit
BIO-201	Biology-III Biochemical Constituents of Life	4
	Chemistry*	4
	Physics*	4
	Environmental Science*	3
	Open Elective II (offered by the Social Science Dept)*	3

*Content for Paper will be designed and given by respective Department

Semester IV

Course Code	Course Name	Credits
BIO-202	Biology-IV Structural Organization of Life	3
BIO-203	Biology Practical-II	1
	Chemistry*	4
	One Subject out of Math/Physics/Statistics/CS/ Economics*	4
BIO-204	Open Elective-I (offered by the any Science Department) **Ecology and Evolution**	3

	Open Elective II (offered by the Social Science Department) *	3

*Content for Paper will be designed and given by respective Department

Semester V

Course Code	Course Name	Credits
BIO-301	Biology-V Functional Organization of Life	3
BIO-302	Biology-VI Reproductive Biology	3
BIO-303	Biology-VII Genetics	3
BIO-304	Biology Practical-III	3
BIO-305	Open Elective I (offered by other Science Dept) Laboratory safety, Ethics in Bio-Sciences and Intellectual Property Right	3
	Open Elective II (offered by other Science Dept)	3

Semester VI

Course Code	Course Name	Credits
BIO-306	Biology-VIII Interactive Biology	3
BIO-307	Biology-IX Introduction to Gene Technology	3
BIO-308	Biology-X Trends in Biology	3
BIO-309	Biology Practical-IV	3
	Open Elective I- (offered by the any Science Department) Current Trends in Environmental Sciences	3
	Open Elective II- (offered by other than Science Department) *	3

Semester

VII	*(Courses As per M.Sc. Biotechnology I Semester)*	24
VIII	*(Courses As per M.Sc. Biotechnology II Semester)*	24
IX	*(Courses As per M.Sc. Biotechnology II Semester)*	24
X	*(Courses As per M.Sc. Biotechnology IV Semester)*	24

Course Outcome: (May be / May be not point wise/bulleted)

At the end of the program the student will be able to:

1.	demonstrate in-depth knowledge of basic and applied science subjects that constitute the field of Biotechnology using multidisciplinary approach.
2.	demonstrate an insight into current research and development in the biotechnology field.
3.	work in the R&D laboratories of both public and private sectors.

4.	apply research based knowledge and biotechnological techniques to investigate complex biological problems.
5.	use software tools to understand biological systems.
6.	assess personnel, product and environmental safety, intellectual property and social responsibilities related to modern biotechnological research and development.
7.	identify measures for environment, health, safety and society following ethical principles.
8.	participate in R&D projects in biotechnology, able to work in multi-disciplinary teams to attain project objectives, document the activities, and present reports effectively.

Mapping of program outcomes with courses offered in Integrated M.Sc. Biotechnology

Program Outcomes	Outcome-1	Outcome-2	Outcome-3	Outcome-4	Outcome-5	Outcome-6	Outcome-7	Outcome-8
BIO-101	X							
BIO-102	X		X					
Chemistry*	X							
Mathematics*	X							
Physics*	X							
English*	X							
BIO-103	X							
Chemistry*	X							
Mathematics*	X							
Physics*	X							
English/ICT*	X				X			
BIO-201	X							
Chemistry*	X							
Physics*	X							
Environmental Science*	X					X	X	
Open Elective II (offered by the Social Science Dept)*	X					X	X	
BIO-202	X							
BIO-203	X		X					
Chemistry*	X							
One Subject out of Math/Physics/ Statistics/CS/ Economics*	X				X			
BIO-204	X							
BIO-301	X							
BIO-302	X							
BIO-303	X							
BIO-304	X		X					
BIO-305	X					X	X	
Open Elective II- (offered by other than Science Department) *	X							
BIO-306	X	X						
BIO-307	X	X						

BIO-308	X	X						
BIO-309	X		X					
Open Elective I- (offered by the any Science Department) Current Trends in Environmental Sciences	X							
Open Elective II- (offered by other than Science Department) *	X							
BTY-401	X							
BTY-402	X							
BTY-403	X							
BTY-404	X							
BTY-405	X			X	X			
BTY-406	X							
BTY-407	X		X					
BTY-408	X		X					
BTY-409	X							
BTY-410	X	X		X	X			
BTY-411	X					X	X	
BTY-412	X							
BTY-413	X							
BTY-414	X							
BTY-415	X		X	X	X			
BTY-416	X		X					
BTY- 501	X			X				
BTY-502	X	X		X				
BTY-503	X							
BTY-504		X				X	X	
BTY-505			X	X				X
BTY-506	X			X				
BTY-507	X	X	X					
BTY-508	X		X					
BTY-509		X		X	X			
BTY-510		X		X				X
BTY-511			X	X	X			X
BTY-512				X				X

Semester I

BIO-101 **Biology-I (T) Diversity of Life** **Credits 3**

Course Structure

Unit I: Microbial Diversity and Diversity in Lower Plants
Bacteria: General characteristics, cell structure of bacteria and their components, mycoplasma, archaebacteria, cyanobacteria, microbes in extreme environments. Fungi: General characteristics and classification Viruses: General characteristics and classification.
Diversity in Lower Plants: General characteristics, reproduction, classification and economic importance of algae, lichens, bryophytes and pteridophytes, alternation and generation in bryophytes and pteridophytes, vascular system in pteridophytes, economic importance of bryophytes and pteridophytes.

Unit II: Diversity in Higher Plants and Diversity in Lower Animals
Diversity in Higher Plants: General characteristics, reproduction, classification of gymnosperms, life cycle of gymnosperms and angiosperms, salient features of botanical nomenclature, economic importance of gymnosperms and angiosperms.
Diversity in Lower Animals: General characteristics, classification of various groups of protozoans, porifera, coelenterate, helminthes, annelida, arthropoda, mollusc, and echinodermata. Canal system in sponges, polymorphism of sponges, different larvaes, classification, mechanism of formation, and significance of coral reefs.

Unit III: Diversity of Higher Animals
General features of hemichordates, cephalochardates & urochardates. General characters and classification of pisces, amphibia, reptilia, aves, and mammalia, parental care in fishes and amphibia, poison apparatus and biting mechanism of poisonous snakes, identification of poisonous and non-poisonous snakes, flight adaptation of birds, dentition in mammals, connecting links, flying and aquatic mammals.

Suggested Readings

1. Ananthanarayan and Paniker (2017) A text book of Microbiology, :10th Edition. Orient Blackswan Publisher, Delhi
2. Nigam HC. (2017) Biology of Chordates, 25th Edition Vishal Publishing Co.
3. Cambell and Reece: Biology (2016) Biology 11th Edition, Pearson
4. Kotpal, R.L. (2016) Modern Textbook of Zoology - Invertebrates Rastogi Publications, Meerut.
5. Willey, J. Sherwood L, Woolverton C, (2016), Prescott Microbiology. 10th Edition, McGraw-Hill Publisher, Columbus, OH
6. Kotpal RL. (2015) Modern Textbook Of Zoology Vertebrates. Rastogi Publications
7. Singh, Pandey, Jain. (2011). A Text Book of Botany- Rastogi Publication.
8. Ganguly, Das & Dutta. College Botany. (2011) New Central Book Agency.
9. Pelczar Mi J., Chan, E.C.S., Krieg, NR, (2009). Microbiology, McGraw-Hill publication

BIO-102 **Biology Practical-1** **Credit 1**

Course Structure
List of laboratory practical

1. Specimen observation of Bacteria and viruses.
2. Microscopic observation of algae and cyanobacteria/
3. Specimen observation of bryophytes and pteridophytes.
4. Study of transverse sections/chart of the following: Sycon (as an example of Parazoa to show its structure, spicules and canal system), Hydra (as an example of diploblastic animal), Fasciola (as an example of triploblastic acoelomate animal), Ascaris (as an example of triploblastic pseudocoelomate animal), Hirudinaria (as an example of triploblastic schizocoelomate animal), Frog (as an example of triploblastic enterocoelomate animal)
5. Study of salient features and classification up to classes of the non-chordates with special emphasis on their adaptive characters using museum specimen.
6. Study of salient features and classification up to classes of the chordates using museum specimens.

Semester II

BIO-103 Biology-II (T) Techniques for Biology Credits 4

Course Structure

Unit I: Chromatography and Centrifugation
Introduction to chromatography, paper chromatography, gel filtration, ion-exchange chromatography, affinity chromatography, hydroxyapatite chromatography, introduction to centrifugation techniques, differential and density gradient centrifugation, separation of different organelles

Unit II: Analysis of Biomolecules
Characterization of proteins and nucleic acids; different electrophoresis like AGE, PAGE, different gel staining methods, auto-radiography, electrophoretic mobility shift assay, chromatin immuno-precipitation.

Unit III: Microscopy
Principles and application of light microscope and electron microscope, magnification and resolution power, An introduction to advance microscopies like fluorescence, confocal, AFM, and cryo-electron microscopy.

Unit IV: Spectrophotometry
Principle and applications of UV-Vis Spectroscopy, An introduction to advance spectrometry like fluorescence, circular dichroism, NMR and mass spectrometry.

Suggested Readings

1. Wilson K, Goulding KH. (2018) Principles and Techniques of Biochemistry and Molecular Biology, Eight Edition , Edited by Hofmann A, Clokie S. Cambridge University Press
2. Plummer DT. (2017) An Introduction to Practical Biochemistry. 3rd Edition McGraw Hill Education
3. Philips, R. Kondev J, Theriot J, Garcia H. (2012). Physical Biology of the Cell. 2nd Edition Garland Science.

Semester III

BIO-201 Biology-III (T) Biochemical Constituents of Life Credits 4

Course Structure

Unit I: Basics of Biochemical Reactions
Concept of different chemical interactions: covalent and non-covalent interactions and their importance in biological system, physical properties of water, concept of acid and bases, pH and buffer, definition of enzymes, co-enzymes, an introduction to kinetic parameters.

Unit II: Carbohydrate and Lipids Chemistry
Structure of classification of monosaccharides, disaccharides, and polysaccharides, reducing and non-reducing sugars, classification of lipids, fatty acids, triglycerides, phospholipids, water and fat-soluble vitamins.

Unit III: Protein and Nucleic acid Chemistry
Structural features of amino acids, classification of amino acids, peptide, structure of polypeptide, Ramachandran plot, protein folding, Structure of purine, pyrimidine, nucleoside & nucleotides, different types of DNA and RNA.

Unit IV: Organization of DNA into chromosomes and its function
Structure of chromatin and chromosomes, DNA replication of prokaryotes and eukaryotes, transcription, translation, regulation of gene expression: transcriptional, translational and post-translational.

Suggested Readings

1. Nelson DL, Cox MM (2017) Lehninger Principles of Biochemistry, 7th Edition. W. H. Freeman
2. Stryer L, Berg JM, Tymoczko JL. Gatto GJ. (2015) Biochemistry, 8th Edition. W. H. Freeman
3. Satyanarayana U, (2013), Biochemistry Elsevier
4. Voet DV, Voet JG. (2011) Biochemistry, Wiley
5. Karp G. (2015) Cell and Molecular Biology: Concepts and Experiments.5th Edition. John Wiley Publication.

Semester IV

BIO-202 Biology-IV (T) Structural Organization of Life Credits 4
Course Structure

Unit I: Cell Organization, cell cycle and signaling
Eukaryotic sub-cellular components: Nucleus, chromosomes, plasma membrane, endoplasmic reticulum, lysosomes, peroxisomes, Golgi apparatus, mitochondria, chloroplast, cytoskeleton.Mitosis and meiosis, cell cycle, cell-cell adhesion, extracellular matrix, interaction and communication between the cells (animal, plant and bacteria), cell signaling, differentiation and organogenesis.

Unit II: Plant Anatomy
Plant cell wall and membranes; plant structure organization, anatomy of root, stem and leaves, floral parts, embryo and young seedlings, meristems, vascular system in plants, life cycle of an angiosperm, pollination, fertilization, embryogenesis, seed formation, cellular totipotency, clonal propagation, organogenesis and somatic embryogenesis, in-vitro fertilization.

Unit III: Animal Anatomy-I
Organizational level of animal body structure and function: tissue, body cavities, anatomy of integumentary, skeletal (articulations), muscular (skeletal, smooth & cardiac muscles), nervous (CNS and PNS; cranial nerves), sensory (eye, ear, nose, tongue).

Unit IV: Animal Anatomy-II
Cardiovascular (heart and blood vessels), blood circulation, lymphatic, Respiratory (structure of organs of respiration), digestive, urinary, male and female reproductive systems.

Suggested Readings

1. Nelson DL, Cox MM (2017) Lehninger Principles of Biochemistry, 7th Edition. W. H. Freeman
2. Stryer L, Berg JM, Tymoczko JL. Gatto GJ. (2015) Biochemistry, 8th Edition. W. H. Freeman
3. Grisham CM, Garrett RH. (2012) Biochemistry. 6th Edition. Brooks Cole
4. Voet DV, Voet JG. (2011) Biochemistry, Wiley
5. K.L. Moore, A.R. Delley. A. M. Abgur. (2017) Clinical Oriented Anatory. Lippincott Williams and Wilkins; Eighth, North American Edition.
6. Koelling C. (2016) Plant Anatomy, Morphology and Physiology. Syrawood Publishing House
7. Tortora GJ, Derrickson BH. (2013) Principles of Anatomy and Physiology. John Wiley & Sons.
8. David F. Cutler, Ted Botha, Dennis Wm. Stevenson. (2009) Plant Anatomy; An applied approach. Wiley –Blackwell Publication.
9. Pelczar Mi J., Chan, E.C.S., Krieg, NR, (2009). Microbiology, McGraw-Hill publisher
10. W. C. Dickson. (2000). Integrative Plant Anatomy. Academic Press

BIO-203 **Biology Practical-II (P)** **Credits 3**

Course Structure

List of laboratory practical

1. Study of Floral characters and Floral diagram of representative member of some families: Malvaceae, Brassicaceae, Asclepiadaceae, Solanaceae, Euphorbiaceae, Poaceae
2. Study of type of ovary, ovules, placentation types, types of pollen grains and stages of dicot embryo.
3. Transverse section of leaf, stem and root for different plants in University campus.
4. Demonstration of phenomenon of osmosis and diffusion.
5. Demonstration of functioning of heart using model.
6. Counting of red blood corpuscles and white blood corpuscles
7. Determination of hemoglobin content.
8. Demonstration of blood grouping.
9. Identification of amino acids in the mixture using paper chromatography
10. Principle & operation of Spectrophotometer, Verification of Beer's Law Spectrophotometrically and Qualitative tests for identification of sugars
11. Estimation of protein by Biuret method and Folin Lowry method
12. Observation of permanent slides of mitosis and meiosis.

Open Elective I

BIO-204 **Ecology &Evolution** **Credits 3**

Course Structure

Unit-I: Ecological Factors, Population and Community
Ecological factors, Laws of limiting factors- Liebig's law of minimum, Shelford's law of tolerance. Structure and composition of atmosphere, hydrosphere, lithosphere and biosphere, Levels of organization- species, population characteristics, species interactions: predation, herbivory, competition, parasitism, mutualism and commensalism. Population regulation, community characteristics, ecotone, edge effect & ecological Successions.

Unit-II: Ecosystem Ecology
Ecosystem - concept, structure (biotic and abiotic), food chain, food web, ecological efficiency, energy flow and production. Fixation of solar energy and sustenance of trophic levels, measurement and efficiency of primary production and secondary production, biogeochemical cycles, succession, homeostasis and stability of ecosystem. Microbial community in biosphere, biofilm and its ecological implication, microbial diversity, extremophiles.

Unit-III: Evolution and Conservation Biology
Concept of evolution and theories- Lamarckism, Darwinism, Neo Darwinism, isolation, mutation, speciation, germplasm and genetic drifts, Geographical range of species and range extensions, Concepts of neutral evolution, molecular divergence and molecular clocks; Molecular tools in phylogeny, classification and identification; Gene duplication and divergence. Biodiversity and conservation: hotspots, causes of depletion, conservation methods and endangered species, wild life of India and its conservation.

Suggested Readings

1. Botkin, Daniel B. and Keller, Edward A. (2014). Environmental Science: Earth as a Living Planet. 6th ed. John Wiley & Sons.
2. Krebs, C. (2008) The Ecological World View. CISIRO Publishing
3. McArthur, (2006) Microbial Ecology, Elsevier.
4. Odum, E.P. (2005) Fundamentals of Ecology. Cengage.

Semester V

BIO-301 Biology-V (T) Functional organization of Life-Physiology Credits 3

Course Structure

Unit I: Microbial Physiology

Common nutrient requirements and nutrient uptake in microbes, microbial growths- measurement, growth curve, effect of environmental factor on growth. An introduction to metabolism of carbohydrates, nucleic acid, lipids and proteins, microbial electron transport system

Unit II: Plant Physiology

Water movement in plant, transpiration, photosynthesis, respiration and photorespiration, nitrogen metabolism, physiological effects and mechanisms of action of plant hormones, photoreceptors-phytochromes, cryptochromes and phototropins, photoperiodism

Unit III: Animal Physiology

Exchange and transport of gases, regulation of respiration, physiology of circulatory system, physiology of execratory system, organization of nervous system, synapses and synaptic transmission, endocrine and exocrine glands, hormones, regulation of hormone secretion, mode of action, effects of abnormal secretions of hormones and placental hormones.

Suggested Readings

1. K.L. Moore, A.R. Delley. A. M. Abgur. (2017) Clinical Oriented Anatory. Lippincott Williams and Wilkins; Eighth, North American Edition.
2. Koelling C. (2016) Plant Anatomy, Morphology and Physiology. Syrawood Publishing House
3. Willey, J. Sherwood L, Woolverton C, (2016), Prescott Microbiology. 10th Edition, McGraw-Hill Publisher, Columbus, OH
4. Barrett K, Brooks H, Boitano S, Barman S. (2015) Ganong's Review of Medical Physiology, Twenty-Fifth Edition (Lange Medical Book)
5. Hall JE. (2015). Guyton and Hall Textbook of Medical Physiology, 13th Edition. Elsevier.
6. Tortora GJ, Derrickson BH. (2013) Principles of Anatomy and Physiology. John Wiley & Sons.
7. Taiz L, Zeiger E. (2010). Plant Physiology Fifth Edition, Sinauer Associates, Inc
8. Reddy, Rao, Reddy, Reddy, Chary. (2007). University Botany III (Plant Taxonomy, Plant Embryology, Plant Physiology), New Age International.
9. Trivedi PC. (2006) Advances in Plant Physiology; I. K. International Publishing House

BIO-302 **Biology-VI(T) Reproductive Biology** **Credits 3**

Course Structure

Unit I: Microbial Reproduction
Basic of microbial reproduction, Bacterial- Conjugation, transformation and transduction and Fungal reproduction- vegetative, asexual, and sexual, Algal Reproduction: vegetative, asexual and sexual. Viral reproduction: lytic and lysogenic cycle, reproduction of phages, Protozoan Reproduction (Amoeba, Paramecium and Plasmodium).

Unit II: Plant Reproductive and Developmental Biology
Reproductive development, induction of flowering, flower as a modified determinate shoot. flower development, genetic and molecular aspects, anther and pollen biology, pollination and fertilization, seed and fruit development, seed structure, types and their dispersal mechanisms.

Unit III: Animal Reproductive and Developmental Biology
Reproductive strategies and reproductive cycles in vertebrates, spermatogenesis, oogenesis, hormonal regulation in gametogenesis in male and female, physiology of male and female reproduction, mechanism of fertilization, types of eggs and pattern of cleavage, gastrulation and fate map, comparison of cleavage and gastrulation in sea urchin, frog and chick embryos, In-vitro fertilization, embryo transfer technology.

Suggested Readings

1. Gilbert SF, Barresi MJF, (2016), Developmental Biology 11th Edition Sinauer Associates
2. Albertis B, Jhonson A, Lewis L, Morgan D, Raff M, Roberts K, Emeritus, Walter P, (2014) Molecular Biology of the Cell. 6th Edition, Garland Science
3. Bhojwani, S.S. and Bhatnagar, S.P. (2014). The Embryology of Angiosperms, Vikas Publishing House. Delhi.
4. Karp G. (2007) Cell and Molecular Biology. John Wiley Publication.
5. Shivanna, K.R. (2003). Pollen Biology and Biotechnology. Oxford and IBH Publishing Co. Pvt. Ltd. Delhi.
6. Raghavan, V. (2000). Developmental Biology of Flowering plants, Springer, Netherlands.

BIO-303 **Biology-VII(T) Genetics** **Credits 3**

Course Structure

Unit I: Basic of Genetics
Introduction to genetics, pre-Mendelian, Mendelian and non-Mendelian inheritance, genetic linkage, recombination and crossing over, chromosomal basis of inheritance, mutations and mutagenesis, genetic basis of sex determination, extra-nuclear inheritance, exchange of genetic material.

Unit II: Molecular Genetics
Plasmid replication, copy number control, incompatibility, maintenance, curing & function, distribution & importance. Composite transposons, replicative and non-replicative transposons, Tn-transposons and evolution, mobile genetic elements, methods of genetic transfer: Transformation, Conjugation, Transduction and sexduction, mapping genes by interrupted mating, fine structure analysis of genes.

Unit III: Human Genetics and Population Genetics
Chromosomal abnormalities: aneuploidy, translocation and deletion. Genetic counseling. Hardy-Weinberg principle, evolutionary agents, selection, fitness, migration and random drift, modes of speciation (allopatric and sympatric).

Suggested Readings

1. Snustad DP, Simmons MJ. (2015) Principles of Genetics, 7th Edition , Wiley.
2. Albertis B, Jhonson A, Lewis L, Morgan D, Raff M, Roberts K, Emeritus, Walter P (2014) Molecular Biology of the Cell. 6th Edition, Garland Science
3. Anthony J.F. Griffiths, Susan R. Wessler, Sean B. Carroll and John Doebley. (2011) Introduction to Genetic Analysis: International Edition.
4. Brown TA. (2011) Introduction to Genetics: A Molecular Approach. Garland Science
5. Karp G. (2007) Cell and Molecular Biology. John Wiley Publication.

BIO-304 **Biology Practical- III** **Credits 3**

Course Structure

List of laboratory practical

1. Study of cross-section of reproductive structure of flowering plants.
2. Preparation of different media for bacterial and fungal isolation.
3. Demonstration of Autoclave, laminar air flow, hot air oven, centrifuge and pH meter: principle and its working
4. Demonstration of serial dilution, pouring, plating and streaking.
5. Identification of micro-organisms: simple staining, differential staining, acid fast staining, capsule staining, spore staining and motility
6. Demonstration of microbial reproduction, Bacterial- Conjugation, transformation and transduction.
7. Demonstration of mendalian genetics using pea plant and drosophila
8. Qualitative and Quantitative studies of Plant communities.
9. Demonstration of food web from the given set of data, (Representative of a natural ecosystem).
10. Field activity for construction of ecological pyramids of number, biomass, energy from the given set of data (Representative of a natural ecosystem).

BIO-305 Open Elective I: Laboratory safety, Ethics in Bio-Sciences and Intellectual Property Rights **Credits 3**
Course Structure

Unit I. Laboratory Safety
Laboratory safety guidelines and regulations, standard operating protocols (SOP),use of Genetically Modified Organisms (GMOs) and their release in the environment. Laboratory safety measures for production of transgenic organisms. Hazardous Materials used in Bio-sciences, their Handling and Disposal. Good Laboratory Practice (GLP) and Good Manufacturing Practice (GMP).

Unit II. Bioethics
Introduction to bioethics, ethical Issues in Genetic Manipulations and Genetically Modified Organisms: foods and crops, GMO labeling, Ethical issues involved in stem cell research and use. Use of animals in research and testing and alternatives for animals in research. Animal cloning, human cloning and their ethical Aspects. Testing of drugs on human volunteers. Organ transplantation and ethical issues. Ethical, legal and social implications of Human Genome Project

Unit III Intellectual Property Right
Intellectual Property Rights. Introduction to Patent and Process Involved in Patenting. Patenting Living Organisms, Patent of agricultural technology, and their implications for India and other developing countries. Copyright, trademark, trade secret, Traditional Knowledge and Geographical indication. Commercial Exploitation, and Protection of IPR. Participation in Biosafety and Protection of Biodiversity. Indian Biodiversity Act

Suggested Readings

1. Singh. B.D. 2010 Biotechnology Expanding Horizons, Third Edition, Kalyani Publishers
2. Bioethics and Biosafety in Biotechnology by Sree Krishna V., New Age International (P) Ltd., Publ., Mumbai. 2007
3. Intellectual Property Rights by Deborah E. Bouchoux., Delmar Cenage Learning. 2005
4. Biodiversity and Conservation by G. Melchias, Oxford & IBH Publishing Co. Pvt. Ltd., New Delhi, 2001
5. An Advanced textbook on Biodiversity: Principles and Practice by K.V. Krishnamurthy, Oxford & IBH Publishing Co. Pvt. Ltd., New Delhi, 2003.
6. The Indian Environmental Protection Act (EPA), 1986
7. Rules for manufacture, use/import/export and storage of hazardous microorganisms or cells Act, 1989
8. Food Safety and Standards act (Government of India), 2006
9. Intellectual Property Rights on Biotechnology by Singh, KC, BCIL, New Delhi

Semester VI

BIO-306 Biology-VIII (T) Interactive Biology Credits 4

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Unit I: Plant-Microbe Interaction
Basic concepts of plant pathology and phytobacteriology, mutualism, commensalism, parasitism, Plant microbe symbiotic interactions. Plant pathogen interactions**,** Bacterial plant diseases, their symptoms, and control, general concepts of plant immunity, Virulence determinants of plant pathogenic bacteria, plant immunity, application of plant-microbe interaction in genetic engineering.

Unit II: Animal- Microbe Interaction
Interaction of host and microbes process of recognition and entry in host cells by different pathogens, human microbiome and their symbiotic relation, rumen ectosymbiosis, Host parasite relationship, microbial diseases in animals, alteration of host cell behavior by pathogens.

Unit III: Human Immunity
Introduction to immune system, innate and acquired immunity, antibody, major histocompatibility complex, complement systems, T and B-cell maturation and differentiation, antigen processing and presentation, hypersensitive reaction and autoimmune disease.

Unit IV: Microbial Response to antimicrobial therapeutics
History of antimicrobial discovery, antibiotics used to control animal and plant pathogens, mode of action of antimicrobial molecules and response of pathogen, modulation of the host immune response, evolution of virulence and resistance of bacteria, virus and other pathogens.

Suggested Readings

1. Willey, J. Sherwood L, Woolverton C, (2016), Prescott Microbiology. 10th Edition, McGraw-Hill Publisher, Columbus, OH
2. Pelczar Mi J., Chan, E.C.S., Krieg, NR, (2009). Microbiology, McGraw-Hill publisher
3. Kuby, J. (2006) Immunology 6th Edition W.H. Freeman and Company, New York

BIO-307 Biology-IX (T) Introduction to Gene Technology Credits 4

Course Structure

Unit I: Cloning and Expression Vehicles
Enzymes in DNA manipulation, restriction digestion, ligation (adapters, linkers etc.) and transformation (chemical, physical and biological; transformation efficiency, competence), vectors & hosts of RDT: plasmid, phage, cosmid, phagemid, YAC, BAC, Ti plasmid vectors, cloning and expression, vector for bacterial, plant and animal systems.

Unit II: **Tools for Gene Technology**
Polymerase Chain Reaction: general concept, primer designing, PCR efficiency, various types (Gradient, Inverse, Multiplex, Reverse Transcriptase PCR, real time PCR), PCR product cloning, 5' and 3' RACE, molecular cloning of DNA or RNA fragment in bacterial and eukaryotic (plant & animal) systems.

Unit III: **Protein Expression in Bacteria, Animal and Plants**
Expression of recombinant proteins using bacterial, animal and plant vectors. Over expression of proteins in bacteria, plant and animal-general idea, basic idea of protein engineering, protein array & their applications.

Unit IV: Genetically Engineered Organism and Gene Therapy.
Strategies for gene transfer to plant cells, generation and significance of transgenic plants, production of transgenic mice, ES cells can be used for gene targeting in mice, transgenic animals, basic introduction to knocked down, knocked-out, gene editing and gene therapy.

Suggested Readings

1. Nelson DL, Cox MM (2017) Lehninger Principles of Biochemistry, 7th Edition. W. H. Freeman
2. Karp G. (2015) Cell and Molecular Biology: Concepts and Experiments.5th Edition. John Wiley Publication.
3. S. B. Primrose & R. M. Twyman (2007) Principles of Gene Manipulation and Genomics (Seventh Edition);. Blackwell Publishing.
4. Lewin B (2007) Genes IX , 9th Revised Edition, Jones and Bartlett Publishers
5. Christopler H. (1995) Gene cloning and Manipulating, Cambridge Universoty Press
6. Nicholl, D.S.T (1994) An Introduction of Genetic Engineering, Cambridge University Press.

BIO-308 **Biology-X (T) Trends in Biology** **Credits 4**

Course Structure

Unit I: Trends in Microbial Biotechnology
Microbial fermentation and production of small and macro molecules, Application of production of therapeutics, and diagnostics, Bioresource and uses of biodiversity, metagenome analysis, molecular approaches to microbial strain identifications

Unit II: Trends in Plant Biotechnology
Tissue culture methods for plants, transgenic plants, Omics methods and their application to agriculture, breeding in plants, Bioremediation and phytoremediation, Biosensors, basic of molecular marker- RFLP, AFLP, SNPs, SSCP, QTL analysis.

Unit III: Trends in Animal Biotechnology
Animal cell culture methods and its application, breeding in animals, transgenic knockdown and knockout animals, Omics approaches and its application to health and gene therapy, various methods of gene editing and changes like CRISPR-Cas technology, Cre-Lox technology etc.

Unit IV: Trends in Computational Biology
Introduction to genomics, proteomics, transcriptomics, DNA, RNA, protein and genome sequence databases, searching for sequence database, an introduction to computational modeling of biological systems

Suggested Readings

1. Freshney RJ, (2016) Culture of Animal Cells: A Manual of Basic Technique and Specialized Applications, Wiley Blackwell
2. Reinert J, Bajaj YS (2013) Applied and fundamental Aspects of Plant Cell, Tissue, and Organ Culture, Narosa Publishning House.
3. Xiong J (2006) Essential Bioinformatics, Cambridge University Press
4. Mount DW (2001) Bioinformatics: Sequence and Genome Analysis, University of Arizona, Tucson
5. Crueger W, Crueger A, (2000) A text of Industrial Microbiology, 2nd Edition, Panima Publishing Corp.
6. Stanbury PF, Ehitaker H, Hall SJ (1997) Principles of Fermentation Technology., Aditya Books (P) Ltd.

BIO-309 **Biology Practical-IV (P)** **Credits 3**

Course Structure
List of laboratory practical

1. Isolation of DNA and RNA from bacteria.
2. SDS Page for given protein sample.
3. Primer designing
4. Polymerase chain reaction.
5. Isolation of Plasmid.
6. Restriction digestion and ligation
7. Preparation of competent cell
8. Demonstration of antibiotic resistance in different microbes.
9. Downloading various sequences from GenBank in FAST format,
10. Demonstration of BLASTn, BLASTp and phylogentic tree preparation using MEGA software.

M.Sc. Biotechnology (2years) and Integrated M.Sc. VII to X semester - Revised Course Structure

(from academic session 2019- 20 onwards)

Semester I			
Course Code	**Course Name**	**Course Type**	**Credits**
BTY-401	Biomolecules and Enzymes	T	3
BTY-402	Cell Biology: Microbes, Plants and Animals	T	3
BTY-403	Molecular Biophysics and Structural Biology	T	3
BTY-404	Genetics and Molecular Genetics	T	3
BTY-405	Introduction to Computer Science and Data Analytics	T	3
BTY-406	**Elective I** A. Ecology and Evolutionary Biology B. Open elective of CURAJ	T	3
BTY-407	Basic Biochemistry Laboratory	L	3
BTY-408	Microbiology Laboratory	L	3
	Total credits		**24**
Semester II			
Course Code	**Course Name**	**Course Type**	**Credits**
BTY-409	Cell Metabolism: Microbial, Plant & Animals	T	3
BTY-410	Computational and Systems Biology	T	3
BTY-411	Scientific Ethics, Biosafety and IPR	T	3
BTY-412	Infection and Immunity	T	3
BTY-413	Analytical Techniques and Molecular Diagnostics	T	3
BTY-414	**Elective II** A. Nanobiotechnology B. Agriculture Biotechnology C. Open elective of CURAJ	T	3
BTY-415	Bioinformatics and Genome informatics Laboratory	L	3
BTY-416	Immunology & Cell Biology Laboratory	L	3
	Total credits		**24**
Semester III			
Course Code	**Course Name**	**Course Type**	**Credits**
BTY- 501	Fermentation & Bioprocess Technology	T	3
BTY-502	Genome Engineering and Synthetic Biology	T	3
BTY-503	Development Biology: Plant and Animal	T	3
BTY-504	Innovation and Entrepreneurship in Biotechnology	T	3
BTY-505	Project Design and Proof of Concept		3

BTY-506	**Elective III** A. Industrial Biotechnology B. Open elective of CURAJ	T	3
BTY-507	Animal and Plant Cell Culture Laboratory	L	3
BTY-508	Genetic Engineering Laboratory	L	3
	Total credits		**24**
Semester IV			
Course Code	**Course Name**	**Course Type**	**Credits**
BTY-509	**Elective IV** A. Molecular Basis of Drug Design B. Open elective of CURAJ	Tu/P	3
BTY-510	Journal Club Presentation	Tu	3
BTY-511	Major Project (Research Dissertation)	Tu/L	15
BTY-512	Research Dissertation Presentation	Tu/ P	3
	Total credits		**24**
	Grand Total Credits		**96**

T: Teaching Classes, **L:** Laboratory Classes, **Tu:** Tutorial Classes, **P:** Presentation

BTY – 401 Biomolecules and Enzymes Credits 3

Learning Objectives: To understand the chemistry of biomolecules and role of enzymes and enzymatic pathways using appropriate examples.

Prerequisites: Basic knowledge of chemistry/ biochemistry at Graduate level.

Learning Outcomes: Understanding the chemistry of biomolecules (Proteins, Lipids, Carbohydrates and Nucleic acids), enzymes and key metabolites/co-factors.

Syllabus:

Name of Topic	No. of Classes (45*)
UNIT I	
Properties of water; acid, bases and buffers	4
Carbohydrates: structure, function and classifications	5
Structure and function of glycoconjugates: proteoglycans, glycoproteins, and glycolipids	2
Structure and biological role of lipids, steroid and cholesterol	4
UNIT II	
Classification, structure and properties of amino acids,	4
Outline of biological functions of peptides and proteins	3
Structure, function and classification of nucleotides	3
Classification and biological role of vitamins	2
Coenzymes and cofactors	3
UNIT III	
General characteristics, nomenclature and classification of enzymes	2
Catalytic strategies and mechanisms of enzyme action	2
Regulation of enzyme action	2
Thermodynamics and kinetics of enzyme-catalyzed reactions	2
Ribozymes	2
Protein engineering strategies to improve enzyme stability	2
Enzyme immobilization and industrial application of enzymes	3

*The total classes includes 2 classes for internal assessment

Books recommended

- Biochemistry by Voet D., Voet J.G.; John Wiley and Sons.
- Lehninger Principles of Biochemistry by Nelson, D. C. and Cox, M.M.; W. H. Freeman.
- Fundamentals of Enzymology by Nicholas Price and Lewis Stevens; Oxford University Press.
- Enzyme Technology by Martin Chaplin and Christopher Bucke; Cambridge University Press. Enzymes, (Biochemistry, Biotechnology, Clinical Chemistry) by T Palmer and P L Bonner, Woodhead Publishing.
- Biocatalysts and Enzyme Technology by Klaus Buchholz, Volker Kasche, Uwe Theo Bornscheuer, Wiley-Blackwell.

BTY – 402 Cell Biology: Microbes, Plants and Animals Credits 3

Learning Objectives: To understand the cell (microbial, plant and animal) and its structural organization, cell division and cell cycle, different signaling mechanism and pathways operating within a cell, the concept of Stem cells, and technologies utilizing stem cells in medicines and therapeutics.

Prerequisites: Basic knowledge of biology at Graduate level

Learning Outcomes: Understanding about organization of all type of cells including stem cells and its uses in therapeutics.

Syllabus:

Name of Topic	No. of Classes (45*)
UNIT I	
Comparative Cell Architecture	3
Membrane structure and function	3
Structure and function of intracellular organelles and Nuclear sub compartments	4
Cytoskeleton and its dynamics	4
UNIT II	
Intra cellular transport of Biomolecules	4
Principle of Cell – cell communication (Animals, plants and microbes)	5
Cell singling in prokaryotes and eukaryotes	5
UNIT III	
Cell division	4
Cell Migration	2
Aging and cell death	4
Cancer and Stem cell biology	4

*The total classes includes 2 classes for internal assessment

Books recommended

- Cell Biology by Pollard, T. D., and Earnshaw, W. C.; Saunders.
- Cell and Molecular Biology, Concept and Experiment by Gerald K.; Wiley.
- Molecular Cell Biology by Lodish, H., Berk A., Kaiser C. A., Krieger M., Bretscher A., Ploegh H., and Scott M.P.;, Freeman, W. H. and Co.
- Molecular Biology of the Cell by Alberts B., Walter P., Johnson A., Lewis J., Morgan D., and Raff. M., Roberts K., Walter P.; Garland Publishing Inc.
- Principles of Stem Cell Biology and Cancer: Future Applications and Therapeutics (2015). Eds. Tarik Regad, Thomas J. Sayers , Robert C. Rees, Wiley & Sons.

BTY – 403 Molecular Biophysics and Structural Biology Credits 3

Learning Objectives: To understand key principles of biophysics towards evaluating structure and functions of proteins and nucleic acids.

Prerequisites: Organic Chemistry at graduate level

Learning Outcomes: Understanding biophysical aspects of molecular structure, functions, interactions and recognition.

Syllabus:

Name of Topic	No. of Classes (45*)
UNIT I	
Basic quantum mechanics	3
Forces determining bimolecular structures and interactions	6
Laws of thermodynamics	5
UNIT II	
Peptide bonds, Steric effect**;** Concept of dihedral angles, Ramachandran plot	4
Primary, secondary, tertiary and quaternary structure of proteins	8
Protein folding and protein-protein Interaction	3
UNIT III	
Structure of nucleotides	4
DNA structure and polymorphism	4
Structure of RNA	3
DNA-Protein interaction	3

*The total classes includes 2 classes for internal assessment

Books recommended

- Introduction to Protein structure by C. Branden, J. Tooze Second Edition (1999) Garland Publishing Inc.
- Biochemistry by L. Stryer (1999) WH Freeman and Co.
- Biophyscial chemistry Part I & III by Cantor and Schimmel (1980) WH Freeman & Company.
- Nucleic acid structure by S.Neidle (ed) (1987) VCH Publishing, Weinheim.
- The structure and action of proteins by Dickerson and Geis (1969) Benjamin/ Cummings Publishing.
- Computational Methods in Mol.Biol./.Now Comprehensive Biochemistry Vol.32. S.L.Seizberg, DB Searls, S.Kasif (1998) Elsevier.
- Bioinformatics: Databases and Algorithms by N. Gautham, (2006) Narosa Publications.
- Structural Bioinformatics by Bourne P.E. Ed Weissig, (2003) H. Wiley-Liss.
- Bioinformatics for dummies. Claverie Jean M. & Notredame C. (2007) H. Wiley-Liss.

BTY – 404 Genetics and Molecular Genetics Credits 3

Learning Objectives: To understand principles of classical and molecular genetics with emphasis on organization of genome and differential gene expression.

Prerequisites: One paper on general genetics at graduate level

Learning Outcomes: Understanding concepts of genetics and molecular genetics, gene regulation and genetic manipulations (Prokaryotes and Eukaryotes).

Syllabus:

Name of Topic	No. of Classes (45*)
UNIT I – Genetics	
Introduction to genetic principles	2
Linkage, Recombination and Sex Linked Inheritance	5
Chromosomal Aberrations	4
Basic concepts of population genetics	3
UNIT II – Genome Organization	
Structure and Organization of Genomes	4
Structural elements & their functions	5
Coding sequences of genomes & their characteristics	5
UNIT III – Genome functions and their regulation	
Major Genome Function	6
Differential Gene Expression & their regulation	6
DNA Damage and Repair Systems	3

*The total classes includes 2 classes for internal assessment

Books recommended

- Principles of Genetics: D. Peter Snustad and Michael J. Simmons (8th Edition).
- Molecular Biology of the Gene: Watson, Baker, Bell, Gann, Levine & Losick (7th Edition).
- iGenetics; A molecular Approach: Peter J. Russell (5th Edition).
- Molecular Genetics of Bacteria: Larry Snyder (4th Edition).
- Lewin's GENES: Benjamin Lewin (11th Edition).

BTY – 405 Introduction to Computer Science and Data Analytics Credits 3

Learning Objectives: To understand the key concepts of computer programming, modern statistical theory and Data analytics.

Prerequisites: Open to all

Learning Outcomes: Understanding of computer programming and descriptive statistical methods.

Syllabus:

Name of Topic	No. of Classes (45*)
UNIT I - Basics of Computer Science and Programming	
Basics of Computers	2
Programming language Python	2
Core elements of the program	3
Problem solving	3
Objects in Python, Debugging	3
Understanding Program Efficiency	2
UNIT II – Data Analysis	
Basic Statistical Concepts	2
Inference for Means	4
Inference for Categorical data	3
Modelling Relationships	3
Design and Analysis Techniques for Epidemiologic Studies	2
UNIT III – Programming	
R Basics: Functions, and Data Types	3
Vectors and Sorting	3
Indexing, Data Manipulation, and Plots	3
Programming Basics	5

*The total classes includes 2 classes for internal assessment

Books recommended

- Statistics at the Bench: A Step-by-Step Handbook for Biologists by Martina Bremer and Rebecca W. Doerge; Cold Spring Harbor Laboratory Press.
- Developing Bioinformatics Computer Skill by Cynthia Gibas and Per Jambeck; O'Reilly Publication.
- The Art of R Programming by Nornam Matloff; No Starch Press.
- Statistics for the Life Sciences, Global Edition (2016); by Myra L. Samuels and Jeffrey A. Witmer, Pearson.
- Python Programming for Biology Bioinformatics and Beyond.

BTY – 406 Elective I

A. Ecology and Evolutionary Biology Credits 3

Learning Objectives: To understand ecosystems and origin of life.

Prerequisites: Open to all

Learning Outcomes: Understanding the complex interaction between different organisms and the environment.

Syllabus:

Name of Topic	No. of Classes (45*)
UNIT I	
Introduction to Ecology	2
Environment	3
Habitat and niche	3
Population ecology	4
Concept of metapopulation	2
UNIT II	
Species interaction	4
Community ecology	3
Edges and ecotones	2
Ecological succession	3
Ecosystem	3
UNIT III	
Basic concepts of evolution	4
Origin of molecules and life	2
Evolution of prokaryotes	3
Evolution of eukaryotes	3
Multicellularity and development	2

*The total classes includes 2 classes for internal assessment

Books recommended

- Begon, M., Townsend, C. R., and Harper, J. L. Ecology from Individuals to Ecosystems. Wiley-Blackwell, USA. 2005.
- Chapman, J. L. and Reiss, M. J. Ecology: Principles and Applications. Cambridge University Press, UK, 1998.
- Kemp, M. J. Environmental Science. The McGraw-Hill Companies. 1997.
- Barton, N.H., Briggs, D.E.G., Eisen, J.A., Goldstein, D.B., Patel, N.H., Evolution. Cold Spring Harbor Laboratory Press, New York, 2007.

BTY – 407 Basic Biochemistry Laboratory Credits 3

Learning Objectives: To learn basic techniques to study biomolecules.

Prerequisites: Chemistry/ Biochemistry course at Graduate level

Learning Outcomes: Students will learn to study biomolecules both quantitatively and qualitatively.

Syllabus:

- Biochemical estimation of biomolecules using spectrophotometry:
  - Carbohydrate
  - Lipids
  - Nucleic acids
- Separation of amino acids and sugars by thin layer chromatography (TLC)
- Isolation, purification and characterization of proteins/ enzymes from germinated seeds
- Assessment of purity of a given protein using SDS-PAGE
- Determination of T_m & C_m of lysozyme using UV-Visible spectrophotometers
- Estimation of an unknown protein concentration using
  - Spectrophotometry
  - Lowry method
  - Bradford method
- Assessment of protein aggregation using light scattering
- Protein purification and separation by gel chromatography technique
- Demonstration of automated biochemical diagnostic tests (e.g., blood sugar, total serum proteins, C-reactive proteins, etc.)
- Assessment of enzyme activity and determination K_m and V_{max} of alpha amylase

Books recommended

- The Protein Protocol, by John M. Walker, Humana press.
- Proteins: Structures and Molecular Properties by Thomas E. Creighton, W. H. Freeman
- Protein Structure: A Practical Approach, by Thomas E. Creighton, Oxford University Press
- Spectrophotometry and Spectro fluorimetry: A Practical Approach, Editor-Michael G. Gore, Oxford University Press, USA.

BTY – 408 Microbiology Laboratory Credits 3

Learning Objectives: To understand the techniques and methods employed in microbiological manipulation in laboratory.

Prerequisites: Basic biology course at the Graduation level.

Learning Outcomes: The course will empower students to carry out manipulation of microorganism in research laboratories.

Syllabus:

- Sterilization, disinfection, safety in microbiology laboratory
- Preparation of media for growth of various microorganisms
- Identification and culturing of various microorganisms
- Staining and enumeration of microorganisms
- Growth curve, measure of bacterial population by turbidometry and studying the effect of temperature, pH, carbon and nitrogen sources
- Isolation of enzyme producing microorganisms
- UV mutagenesis and Isolation of drug resistant mutants, transposon mutagenesis; Bacterial conjugation.

SEMESTER II

BTY – 409 Cell Metabolism: Microbial, Plant & Animals Credits 3

Learning Objectives: To understand the diversity of metabolic pathways - the energy-yielding and energy requiring reactions and the metabolic regulation in different cells.

Prerequisites: Biology course at the Graduation level

Learning Outcomes: Understanding of different metabolic pathways and its regulation within different types of cell.

Syllabus:

Name of Topic	No. of Classes (45*)
UNIT I - Principles of metabolic control and control mechanisms	
Overview of metabolism	3
Anabolism and catabolism	2
Concepts of metabolic control	5
Control mechanisms	5
UNIT II – Regulation of core metabolism	
Carbohydrate metabolism	4
Lipid metabolism	3
Amino acid metabolism	3
Metabolism in plants	4
UNIT III – Integration and adaptation of metabolism	
Metabolic states and signals	4
Tissue cooperation	4
Adaptation of metabolism to physiological/ pathological situations	6

*The total classes includes 2 classes for internal assessment

Books recommended

- Cell Biology by Pollard, T. D., and Earnshaw, W. C.; Saunders.
- Cell and Molecular Biology, Concept and Experiment by Gerald K.; Wiley.
- Molecular Cell Biology by Lodish, H., Berk A., Kaiser C. A., Krieger M., Bretscher A., Ploegh H., and Scott M.P., Freeman, W. H. and Co.
- Molecular Biology of the Cell by Alberts B., Walter P., Johnson A., Lewis J., Morgan D., and Raff. M., Roberts K., Walter P.; Garland Publishing Inc.

BTY – 410 Computational and Systems Biology Credits 3

Learning Objectives: To understand the integration of data from multiple sources to generate novel findings.

Prerequisites: Basic Bioinformatics and Genetics knowledge at UG or PG level

Learning Outcomes: Understanding system based approaches in biological sciences and explore web-resources and tools that will help them in re-constructing and re-defining complex biological processes.

Syllabus:

Name of Topic	No. of Classes (45*)
UNIT I – Introduction to Computational and Systems Biology	
Introduction and history of Computational and Systems Biology	3
Omics Technologies (Genomics, Transcriptomics, Proteomics)	5
Regulatory Network and their role in Systems Biology	3
Quantitative Traits Analyses	2
UNIT II – Genomic Analyses	
Local and Global Sequence Analyses	2
DNA sequence: short sequence read assembly and annotation	3
Genome & metagenome assembly and annotation	4
RNA sequence analyses: Expression and Isoform characterization	3
Comparative Genomic (SNP Analyses, Genome Wide Associations)	3
UNIT III – Biological Function Modelling	
Markov and Hidden Markov Models of Genomic and Protein Features	4
Modeling Protein Structure, Functions	4
Modeling & Predicting Protein - Interaction	4
Modeling Cell Signaling Networks	3

*The total classes includes 2 classes for internal assessment

Books recommended

- Computational Systems Biology 1st Edition Inference and Modelling: Paola Lecca, Angela Re, Adaoha Ihekwaba, Ivan Mura, Thanh-Phuong Nguyen (2016). Woodhead Publishing.
- Fundamentals of Systems Biology: Markus W. Covert (2015) Taylor & Francis Publications.
- Synthetic Biology - A Primer (Revised Edition): Paul Simon Freemont Imperial College Press; Revised edition.
- Synthetic Biology: A Very Short Introduction: Jamie A. Davies: OUP Oxford (2018).

BTY – 411 Scientific Ethics, Biosafety and IPR Credits 3

Learning Objectives: To understand issues related to ethics, biosafety and IPR that emerges along with products, services and technologies using biological principles.

Prerequisites: Open to all

Learning Outcomes: Understanding about the issues related to ethics, biosafety and IPR that emerges along with products, services and technologies using biological principles.

Syllabus:

Name of Topic	No. of Classes (45*)
UNIT I - Scientific Ethics	
Importance of Scientific Ethics, Structure and Practice of Ethics Committees & Govt. Regulations	2
Scientific Ethics in Research Planning and Execution	4
Research Misconduct (Bias in research design, Unethical practices in data acquisition and data Management, Data Fabrication)	5
Research Publishing: plagiarism, credit, responsibility and funding	2
Research ethics and misconduct: Case studies	1
UNIT II - Laboratory Safety and Biological Safety	
Concepts of Laboratory Safety (Chemical, Physical Hazards and Fire Safety)	4
Occupational Health Safety	2
Concepts of Biological Safety (Biological Hazards, Biosafety Level Classification, Good Laboratory Practices for handling biological hazards)	5
Biological Safety Committee, Govt. Regulation and International Agreements on Biological Safety	4
UNIT III - Intellectual Property Rights	
Basic concepts of Intellectual Property Rights	2
Types of IP (Patents, Trade-marks, Copyrights, Industrial Designs, Traditional Knowledge & Geographical Locations with examples)	5
IP in Biotechnology and its relevance with Case studies	4
GATT, WTO, WIPO and TRIPS (History, present status & functions)	3

*The total classes includes 2 classes for internal assessment

Books recommended

- CRC Press – Handbook of Laboratory Safety.
- Biological Safety: Principles And Practices: Fleming amd1 Hunt
- Biosafety in Microbiological and Biomedical Laboratories: U.S. Department of Health and Human Services.
- Handbook on Recombinant DNA Safety Guidelines and Regulation and IBSCs: (2017) DBT, Govt. of India
- Class notes

BTY – 412 Infection and Immunity Credits 3

Learning Objectives: To understand the molecular and cellular basis of immune responses against pathogens.

Prerequisites: Basic biology course at Graduation level

Learning Outcomes: Understanding of pathogenesis against different pathogen and their interaction with the immune system.

Syllabus:

Name of Topic	No. of Classes (45*)
UNIT I	
Overview of the Immune System	1
Innate Immunity	2
The Complement system and MHC	4
T and B Cell Development	4
Soluble mediators	4
UNIT II	
Immune response in health - Allergens, types of hypersensitivity reactions	3
Immune reaction to infectious diseases	5
Vaccines	2
Autoimmunity	2
Cancer Immunology	2
UNIT III	
Pathogenesis of infectious disease	3
Aspects of Infection/host parasite interaction	4
Epidemiology of Infectious Disease	3
Tolerance, Autoimmunity and Transplantation	2
Chemotherapy and Immunotherapy	2

*The total classes includes 2 classes for internal assessment

Books recommended

- Janeway's Immuno Biology by Kenneth M. Murphy, Paul Travers and Mark Walport; Garland Science.
- Kuby Immunology by Kindt, T. J., Osborne, B. A. and Goldsby, R. A.; W. H. Freeman.
- Fundamental Immunology by Paul, W. E.; Lippincott Williams and Wilkins.
- Cellular and Molecular Immunology by Abbas, A. K., Lichtman, A. H. and Pillai, S.; Saunders.

BTY – 413 Analytical techniques and Molecular Diagnostics Credits 3

Learning Objectives: To understand the tools and techniques employed in biotechnological manipulations and molecular diagnostics.

Prerequisites: Open to all

Learning Outcomes: Understanding the tools and techniques employed in biotechnological manipulations and molecular diagnostics.

Syllabus:

Name of Topic	No. of Classes (45*)
UNIT I – Microscopy and Separation Techniques	
Optical Microscopy	3
Super Resolution Microscopy	1
Electron Microscopy	3
Chromatographic Techniques, Electrophoresis and Centrifugation	7
UNIT II – Biophysical Techniques	
Spectroscopy	3
Nuclear Magnetic Resonance (NMR)	2
Circular Dichroism (CD) and X-ray crystallography	2
Mass Spectroscopy	6
Surface Plasmon Resonance (SPR) and Differential Scanning Calorimetry (DSC)	2
UNIT III – Molecular Diagnosis	
Tools and Techniques in Molecular Diagnosis	1
ELISA and Western blotting	2
PCR and Real Time PCR	2
Flow cytometry	2
Immunohistochemistry and Hybridization	4
Sequencing methods	3

*The total classes includes 2 classes for internal assessment

Books recommended

- K. Wilson, J. M. Walker, Eds., Principles and techniques of biochemistry and molecular biology (Cambridge University Press, Cambridge, UK : New York.
- R. Katoch, Analytical techniques in biochemistry and molecular biology (Springer, New York, 2011).
- R. M. Silverstein, Spectrometric identification of organic compounds (John Wiley & Sons, Hoboken, NJ, 7th ed., 2005).
- D. Harvey, Modern analytical chemistry (McGraw-Hill, Boston, 2000).

Elective II

BTY – 414

A. Nanobiotechnology **Credits 3**

Learning Objectives: To understand the concepts of nanobiotechnology and its role in drug/ gene delivery systems.

Prerequisites: Open to all

Learning Outcomes: Understanding the concepts of nanobiotechnology and its role in drug/ gene delivery systems.

Syllabus:

Name of Topic	No. of Classes (45*)
UNIT I	
Principles of Nanobiotechnology	1
Introduction to Nanomaterials	3
Synthesis of Nanomaterials	4
Chemical transformation of Biomaterials	4
Self-assembling systems	2
UNIT II	
Protein and Peptide based Nanostructures	3
Concepts of Green synthesis of Nanomaterials	2
Biosynthesis of nanoparticles	5
DNA based Nanostructures	2
DNA-protein Nanostructures	2
UNIT III	
Nanomaterials for Therapeutics	2
Liposomes and Lipid based nanoparticles	2
Solid Lipid Nanoparticles (SLP), Nanotubes, Nanorods, Nanofibers, and Fullerenes for nanoscale drug delivery, Carbon nanotubes,	6
Biocompatibility and drug delivery	2
Toxicity of nanomaterials	2

*The total classes includes 2 classes for internal assessment

Books recommended

- C.M. Niemeyer and C.A. Mirkin, Nanobiotechnology, Concepts, Applications and perspectives, WILEY-VCH, Verlag Gmb H&Co, 2004.
- S. David Goodsell, Bionanotechnology, Lessons from Nature, Wiley-Liss, Inc, 2004
- C.M. Niemeyer and C.A. Mirkin, Nanobiotechnology - II more concepts and applications, WILEY-VCH, Verlag Gmb H&Co, 2007.
- Tuan Vo-Dinh, Nanotechnology in Biology and Medicine: Methods, Devices, and Applications, CRDC press 2007.

Elective II

BTY – 414

B. Agricultural Biotechnology **Credits 3**

Learning Objectives: To understand the biotechnological tools and technologies for crop improvement.

Prerequisites: Basic biology course at Graduation level

Learning Outcomes: Understanding biotechnological tools and technologies for crop improvement.

Syllabus:

Name of Topic	No. of Classes (45*)
UNIT I	
Plant nuclear genome organization	6
Organization of chloroplast genome	3
Organization of mitochondrial genome and male sterility	5
UNIT II	
Genetic transformation of plants	6
Vector mediated transformation	4
Direct gene transfer	2
Strategies for elimination of selectable genes in transgenic plants	2
UNIT III	
Genetic engineering of plants for biotic and abiotic stresses	8
Improvement of seed storage proteins and delayed fruit ripening by genetic engineering	3
Plants as bio-factories- Production of antibodies, pharmaceutical useful proteins in transgenic plants	4

*The total classes includes 2 classes for internal assessment

Books recommended

- Plant Molecular Biology by Grierson, C., and S.N. Covey; Blackie, London.
- Plant Biotechnology: The genetic manipulation of plants by Slater, A., N. Scott and M. Fowler; Oxford University Press.
- Biochemistry and Molecular Biology of Plants by Buchanan, B.B., W. Gruissen and R.L. Jones;. American Society of Plant Biologists. Rockville, USA.
- Plant Biotechnology by Hammond, J.H., P. Mcgarvey and V. Yusibov;. Springer Verlag, Heidelberg.
- Text Book of Biotechnology by Das, H.K.; Wiley India Pvt. Ltd., New Delhi.

BTY – 415 Bioinformatics and Genome Informatics Laboratory Credits 3

Learning Objectives: To impart practical training on computational and analytical methods to biological problems.

Prerequisites: Basic biotechnology course at Graduate or post graduate level

Learning Outcomes: Understanding of tools and techniques involved in computational and analytical methods to biological problems.

Syllabus:

- ➢ Database, file, sequence formats and its conversion
- ➢ Databases: NCBI, Uniprot and PDB
- ➢ Genome database browsing: Ensemble, TIGR and PlasmoDB, Genome Browser etc.
- ➢ Sequence annotation tools, for example: RAST, Expasy proteomics tools, EBI services, EMBOSS package
- ➢ Pair-wise and multiple sequence alignment: BLAST, FASTA, Needle, Water, CLUSTAL & Muscle etc.
- ➢ Gene Prediction: Genscan, Glimmer etc.
- ➢ Genome alignment tools: VISTA, Blat etc
- ➢ Phylogenetic analysis: Phylip, MEGA
- ➢ Protein Structure modeling & prediction and visualization: Modeller, I-TASSER, Pymol, Chimera etc.
- ➢ Modeling Protein – Protein interactions: Z-DOCK, CLUSPro, Fire-Dock
- ➢ Modeling Cell Signaling: Scansite, PhosphoSite Plus

BTY – 416 Immunology & Cell Biology Laboratory Credits 3

Learning objectives: To impart training in the area of immunology and cell biology.

Prerequisites: Basic knowledge of cell biology and immunology at Graduate or Post Graduate level

Learning Outcomes: Understanding and acquiring ability to perform cyto-immunological manipulations.

Syllabus:

- ➢ Double diffusion
- ➢ Radial-Immuno diffusion
- ➢ Immuno-electrophoresis
- ➢ ELISA: Dot ELISA, Sandwich ELISA, Competitive ELISA (Including DEMO)
- ➢ Isolation and purification of IgG from serum or IgY from chicken egg
- ➢ Immunohistochemistry
- ➢ Blood smear identification of leucocytes by Giemsa stain
- ➢ Separation of mononuclear cells by Ficoll-Hypaque
- ➢ Nucleus and cell organelles staining
- ➢ Chromosome preparations - mitotic and meiotic

SEMESTER III

BTY – 501 Fermentation and Bioprocess Technology Credits 3

Learning Objectives: To understand biological systems and processes for their industrial applications.

Prerequisites: Basic knowledge of microbiology at Graduate level

Learning Outcomes: Understanding the biological systems and processes relevant to the development of product(s) and service(s) for the betterment of the society.

Syllabus:

Name of Topic	No. of Classes (45*)
Unit 1- Fermentation Process	
Introduction to Fermentation processes, Fermentation modes	3
Kinetics of different modes of fermentations	6
Types and designs of stir tank bioreactors/ fermenters & Process control	3
Factors affecting the performance of fermentation process	2
Unit 2 - Bioprocess Development (Upstream)	
Isolation and characterization of industrially important bio-resource	3
Generation and characterization of mutant strain & recombinants for fermentation.	5
Advance approaches for strain improvement for fermentation	3
Optimization of physiological parameters & media for fermentation	3
Unit 3 - Bioprocess Development (Downstream)	
Recovery and purification of fermentation product	6
Phase extraction of small molecule fermentation products	3
Fermentation production drying, polishing and storage	3
Treatment and Disposal of the Waste generated during fermentation	3

*The total classes includes 2 classes for internal assessment

Books recommended

- Principles of Fermentation Technology: Stansbury & Whitaker
- Bioprocess Engineering Principles: Paulin M. Doran
- Fermentation Microbiology and Biotechnology: El- Mansi and Bryce
- Fermentation: A practical Approach: McNeil and Harvey
- Principles and Technology of Fermentation Engineering: Jian and Cheng

BTY – 502 Genome Engineering and Synthetic Biology Credits 3

Learning Objectives: To understand tools and techniques of genetic engineering and their applications in gene and genome engineering to develop products and services for the betterment of society.

Prerequisites: Basic course in biotechnology at Graduate level

Learning Outcomes: Understanding the techniques used in genetic engineering and their applications in gene and genome engineering.

Syllabus:

Name of Topic	No. of Classes (45*)
UNIT I - Basic Principles of Recombinant DNA technology	
Cloning Vectors and Methodology	4
DNA modifying enzymes	3
DNA polymerases	3
PCR based technology	4
UNIT II	
Advance tools for gene and genome engineering	3
Concept of minimal cell	3
Gene silencing: technology	3
Genome engineering	6
UNIT III	
Applications of gene and genome engineering	3
Metabolic pathway engineering in Microorganisms	4
Gene circuit engineering in Plants and Animals	5
Synthetic morphogenesis	2

*The total classes includes 2 classes for internal assessment

Books recommended

- T.A. Brown, Gene Cloning and DNA Analysis: An Introduction. Fifth Edition, Wiley-Blackwell, 2006.
- S.B. Primrose, R.M. Twyman and R.W.Old; Principles of Gene Manipulation. 6th Edition, S.B.University Press, 2011.
- J. Sambrook and D.W. Russel; Molecular Cloning: A Laboratory Manual, Vols 1-3, CSHL, 2001.
- Desmond S. T. Nicholl, An introduction to genetic engineering, Cambridge University Press, 2002.
- Synthetic Biology: Tools for Engineering Biological Systems (2017); Edited by Daniel G. Gibson, J. Craig Venter et al. Cpld Spring Harbor Laboratory Press.
- Genome Editing and Engineering: From TALENs, ZFNs and CRISPRs to Molecular Surgery (2018); Cambridge University Press.

BTY – 503 Development Biology: Plant and Animal Credits 3

Learning Objectives: To understand the molecular basis of embryonic development and cellular differentiation in living systems.

Prerequisites: Basic biology course at Graduate level

Learning Outcomes: Understanding concepts of embryonic development and cellular differentiation in animal and plants.

Syllabus:

Name of Topic	No. of Classes (45*)
UNIT I	
Basic concepts of Development	3
Gametogenesis, Fertilization	3
Early Development: Cleavage, Gastrulation and Axis Development	6
Building with Ectoderm	3
UNIT II	
Building with Mesoderm	6
Building with Endoderm	5
Development in Health and Diseases	3
UNIT III	
Molecular basis of Seed Germination, Embryo and flower development in plants	5
Concept of Totipotency and in vitro plant regeneration	4
Role of Growth regulators and Light during cyto-differentiation in vivo and in vitro	5

*The total classes includes 2 classes for internal assessment

Books recommended

- Developmental Biology 11th edition by Scott F. Gilbert; Sinauer.
- Molecular Genetics of Plant Development (1998); Howell, S.H. Cambridge University Press.

BTY – 504 Innovation and Entrepreneurship in Biotechnology Credits 3

Learning Objectives: To understand the processes of value addition to develop novel products, services and their possible commercialization.

Prerequisites: Open to all

Learning Outcomes: Understanding innovations and entrepreneurship in biotechnology.

Syllabus:

Name of Topic	No. of Classes (45*)
UNIT I	
Integration of Science, technology and business	3
Basic principles and practices of management- Definition, concepts and application; Organization types, coordination, control and decision making in management	4
Entrepreneurship in the biotechnology context; Case studies of successful and unsuccessful bio-entrepreneurs	4
Biotechnology: emerging industries with examples from Transgenics, Environmental biotechnology, New drug development, DNA chip technology, Stem cell research, Tissue engineering. Contract Research Organization, marketing consultancy, bio-learning module etc.	4
UNIT II	
Factors affecting biotech business: (finance, infrastructure, equipment, manpower , resources , project location, end product, quality issues, etc)	6
Core concept of Market: Identification and evaluation of market potential of various bio-entrepreneur sectors. Marketing, Marketing research- concept and techniques	5
Role of Indian government and schemes, financial institutions in fostering bio- entrepreneurship	4
UNIT III	
Personality and attitude, Organizational behavior, Leadership	3
Principles of effective communication Body language, public speaking, presentations, business proposal writing.	3
Communication aid and application of technology	3
Career Opportunities in the Life Sciences Industry	3
Public policy, regulatory and ethical challenges facing the entrepreneurial biotechnology firm	3

*The total classes includes 2 classes for internal assessment

Books recommended

- Biotechnology Entrepreneurship: Starting, Managing, and Leading Biotech Companies (2014); Craig Shimasaki, ed. Elsevier Inc.
- Innovation and Entrepreneurship in Biotechnology, An International Perspective Concepts, Theories and Cases (2006); Damian Hine and John Kapeleris Edward Elgar Publishing Limited
- Information for startups from Indian Govt website, BIRAC website.

BTY – 505 Project Design and Proof of Concept Credits 3

Learning Objectives: To understand the process of identifying a biological question, hypothesis generation, and devising strategies to answer it.

Prerequisites: Basic biology course at Graduate level

Learning Outcomes: Understanding the gaps in the existing literature and formulating approaches to address the issues.

BTY – 506 Elective III

A. Industrial Biotechnology Credits 3

Learning Objectives: To understand biological systems and processes for their industrial applications.

Prerequisites: Basic knowledge of microbiology at Graduate level

Learning Outcomes: Understanding the biological systems and processes relevant to the development of product(s) and service(s) for the betterment of the society.

Syllabus:

Name of Topic	No. of Classes (45*)
UNIT I - Introduction to Industrial bioprocess	
Introduction to Industrial Bioprocess & Lab Design	4
Bioprocess control	4
Bioprocess classification – Upstream, Downstream & Fermentation	4
Bioprocess hypothesis generation and pilot scale testing	3
UNIT II - Industrial Processes Bio products	
Process development and optimization	4
Assessment of product formation efficiency – Mass Balance	4
Bioprocess - product recovery & polishing	3
Quality assessment and storage of recovered products	2
UNIT III - Environmental & Economic aspects	
Waste generation and management in industrial bioprocess	4
Economics of industrial bioprocesses (Global & Local Markets)	4
Product value assessment and competence improvement	4
Cost cutting strategies in Industrial Bioprocess	3

*The total classes includes 2 classes for internal assessment

Books recommended

- Industrial Biotechnology: Products and Processes: Editor(s): Christoph Wittmann James C. Liao (2016 Edition).
- Industrial Biotechnology (Volumes 1 & 2): Watson K. CBS Publication; 1 edition (2005).
- Industrial Biotechnology: Benvenuto Mark Anthony.
- Cruegers Biotechnology: A Textbook of Industrial Microbiology: Wulf Crueger.

BTY – 507 Animal and Plant Cell Culture Laboratory Credits 3

Learning Objectives: To provide practical training to work with animal and cell culture.

Prerequisites: Basic course in microbiology at Graduate level

Learning Outcomes: To facilitate students to acquire the necessary practical skills for the culture and maintenance of animals and plant cells for *in vitro* studies.

Syllabus:

Plant tissue culture techniques

- ➢ Isolation of Genomic DNA and total RNA from plant tissues
- ➢ Cloning of selected genes into plant expression vectors
- ➢ Plant Transformation techniques: Agrobacterium mediated, Gene gun method
- ➢ Southern blotting and hybridization
- ➢ Introduction to plant tissue culture techniques
- ➢ Surface sterilization: Chemical and Physical
- ➢ Media preparation; Role of additives in different explant culture
- ➢ Organogenesis and Somatic embryogenesis
- ➢ Best Management Practices of Green house

Animal Cell Culture Techniques

- ➢ Familiarization with animal cell culture laboratory and P1 to P4 facilities
- ➢ Sterilization techniques for animal cell culture laboratory
- ➢ Introduction to cell culture medium and the function of different components of the medium on cell growth
- ➢ Preparation of glassware and animal cell culture media
- ➢ Feeding and routine maintenance of animal cell culture
- ➢ Cell counting and viability
- ➢ Passaging of animal cell culture
- ➢ Cryopreservation of animal cells
- ➢ Revival of animal cells from cryopreserved cells
- ➢ Cell viability assays

Books recommended

- Cell culture and Somatic Cell Genetics of plants by Brown C. W and Thorpe T. A.; Academic Press Orlando
- Plant Tissue Culture by Chu, C.; Peking Science Press, Peking
- Plant Cell, Tissue culture and Organ culture Fundamental Methods by Gamborg O. L and Phillips. G.G.; Narosa Publishing House, New Delhi
- Plant Molecular Biology — A Laboratory Manual by Clark, Melody S. (Ed.); Springer Berlin.

BTY – 508 Genetic Engineering Laboratory Credits 3

Learning Objectives: To impart practical knowledge for manipulation of genomic DNA and other molecular biology techniques.

Prerequisites: Basic knowledge of cell biology/ molecular biology at UG or PG level

Learning Outcomes: Ability to handle DNA isolation, purification and other gene manipulation experiments independently.

Syllabus:

- Isolation of genomic DNA from bacteria
- Primer designing
- PCR amplification of a gene and it's analysis by agarose gel electrophoresis
- Isolation of plasmid DNA and restriction digestion for cloning
- *In vitro* DNA ligation and transformation of *E. coli*
- Characterization of transformants using blue white selection / restriction digestion analysis using gel electrophoresis
- Restriction map analysis
- Southern blot analysis
- Isolation of cytoplasmic total RNA
- Separation of mRNA using oligo dT column
- Electrophoresis of RNA on denaturing gel
- RT -PCR technique

SEMESTER IV

BTY – 509 Elective IV

Computer Aided Drug Design **Credits 3**

Learning Objectives: To understand the fundamental concepts of molecular modeling and computational-driven drug discovery.

Prerequisites: Biophysics and Structural biology course at UG of PG level

Learning Outcomes: Understanding the role of synthetic chemistry in the development of pharmaceutical agents; and the modification of chemical structures to develop new drug molecules.

Syllabus:

Name of Topic	No. of Classes (45*)
UNIT I	
Molecular modelling concept and methods	3
Force fields and molecular energy minimization	3
Monte Carlo and molecular dynamics simulation	3
Molecular modelling challenges	3
Computer representations of molecules	2
UNIT II	
Chemical databases and 3D database search	3
Pharmacophore modeling and its application	3
Molecular similarity	2
Molecular Docking methods and docking based screening	3
Lead discovery and lead optimization	2
combinatorial library	2
UNIT III	
Identification of drug targets	2
Quantitative Structure Activity Relationship (QSAR)	3
Pharmacokinetics and pharmacogenomics	2
Chemoinformatics and chemogenomics	2
Metabolism of drug:, ADMET studies; Adverse drug reactions	3
Case studies of drug development	2

*The total classes includes 2 classes for internal assessment

Books recommended

- Drug Action at the Molecular Level by Robert GCK, ed.; University Park Press Baltimore.
- Drug Discovery and Development by William H, Malick JB; Humana Press Clifton.
- The Basis of Medicinal Chemistry, Burer's Medicinal Chemistry by Wolf ME, ed; John Wiley & Sons, New York.
- Drugs from discovery to approval by Rick, N.G.; Wiley-Blackwell, USA.
- Molecular Modelling: Principles and applications by Leach AR; Prentice Hall, Pearson Education Ltd.

BTY – 510 Journal Club Presentation Credits 3

Learning Objectives: To understand and gain an insight into current research and development in the field of biotechnology and critically analyze the ongoing research and present it.

Prerequisites: Basic biology course at Graduate level

Learning Outcomes: Understanding the ongoing and upcoming research in biotechnology and improvement of presentation skills.

BTY – 511 Major Project (Research Dissertation) Credits 15

Learning Objectives: To understand the process of recognizing a biological question, generating and validating a hypothesis by performing experiments in the laboratory.

Prerequisites: Basic biology course at Graduate level

Learning Outcomes: Understanding the gaps in the existing literature, formulating a hypothesis and testing it in laboratory by experimentation.

BTY – 512 Research Dissertation Presentation Credits 3

Learning Objectives: To understand the rationale of the project work, present the methodology used and the results obtained and to be able to defend their work.

Prerequisites: Basic biology course at Graduate level

Learning Outcomes: Understanding the background of the research work, present and defend their project and improvement of presentation skills.