COURSES OF STUDY

M.Sc. in BOTANY

(Effective from the session 2020- 2021)

Under Choice Based Credit System (CBCS)

BERHAMPUR UNIVERSITY
BHANJA BIHAR
BERHAMPUR – 760 007 (GANJAM)
ODISHA
2020

A brief profile of the Department

The department of Botany was established in the 1969 and founded by late Prof. Harihar Patanaik, a renowned algologist. Since its inception the department has grown appreciably, not only in terms of students and faculty strength but also in terms of the introduction of new courses, specializations and broadening research activities. The department is funded by the Government agencies in form of research grants from CSIR, UGC, DBT, DAE, MoEF and CC, Government of India, OFSD, S & T Department, Government of Odisha. Till date 25 research projects have been completed by the faculties of the department and presently 6 major research projects are ongoing by the present faculties. Weekly seminars are one of the important departmental activities, where students, research scholars and faculty members sit together and discuss on different topics along with the annual study tours and field trips. Students are being provided with free access to computer and internet facilities, study materials and text books through department/seminar libraries. Departmental common Instrumentation facility is well equipped with modern Instruments and 5 specialized laboratories (Algal Biotechnology, Microbiology, Biochemistry, Molecular biology, Computational Biology and Bioinformatics) are being used by the students for their experiments during routine practical classes.

Many students passed out from the department have qualified in the joint NET conducted by UGC-CSIR during 1997-2020. Students presently working in various ongoing research projects under different faculty members as Research Scholars/Associates in the Department are availing fellowships directly from UGC/CSIR/DST/MoEF& CC. Some of our students are pursuing their Ph.D. in National Laboratories (NIT-Rourkela; CCMB, Hyderabad; BARC, Mumbai; BSI, Kolkata; NBRI and CDRI, Lucknow; IARI, ICGEB, New Delhi). Some of them have also taken up positions as scientists and faculties in prestigious institutions like IIT, Mandi; BARC, Mumbai; ILS, Bhubaneswar; NBRI, Lucknow; BSI, Kolkata; AIS, Pune; Viswa Bharati, Shantiniketan; Central University, Jharkhand; DST, New Delhi and Reliance Industries Limited, Mumbai etc.. Our alumnies are placed in best private sectors or universities of USA e.g. Celgene, San Diego; Ohio State University, Columbus; Stanford University, Stanford etc. A few have entered into Indian Forest Service, Banking, State Administration, Education and Economics service in Odisha or outside the state. Many of them have joined as Lecturers/ Assistant Professors in Govt. colleges of Odisha and in other states.

Course Outcome: M.Sc. in Botany

M.Sc. in Botany is a two years regular course, offered by PG department of Botany, Berhampur University. The present syllabus covers different components of theoretical and practical, as well as project work, field study and seminar presentations, which will help the students to get in depth knowledge on advanced Botany. During and after the completion of this course, students are expected to have an overall knowledge on Microbiology, different lower (Cryptogams) and higher plants (Phanerogams), their anatomy, physiology,

biochemistry, biostatistics, reproductive biology, genetics, evolutionary history and Paleobotany etc. The students can learn about the origin and history of different cultivated plants, their economic importance, utilization and conservation of natural resources, different renewable and nonrenewable energy sources. The course curriculum is designed to introduce the students about sensory biology and stress physiology along with the hands on training on the theory and practical aspects of different instruments along with microbial and plant tissue culture. The course also encompasses the basic knowledge on Ecology, Environment and environmental pollutions. After completion of this course, students are expected to have practical knowledge on how to handle and operate basic instruments for their experimental purposes. They might have basic idea on experimental designing, project handling and writing their project reports, which may be beneficial for them in future and improve their capability to write notes and research articles for different scientific journals. The degree of M.Sc. Botany may open their path into academia/research career at national and international level as a scientist, as a teaching faculty or as a scholar or into different administrative positions.

Course curriculum

The Post-Graduate (M.Sc.) curricula in Botany is of two-year duration in choice based credit system (CBCS) with total of 80 Credit and 2000 marks. The system of examination is of semester pattern. There will be four semesters each consisting of five papers with 4 credit and 100 marks each. In first and second semester there will be 4 core papers including 4 theory papers and 1 practical. In third semester there will be four core papers and one Seminar & Field Study/ Industrial Visit/Scientific Visit paper. Students have to present a subject relevant topic as seminar presentation in the department and submit a Field Study/ Industrial Visit/Scientific Visit report, which will be evaluated by an external and faculty members of the department. Presentation of Seminar, carries 50 marks and Field Study/ Industrial Visit/Scientific Visit paper, carries 50 marks. In fourth semester there will be three core papers and a dissertation/project work. The three core papers include 2 core theory papers and 1 practical paper. For dissertation/project work, each student is required to work on a particular problem related to Botany/Biosciences with one of the faculty members of the Post Graduate department of Botany or from any reputed Universities/Institutes/Organizations to submit a thesis/dissertation with power point presentation, which carries 200 (150+50) marks (8 credits) to fulfill the Master's degree. For all the theory papers 20 marks is for internal evaluation and 80 marks is for end term examination.

Core Research Areas

The faculty members of the department work on all current topics in Botany, ranging from Phycology, Microbiology, Ecology, Bioinformatics & Computational Biology, Molecular Biology, Biochemistry, etc.

Course Name: Botany
Semester: I/II/III/IV; Credit: 80; Core/Elective: Core 17**;** Elective: 02

Course Structure M. Sc. Botany							
Sem.	**Course No.**	**Paper Name**	**Credit**	**Type (Core/ Elective)**	**Mid Term (Marks)**	**End term (Marks)**	**Total (Marks)**
I	BOTA C101	Microbiology	4	Core	20	80	100
	BOTA C102	Lower Plant Diversity and Paleobotany	4	Core	20	80	100
	BOTA C103	Cell Biology and Evolution	4	Core	20	80	100
	BOTA E104	Ecology and Environment	4	Elective	20	80	100
	BOTA P105	Practical	4	Core	-		100
II	BOTA C201	Genetics and Molecular Genetics	4	Core	20	80	100
	BOTA C202	Plant Physiology and Metabolism	4	Core	20	80	100
	BOTA C203	Biochemistry and Immunology	4	Core	20	80	100
	BOTA C204	Natural Resources, Conservation and Utilization	4	Core	20	80	100
	BOTA P205	Practical	4	Core	-	-	100
III	BOTA C301	Systematics of Angiosperms	4	Core	20	80	100
	BOTA C302	Plant Embryology and Anatomy	4	Core	20	80	100
	BOTA E303	Bioinstrumentation, Bioinformatics and Biostatistics	4	Elective	20	80	100
	BOTA P304	Practical	4	Core			100
	BOTA C305	Seminar presentation and Field Study/ Industrial Visit/Scientific Visit	4	Core	-	-	100 (50+50)
IV	BOTA C401	Microbial and Molecular Techniques	4	Core	20	80	100
	BOTA C402	Plant Biotechnology and Tissue Culture	4	Core	20	80	100
	BOTA P403	Practical	4	Core	-	-	100
	BOTA D404	Dissertation (Project Work)	8	Core			200 (150+ 50)
			Total Credit: 80				**Total Marks: 2000**

Elective papers to be opted by students from Botany department as well as from other departments.

DETAILS OF SYLLABUS

SEMESTER: I

Semester: I Course No: BOTA C101
Course Name: Microbiology

Credits: 4 **Core/Elective: Core**

Course details

Chapter	Contents	Hours
Unit- I	**History and development of Microbiology;** Microbial evolution; classification of microorganisms: five kingdom classification, three domain classification; modern approaches in microbial taxonomy, ribotyping, ribosomal RNA sequencing; Bergy's manual of bacterial classification. **Bacteria and Archaea:** cell structure; nutrition; reproduction; Bacterial genetics: conjugation, transduction and transformation, sex-duction, mapping genes by interrupted mating; plasmid; episome; Mutation and mutagenesis in bacteria, microbial growth & methods of microbial growth measurements; bacterial toxin; role of bacteria and archaea in human health, medicine, agriculture and industry.	**12**
Unit- II	**Cyanobacteria:** Classification, cell structure, nutrition, reproduction, cellular differentiation, akinetes and its function, heterocyst and its function, cyanotoxin; role of cyanobacteria in human health, medicine, agriculture, bioenergy and industry. General characteristics of prochlorophyceae, Evolutionary significance of *Prochloron*. General features and pathogenicity of Mycoplasma, Rickettsia and Spirochetes.	**12**
Unit- III	**Virus:** General properties; structure, purification, cultivation, principle of viral taxonomy, classification, one step growth experiment, virus-vector relationship, Phage and its life cycle, RNA phages, DNA viruses, RNA viruses; viriods and prions; structure, transmission, pathogenicity and replication of plant virus (TMV) and animal viruses (HIV); Economic importance of virus	**12**
Unit- IV	**Phytopathology:** Plant disease symptoms, modes of infection and dissemination; altered metabolism of plants under biotic and abiotic stresses; host-parasite relationship, molecular mechanism of pathogenesis, recognition phenomenon, penetration and invasion. Primary disease determinant; enzymes and toxins in relation to plant diseases; mechanism of resistance; phytoalexins, PR proteins, antiviral proteins, SAR, HR and active oxygen radicals.	**12**
Total		**48**

Referred Text books:

1. Microbiology by Prescott, L. M., Harley, J. P. and Klen, D. A, Tata McGraw-Hill, New York.
2. Microbiology by Pelczar, Jr., M. J., Chan E.C.S. and Krieg, N. R, Tata McGraw-Hill, New Delhi.
3. General Microbiology by Stanier, R.Y., Ingraham, J.L., Wheelis, M.L., and Painter, P.R. The McMillan Press Ltd.
4. Brook Biology of Microorganisms by Madigan, M.T., Martinko, J.M. and Parker, J. Prentice-Hall.
5. Microbial Genetics by Maloy, S.R., Cronan, J.E.Jr., and Friefelder, D. Jones and Bartlett Publishers.
6. Phycology by R.E. Lee, Cambridge University Press (for Cyanobacteria)

7. Plant Pathology by Mehrotra, R. S. and Aggarwal, A., Mc Graw Hill Education.

Semester: I Course No: BOTA C102

Course Name: Lower Plant diversity and Paleobotany

Credits: 4 Core/Elective: Core

Course details

Chapter	Contents	Hours
Unit- I	**Algae:** Distribution (terrestrial, freshwater, marine); thallus organization; cell structure; criteria for classification of algae; pigments, reserve food, flagella, reproduction (vegetative, asexual, sexual). Salient features of Glaucophyta, Rhodophyta, Euglenophyta, Phaeophyta Bacillariophyta, Xanthophyta, Chlorophyta and Charophyta; algal blooms and toxins; economic importance of algae; algae as biofertilizer, food, feed and uses in industry	**12**
Unit- II	**Fungi:** General characters of fungi; recent trends in classification; phylogeny of fungi; cell ultra-structure, unicellular and multicellular organization; substrate relationship in fungi; nutrition (saprobic, biotrophic, symbiotic); reproduction (vegetative, asexual, sexual); heterothallism; heterokaryosis; parasexuality; general account of Mastigomycotina, Zygomycotina, Ascomycotina, Basidiomycotina, Deuteromycotina; fungal toxins, Mycorrhizae, Economic importance of Fungi i.e. medicine, food, industry, and disease Lichen: General account of lichen; classification, distribution, reproduction. Economic Importance.	**12**
Unit- III	**Bryophyta:** Classification; theories of origin (algal and pteridophytean), Phylogenetic relationships among Bryophytes; distribution, morphology, structure, reproduction and life history; general account of Marchantiales, Jungermaniales, Anthocerotales, Sphagnales, Funariales and Polytrichales; Ecological importance; Evolution of gametophytes and sporophytes in bryophytes. **Pteridophyta**: Morphology, anatomy and reproduction; classification; evolution of stele; heterospory and origin of seed habit. General account of Psilopsida, Lycopsida; Sphenopsida and Pteropsida.	**12**
Unit- IV	**Gymnosperms:** General characteristic features of Gymnosperms, Classification of Gymnosperms and their distribution in India. General account of Cycadales, Coniferales, Ephedrales, and Gnetales. **Paleobotany:** Geological time scale, origin and geological evidences; evolutionary time scale (eras, periods and epoch). Types of fossils, processes of fossilization, role of fossils in evolution. Brief account of fossil Pteridophytes and Gymnosperms. Cycadeoidales, Pentoxylales, Medullosales and Glosspteriodales.	**12**
Total		**48**

Referred Text books:

1. Phycology by R.E. Lee, Cambrige University Press
2. Algae by L.E. Graham and L. W. Wilcox Prentice Hall
3. Introductory Phycology by Kumar, H. D. (1988), East-West Press, New Delhi.
4. Bryophyta by B.R. Vasista, S. Chand Publication

5. Bryophyta by N. S, Parihar, Central Book Depot, Allahabad.
6. Gymnosperms by Bhatnagar, S. P. and Moitra, A., New Age International, New Delhi.
7. Biology and Morphology of Pteridophytes by Parihar, N. S., Central Book Depot, Allahabad.
8. Gymnosperms: Structure and Evolution by Chamberlin, C. J., Dover Publications, New York.
9. Introductory Mycology by Alexopoulus, C. J., Mims, C. W. and Blackwel, M., John Wiley, New York.
10. An Introduction to Mycology by Mehrotra, R. S. and Aneja, R. S., New Age International, New Delhi.

Semester: I Course No: BOTA C103

Course Name: Cell Biology and Evolution

Credits: 4 **Core/Elective: Core**

Course details

Chapter	Contents	Hours
Unit- I	**Structural organization of the plant cell and their function:** Structure and functions of cell wall, plasma membrane, ion carriers, channels and pumps, receptors, chloroplast, mitochondria, peroxisome, endoplasmic reticulum, ribosome, lysosome, vacuole, nuclear pore and nucleolus. Cell shape and motility: cytoskeleton organization, role of microtubules and microfilaments in flagella and other moments.	**12**
Unit- II	**Cell cycle:** Mitosis, meiosis, DNA synthesis in cell cycle, regulation of cell cycle: role of cyclins and cyclin-dependent kinases; cytokinesis and cell plate formation; cell surface receptors, G-protein coupled receptors, signal transduction pathways, secondary messengers, regulation of signaling pathways.	**12**
Unit- III	**Structure and organization of eukaryotic chromosomes:** Chromatin - heterochromatin and euchromatin, special types of chromosomes, chromosome morphology, karyotype, chromosome banding, sex chromosomes, sex determination in plants, dosage compensation, B-chromosomes, Chromosome organization, DNA packing, Nucleosome, Nuclear DNA content, C-value paradox, satellite-DNA, cot-curve, unique and repetitive DNA, Junk DNA and ENCODE project, *In situ* hybridization concept and techniques, FISH and GISH.	**12**
Unit- IV	**Evolution:** Theories and evidences of organic evolution, Lamarckism; Darwinism-concepts of variation, adaptation, struggle, fitness and natural selection. Neo-Darwinism, synthetic theory of evolution, genetic polymorphism, gene pool, gene frequency; Hardy-Weinberg Law, Isolating mechanisms- speciation, Convergent evolution, Co-evolution, Origin of new genes and proteins; molecular evolution, epigenetics and adaptive evolution.	**12**
Total		**48**

Referred Text books:

1. Cell Biology by De-Robertis Saunders, Singapore.
2. Reproduction in eukaryotic cells, Prescott DM, Academic Press.
3. Developmental Biology, Gilbert SF, Sinauer Assoc. Inc.
4. Cell in Development and Inheritance, Wilson EB, McMillan, New York.
5. Molecular Biology of Cells, Alberts B et al.
6. Molecular Cell Biology, Lodisch et al.

7. Molecular Biology of steroid and Nuclear Hormone Receptor, Freedman LP, Birkhauser, Basel.
8. Buchanan, B. B., Grissem, W. and Jones, R. L. J., (2000). Biochemistry and molecular biology of plants. American Society of plant physiologists, Rockville, USA
9. The Cell: A molecular approach by Cooper G. M., ASM Press, Washington, D. C., USA.
10. Essentials of Molecular Biology by Malacinski, G. M and Feidfelder, D Ed. Jones and Bartel, London.
11. Gene IX or X by Lewine, B. Person-Prentice Hall, London.

Semester: I Course No: BOTA E104

Course Name: Ecology and Environment

Credits: 4 Core/Elective: Elective

Course details

Chapter	Contents	Hours
Unit- I	**Ecosystem organization & function:** Biotic and abiotic components, trophic level, food chain, food web, Aquatic ecosystems, Marine ecosystems, Wetland ecosystems, Grassland ecosystems, Forest ecosystems. Ecological adaptations: morphological and anatomical adaptations. Energy flow in the ecosystem, primary production (methods of measurement), decomposition, energy dynamics (trophic organization, energy flow pathways, ecological efficiencies, concept of energy subsidy, universal energy flow, cybernetics, Ecological pyramids, The Gaia hypothesis, Biogeochemical cycles (Hydrological cycles, gaseous cycles, sedimentary cycles).	**14**
Unit- II	**Population ecology:** Population interactions (population density, natality, mortality, population age structure, carrying capacity, Community ecology: Ecological communities and ecosystems, structural analysis of communities, inter- and intra-specific competitions, Mutualism and commensalism, predation, parasitism, amensalism, competition and coexistence, Habitat and ecological niche.	**12**
Unit- III	**Ecological regulation:** System studies, Chemical transformations, Biochemical transformations, ecological succession, Mechanism of ecological succession and characters of succession, Process of succession, climax concept, Hydrosere, xerosere, ecological biodiversity.	**10**
Unit- IV	**Environmental Pollution:** Concept of pollution, air pollution, water pollution, terrestrial/soil pollution, noise pollution, and radiation pollution. Source of pollutants: natural and anthropogenic pollutants; Global warming and climate change; Greenhouse gases (GHG), Ozone layer depletion, consequences of climate change: smog, acid rain etc. Environmental Pollution and Legislative solution: Legal remedies against pollution, Environmental Protection Acts, water act, air act, environment act; Pollution Control Board; natural and men made disasters and disaster management; Environmental education and awareness, environmental audit, environmental management, environmental crisis, environmental ethics.	**14**
Total		**50**

Referred Text books:

1. Concepts of Ecology by Kormondy, E. J., Prentice-Hall India, New Delhi.
2. Fundamentals of Ecology by Odum, E. P. Saundas, Philadelphia, USA.
3. Ecology and Field Biology bySmith, R. L. Harper Collins, New York.
4. Subrahmanyam, N. S. and Sambamurty, A. V. S. S. (2000). Ecology. Narosa, New Delhi

Semester: I, Course No: BOTA P105

Course Name: Practical

Credits: 4 **Core/Elective: Core**

Course details

Chapter	Contents	Hours
Microbiology **Lower plant diversity** **Cell biology** **Ecology and Environment**	1. Laboratory Protocol, general rules and regulations for laboratory safety. 2. Bacterial staining (simple staining, negative staining, Gram staining and acid-fast staining, spore and capsule staining) 3. Microbial pure culture techniques (Streak plate methods, Pour plate methods); sub-culturing techniques. 4. Microscopic measurement of microorganisms (Micrometry). 5. Measurements cultural characteristics of microorganisms. 6. Measurement growth microorganism (microbial cells counting, CFU counting, spectrophometric/colorimetric analysis etc.) 7. Collection, microscopic identification cyanobacteria, micro and macro algae, preparation permanent slides of caynobacteria, microalgae. Preservation, and preparation of herbarium macroalgae. 8. Study of morphology and reproductive structures of fungi belonging to different classes through permanent microscopic preparations and preserved specimens. 9. Study of temporary & permanent preparation for microscope observation of external and internal features of vegetative and reproductive structure of important genera of Bryophytes. 10. Study of temporary and permanent preparation of vegetative and reproductive structure of Pteridophytes. 11. Study of temporary and permanent preparation of vegetative and reproductive structure of Gymnosperms and Fossils. 12. Squashing techniques for study of mitosis and meiosis in onion root tip and flower bud; Microscopic analysis of different stage cell division and microphotography. 13. Mitotic index of dividing cells of *Allium cepa* root tips. 14. Comparative karyotypic analysis of two species of a genus. 15. Estimation Dissolved oxygen (DO) water samples by Winkler's method 16. Physico-chemical analysis of water and soil (pH, chloride, phosphate, nitrogen. potassium) 17. Determination of primary productivity of water samples. 18. Determination of minimum size and number of quadrants required for reliable estimates of biomass in grassland 19. Determination of frequency, density of a species of a grassland community. 20. Calculation of Important Value Index (IVI) of grassland ecosystem.	**100**
Total		**100**

Referred books/manual/Monographs

1. Microbiology A Laboratory Manual by Cappuccion, J.G., and Sherman, N., Addison Wesley
2. Microbiological Applications (A Laboratory Manual in General Microbiology) by Benson, H.J., W.C.B., Wim C. Brown Publishers

3. Practical Botany, Vol. 2 by S.C. Santra, NCBA publication
4. Handbook of Microbial Technology by Yadav, A.K. and Mowade, S.M.
5. Methods in Plant ecology by S.B. Chapman, Wile and son publications
6. Algal cuture techniques by Andersen
7. Manuals of Phycology by Smith

SEMESTER: II

Semester: II, Course No: BOTA C201

Course Name: Genetics and Molecular Genetics

Credits: 4 **Core/Elective: Core**

Course details

Chapter	Contents	Hours
Unit- I	**Genetics:** Mendelism and deviation of Mendelian ratios, epistasis, linkage and crossing over, sex-linked inheritance, three point test cross and chromosome mapping, Extra chromosomal inheritance, mitochondrial and chloroplast genome.	**12**
Unit- II	**Cytogenetics:** Structural chromosome aberrations: duplication, deficiency, inversion and translocations heterozygotes; Numerical chromosome aberrations: aneuploids: trisomics and monosomics; euploids: autopolyploids, allopolyploids, segmental allopolyploid, role polyploidy in speciation with reference to *Triticum* and *Brassica*.	**12**
Unit- III	**Molecular genetics:** Prokaryotic and eukaryotic DNA replication: DNA polymerases, replisome, replicon, primase, telomerase. RNA transcription: mRNA, tRNA, rRNA, siRNA, miRNA, RNAi, RNA polymerases, RNA-processing, RNA splicing, spliceosome, RNA editing. Genetic code. Protein translation, inhibitors of replication, transcription and translation, post-translational modifications, protein targeting. Regulation of gene expression in prokaryotes and eukaryotes: role of chromatin in regulating gene expression and gene silencing. Fine structure of gene, cis-trans test.	**12**
Unit- IV	**Mutagenesis, DNA damage and repair:** Spontaneous and induced mutations, physical and chemical mutagens, molecular basis of mutations, transposable elements in prokaryotes and eukaryotes, mutations induced by transposons, site directed mutagenesis, DNA damage and repair mechanisms. Environmental mutagenesis and genetic toxicology	**12**
Total		**48**

Referred Text books:

1. Genetics: A Conceptual Approach by Pierce, B. A., W. H. Freeman, New York.
2. Principles of Genetics by Simmons, M.J., Snustad, D.P., Tamarin, R.H.
3. Molecular Biology of the Gene by J.D. Watson, N.H. Hopkins, J.W.Roberts, J.A. Steitz and A.M. Weiner, the Benjamin / Cummings Pub. Co. Inc., California.
4. Genomes by T.A. Brown.
5. Molecular Cell Biology by J. Darnell, H. Lodish and D. Baltimore, Scientific American Books Inc USA 1994.
6. Gene IX by Benjamin Lewin, Oxford University Press, U.K.
7. Molecular Biology of the Cell by B. Alberts, D. Bray, J. Lewis, M. Raff. K. Roberts, and J.D. Watson, Garland Publishing Inc., New York.
8. The Cell: A molecular approach by Cooper G. M., ASM Press, Washington, D. C., USA.

Semester: II, Course No: BOTA C202

Course Name: Plant Physiology and Metabolism

Credits: 4 **Core/Elective: Core**

Course details

Chapter	Contents	Hours
Unit- I	**Membrane transport and translocation of water and solutes:** Plant water relation, mechanism of water transport through xylem, phloem loading and uploading, passive and active solute transport, membrane transport proteins. **Photosynthesis:** Light harvesting complex, structure and chemistry, Photolysis of water and Hill Reaction, Photo-phosphorylation, CO_2-fixation, C_3 and C_4 and CAM pathways, photorespiration.	**12**
Unit- II	**Respiration:** Glycolysis, Fermentation, TCA cycle, pentose phosphate path ways, mitochondrial electron transport and ATP synthesis, alternate oxidase, Glyoxylate Cycle. **Lipid metabolism:** fatty acid biosynthesis, synthesis of membrane lipids, storage lipids and their catabolism.	**12**
Unit- III	**Nitrogen metabolism:** Biological nitrogen fixation, asymbiotic and symbiotic nitrogen fixation, nodule formation, nod and *nif* genes, their regulation and function, mechanism of nitrate uptake and reduction, ammonium transport and assimilation. **Sensory Biology:** Structure, function and mechanisms of action of phytochromes, cryptochromes and phototropins, stomatal physiology; **Phytohormones:** Plant growth regulators, structure and function, ethylene, abscisic acid, brassinosteroids, polyamines, jasmonic acid.	**12**
Unit- IV	**Stress Physiology:** Plant responses to biotic and abiotic stress, mechanisms of biotic and abiotic stress tolerance, water deficit and drought resistance, salinity stress, metal toxicity, freezing and heat stress, oxidative stress. Oxidative metabolism: reactive oxygen species (ROS), antioxidants, antioxidant enzymes: catalase, peroxidases, superoxide dismutase, glutathione transferase, glutathione reductase, *Halliwell–Asada cycle*. Physiology of aging and senescence, influence of hormones and environmental factors on senescence. Programmed cell death.	**12**
Total		**50**

Referred Text books:

1. Plant Physiology by Taiz & Zeiger, Sinauer Publications
2. Biochemistry and Molecular Biology of Plants by Buchachnanan, B. B., Grissem, W. and Jones, R. L. J., American Society of Plant Physiologists, Rockville, USA.
3. Plant Physiology by Devlin, R. N. and Witham, F. H., CBS Publishers, Delhi.
4. Plant Physiology by Salisbury, F. B. and Ross, C. W., Wordworth Publication California, USA

Semester: II, Course No: BOTA C203

Course Name: Biochemistry and Immunology

Credits: 4 **Core/Elective: Core**

Course details

Chapter	Contents	Hours
Unit- I	**Basics of Biochemistry:** Structure of atoms, molecules, chemical bonds, stabilizing interactions (Van der Waals, electrostatic, hydrogen bonding and hydrophobic interactions. Principle of biophysical chemistry and bioenergetics: pH, buffer, reaction kinetics, thermodynamics, colligative properties, couples reactions, group transfer, biological energy transfer.	**12**
Unit- II	**Biomolecules:** Composition, structure, and function of biomolecules (carbohydrates, lipids, proteins, nucleic acids and vitamins). Confirmation and stability of protein (Ramachandra plot, secondary, tertiary and quaternary structure; domains, motif, and fold). Confirmation and stability of nucleic acids (A-, B-, Z- DNA, RNA); phenols and terpenes.	**12**
Unit- III	**Plant enzymes and coenzymes:** Nomenclature and classification of enzymes and coenzymes: Distribution of enzymes in plant, structure and function of Isozymes. Enzyme kinetics, mechanism of enzyme action and its regulation. Factors affecting enzyme action. **Antioxidants**: Structure and functions of ascorbic acid, glutathione, tocopherol, carotenoids etc.	**12**
Unit- IV	**Immunology:** Innate and adaptive immune system Cells and molecules involved in innate and adaptive immunity, antigens, antigenicity and immunogenicity. B and T cell epitopes, structure and function of antibody molecules, generation of antibody diversity, monoclonal antibodies, antibody engineering, antigen-antibody interactions, MHC molecules, antigen processing and presentation, activation and differentiation of B and T cells, B and T cell receptors, humoral and cell-mediated immune responses, primary and secondary immune modulation, complement system.	**12**
Total		**48**

Referred Text books:

1. Lehninger Principle of Biochemistry by Nelson and Cox
2. Advanced Biochemistry by Voet and Voet
3. Principle of Biochemistry by Stryer
4. Biochemistry by Mathews, C. K., Van Holde, K. E. and Ahern, K. G., Addison-Wesley Publishing Company, San Francisco, USA.
5. Genes VH, B. Lewin, Oxford University Press.
6. Kuby Immunology, 4th edition, R.A. Goldsby, Thomas J. Kindt, Barbara A. Osborne (Freeman).
7. Immunology, A Short Course, 4th Edition, Eli Benjamin, RichardCoico, Geoffrey
8. Sunshine (Wiley-Liss).
9. Fundamentals of Immunology, William Paul.
10. Ivan Roitt: Roitt's Essentials of Immunology
11. Proteins – Structure and Molecular Properties, TE Creighton, WH Freeman and Company.
12. Introduction to Protein Structure, C. Branden and J. Tooze, Garland Publishing, New

Semester: II, Course No: BOTA C204

Course Name: Natural Resources and Utilization

Credits: 4 **Core/Elective: Core**

Course details

Chapter	Contents	Hours
Unit- I	**Introduction to Natural Resources**: Concept of natural resources, types and classification. Factors causing resource accessibility, statistical distribution and function. Ecological, social and economic dimension of resource management.	**12**
Unit- II	**Natural resources and management:** Conservation of natural resources, Non-renewable energy resources, Alternative sources of energy, new concepts for alternative energy. Renewable energy resources: Water resources, soil resources, Soil conservation and management. Water resources and conservation: rain water harvesting, water shed management, uses of water, Forest as a renewable resource, deforestation, afforestation, conservation, social forestry, wild-life conservation	**12**
Unit- III	**World centre of primary diversity of domesticated plants:** Basic concepts, origin of agriculture and plant introduction. Origin, evolution, botany, cultivation and uses of (i) Food crops, (ii) fibre crops, (iii) medicinal and aromatic plants, and (iv) vegetable and oil-yielding crops with special reference to local plants. Plants, plant parts and plant products used in homeopathy medicines, Plants, plant parts and plant products used in ayurvedic medicines, Important timber-yielding plants, Important poisonous plants of India. **Concept of phytogeography:** Climate and Vegetation pattern of the World; Endemism, Floristic regions of India; vegetational pattern of India.	**14**
Unit- IV	***In situ* conservation:** International efforts and Indian initiatives; protected areas in India – Sanctuaries, national parks, biosphere reserves, wetlands and mangroves for conservation of wild biodiversity. ***Ex situ* conservation:** Principles and practices; botanical gardens, field gene banks, seed banks, cryobanks, general account of the activities of Botanical Survey of India (BSI), National Bureau of Plant Genetic Resources (NBPGR). Principles of conservation; extinction; environmental status of plants based on IUCN (Now World Conservation Union). Salient features of Biodiversity Act and rules.	**12**
Total		**48**

Referred Text books:

1. An Advance Text book and Biodiversity: Principles and Practice by K.V. Krishnamurthy, Oxford & IBH publication, New Delhi.
2. Plants, Genes and Agriculture by Conway, G. and Barbier, E., Jones and Bartlett, Boston, USA.
3. Tropical Botanical Gardens Their role in Conservation and Development by Heywood, V. H. and Wyse Jackson, P. S., Academic press, San Diego, USA.
4. Understanding Biodiversity: Life sustainability and Equity by Kothari, A, Orient Longman, New York.
5. Biodiversity and its Conseravation in India by Negi, S. S. Indus Publishing Company, New Delhi.
6. Evolution of Crop Plants by Simmonds, N. W., Longman, New York.

Semester: II Course No: BOTA P205

Course Name: Practical

Credits: 4 **Core/Elective: Core**

Course details

Chapter	Contents	Hours
Plant Biochemistry and Physiology Immunology **Natural Resources and Utilization**	1. Determination of Transpiration and Absorption ratios. 2. Measurement of rate of photosynthesis 3. Preparation of Buffers. 4. Quantitative estimation of Protein (Lowry methods/Bradford Method), Sugars (Anthrone Methods), Lipids (Bligh and Dryer Method). 5. Quantitative estimation of Amino acids (Ninhydrine methods) 6. Spectrophotometric analysis of different enzymes (CAT, APX, GR, SOD) 7. Estimation of pigments (chlorophylls and carotenoids) from plant and algal materials. 8. Isolation of plant DNA and quantification of extracted DNA by spectrophotometric method. 9. ELISA for quantitative detection of plant pathogen 10. Immunodiagnostics (demonstration using commercial kits). 11. Preparation of a short list of ten most important sources of firewood and timber of the locality. Give their local names, scientific names and families to which they belong. Mention their characters. 12. Study of biodiversity and important flora of Odisha and India through field trips.	**100**
Total		**100**

Referred practical books/manuals

1. Biochemical Methods by Pingoud, Urbanke, Hoggett and Jeltsch, Willey-VCH
2. Experimental biochemistry bySwitze, R.L. and garrity, L.F., Freeman and Company, New York
3. Analytical Biochemistry and separation Techniques by Palanivelu, P
4. Biochemical calculations, by Segel
5. Phytochemicals Techniques by N. Raaman
6. Phytochemicals methods by Harborne, J.G, Springer

SEMESTER: III

Semester: III, Course No: BOTA C301

Course Name: Systematics of Angiosperms

Credits: 4 **Core/Elective: Core**

Course details

Chapter	Contents	Hours
Unit- I	**Taxonomic Structure:** Taxonomic hierarchy; Concept of species, genus and family, Plant Nomenclature: Salient features of International Code of Nomenclature (ICN) for Algae, Fungi and Plants: priority, effective and valid publications and author citation. Type concept, Taxonomic Tools**:** Field and Herbarium techniques; Floras and Botanic Gardens, Computer and Taxonomy.	**12**
Unit- II	**Systems of Angiosperm Classification:** Artificial, natural and phylogenetic systems, relative merits and demerits of major systems of classification (Bentham and Hooker, Engler and Prantle, Hutchinson and Takthajan). Angiosperm Phylogeny groups (APG)	**12**
Unit- III	**Angiosperm Families:** Floral structure and phylogenetic relationship among the taxa under the following orders: Liliflorales, Scitaminae, Orchidales, Ranales, Rosales, Tubiflorae, Malvales, Asterales and Rubiales.	**12**
Unit- IV	**Taxonomic Evidences:** Morphology, anatomy, palynology, embryology, cytology, phytochemistry and serology. Phylogenetic tree and Cladistics	**12**
Total		**48**

Referred Text books:

1. Principles of Angiosperms Taxonomy byDavis, P. H. and Heywood, V. H., Robert E. Kreiger, New york.
2. Current Concepts in Plant Taxonomy byHeywood, V. H. and Moore, D. M., Academic press, London.
3. Principles and Methods Plant Biosystematics by Solbrig, O. T., MacMillan, London.
4. Plant taxonomy and Biosystematics by Stace, C. A.,Edward Arnold, London.
5. Diversity and Classification of Flowering Plants by Takhtajan, A. L. Columbia University Press, NY.
6. Contemporary Plant Systematics by Woodland, D. W. Prentice-Hall, New Jersey, USA

Semester: III, Course No: BOTA C302

Course Name: Plant Embryology and Anatomy

Credits: 4 **Core/Elective: Core**

Course details

Chapter	Contents	Hours
Unit- I	**Male and female gametophyte:** Structure of anthers, microsporogenesis, role of tapetum, pollen development and gene expression; male sterility, sperm dimorphism and hybrid seed production, pollen germination, pollen tube growth and guidance, pollen storage, pollen allergy, pollen embryos. Female gametophyte**:** Ovule development, megasporogenesis; organization of the embryo sac, structure of the embryo sac cell.	**12**

Unit- II	**Pollination, Pollen-pistil interaction and fertilization:** Floral characteristics, pollination mechanisms and vectors, breeding system; commercial considerations, structure of the pistil, pollen stigma interactions, sporophytic and gametophytic self-incompatibility (cytological, biochemical and molecular aspects), double fertilization, *in vitro* fertilization.	**12**
Unit- III	**Seed development and fruit ripening:** Endosperm development during early, maturation and desiccation stages, embryogenesis, ultra-structure; cell lineages during late embryo development; storage proteins of endosperm and embryo; polyembryony, apomixis; embryo culture, dynamics of fruit growth and ripening; Latent life-dormancy; Importance and types of dormancy, seed dormancy, overcoming seed dormancy, bud dormancy.	**12**
Unit- IV	**Plant Anatomy:** Tissue and tissue system; Meristematic tissue, distribution of mechanical tissues, apical meristem, Anomalous secondary growth (adaptive and non-adaptive), Root-shoot transition, shoot-root development, leaf development and phyllotaxy, transition to flowering.	**12**
Total		**48**

Referred Text books:

1. Seed: physiology of Development and Germination by Bewley, J. D. and Black, M..Plenum, New York.
2. The Embryology of Angiosperms by Bhojwani, S. S. and Bhatnagar, S. P., Vikas Publishing House, New Delhi.
3. Molecular Embryology ofFlowering Plant by Raghavan, V. Cambridge University Press, Cambridge.
4. Developmental Biology of Flowering Plants by Raghavan, V., Springer-Verlag, New York.

Semester: III, Course No: BOTA E303

Course Name: Bioinstrumentation, Bioinformatics and Biostatistics
Credits: 4 **Core/Elective: Elective**

Course details

Chapter	Contents	Hours
Unit- I	**Principle and application of Microscope:** Light microscopy, Fluorescence microscopy, Electron Microscopy (TEM & SEM), Confocal Microscopy. **Principle and application of Radioisotope techniques**: Nature of radioactivity, isotopes in biochemistry, measurement of radioactivity (carbon dating, Geiger-Muller counting and liquid scintillation counting), Autoradiography.	**12**
Unit- II	**Principle and application of** pH electrode, Centrifugation techniques: Basic principles of sedimentation, Types of centrifuges, Types of rotors, Methods in preparatory ultracentrifugation (differential and density gradient centrifugation). Principle, Instrumentation and application of Ultraviolet-visible absorption spectroscopy: Fluorescence spectrophotometry: NMR and ESR spectroscopy Atomic absorption and plasma emission spectroscopy. Principles of biophysical methods used for analysis of biopolymer structure, X-ray diffraction.	**12**
Unit- III	**Bioinformatics:** Introduction to Bio-informatics and different tools, Introduction to data structures and database concepts, Biological sequence analysis, pair wise and multiple sequence alignment, Phylogenetic analysis of protein and genes, Homology modelling and Protein structure prediction. Molecular Docking, Molecular Dynamics simulation theory and applications.	**12**

Unit- IV	**Biostatistics:** Frequency distribution, cumulative and relative frequency. Measurement of central tendency and dispersion, mean, median and mode, mean deviations, variance and standard deviation, coefficient of variation, errors. Analysis of variance (ANOVA). Comparison of means: Students 't' test and paired 't' test. Chi-square (X2) test, 2 x 2 contingency table and association analysis as applied to biological experimental data. Simple correlation and linear regression analysis.	**12**
Total		**48**

Referred text books:

1. Instrumental methods of analysis by Willard *et al*.
2. Principles and Techniques of Biochemistry and Molecular Biology By Wilson and Walker
3. Laboratory Manual of Biotechnology by S. K. Bhatnagar and DeepikaAbrol, S. Chand & Co
4. Fundamentals of Biostatistics by Veer BalaRastogi
5. Fundamentals of Biostatistics by Bernard Roser
6. Computer Fundamentals by Anita Goel.
7. Bioinformatics-Applications-Genomics-Proteomics-Discovery, by SC Rastogi, N. Mediratta, P. Rastogi.

Semester: III, Course No: BOTA P304

Course Name: Practical
Credits: 4 **Core/Elective: Core**

Course details

Chapter	Contents	Hours
Plant Systematics **Plant Embryology and Anatomy** **Bioinformatics**	1. Description and identification of Angiosperms at family, genus and species levels using Floras. 2. Herbarium techniques. 3. Microscopic observation various microsporangium (T.S & L.S.), Microspore tetrad, Pollen structure 4. Pollen counting and viability; staining of pollen tube 5. Microscopic study of ovules (T.S. & L.S.), Ovaries (T.S. & L.S.), structure of embryo sac organisation, types of endosperm etc. 6. Microscopic observation of Primary and Secretory tissue systems, Ecological anatomy, wood anatomy, preparation of permanent slides. 7. Colorimetry & Spectrophometry 8. Determination of Absorption maxima of Dyes and verification of Beer-lambert's Law. 9. Centrifugation 10. Pair wise and multiple sequence alignment by using EMBL-EBI and/or ClustalW2 tools. 11. Phylogenetic analysis of proteins and genes using PHYLIP and /or Phylogenetic analysis using parsimony (PAUP) or any other analytical tools. 12. Protein Structure visualization and Homology modelling of proteins through PyMol, VMD and Swiss-PDBV. 13. Docking of small molecules to protein binding sites by AutoDock-Vina and MGL Tools or protein-protein docking through online modes. 14. Protein structure predictions via online servers like I-TASSER, Phyre2, QUARK, PredictProtein.	**100**

Biostatistics	15. Molecular Dynamics simulation of small protein and water complex by AMBER/GROMACS. 16. Measurement of Central Tendency 17. Measurement of dispersion 18. Students's T test 19. X^2 (chi-square) distribution	
Total		**100**

Referred practical books/ manuals/monographs

1. A Practical Guide for Basic Bioinformatics and Biostatistics by Pallavi Pandey & Pooja Tiwari. Notion Press; First edition (2017), ISBN- 13: 978-1946822260.
2. Introductory Practical Biostatistics by Misra, B.N. and M.K. Misra
3. Practical Biochemistry: Principles and Techniques by Wilson and Walker
4. Plant reproduction by T. Pullaiahm, K. Lakshminarayana, B. Hanumanta Rao
5. Udbhida Sangraha (In Odia) by M.K. Misra
6. Flora of Odisha by Saxena, H.o & M. Brahmam

Semester: III, Course No: BOTA C305

Course Name: Seminar and Field Study/Industrial Visit/Scientific Visit
Credits: 4 **Core/Elective: Core**

Course details

Chapter	Contents	Hours
Seminar Presentation and Field Study	The seminar presentation carries 50 marks and field study report also carries 50 marks. Students have to present one seminar in 3rd semester. The seminar presentation will be evaluated by the department staff members. Students have to submit a detailed field study/scientific visit/filed survey report through the guide/ supervisor. This field study report will be evaluated by an external member and the department staff members. Students have to submit their field study's report within one week, after the completion of 3rd semester end term examinations.	
Total		

SEMESTER: IV

Semester: IV, Course No: BOTA C401

Course Name: Microbial and Molecular Bio-techniques

Credits: 4 **Core/Elective: Core**

Course details

Chapter	Contents	Hours
Unit- I	**Techniques of microbial culture:** Preparation of solid and liquid media for algae, fungi and bacteria, pure culture isolation, maintenance and storage of microbes, culture characteristics, fixation and staining, cytophotometry and flow cytometry	**12**

Unit- II	**Chromatographic techniques:** Principles of chromatography (Adsorption and Partition chromatography), Planar chromatography (Paper and Thin-layer chromatography), Column chromatography (Gas chromatography, Gel exclusion/permeation chromatography, Ion exchange chromatography, Affinity chromatography, HPLC)	**12**
Unit- III	**Molecular Techniques**: Sequencing of Proteins and nucleic acids; Southern, Northern and Southern and Western blotting techniques; Methods for measuring nucleic acid and protein interactions. Polymerase chain reaction (PCR), RT-PCR.	**12**
Unit- IV	**Electrophoretic techniques:** General principles, support media, electrophoresis of proteins (SDS-PAGE, native gels, gradient gels, isoelectric focusing gels and two dimensional gels), electrophoresis of nucleic acids (Agarose, pulse-field and sequencing gels).	**12**
Total		**48**

Referred Text books:

1. Wilson, K. and Walker, J., (1994) Practical Biochemistry: Principles and Techniques 4th ed. Cambridge University Press.
2. Instrumental methods of analysis by Willard *et al*.
3. Practical Biochemistry: Principles and Techniques by Wilson and Walker
4. Principles and Techniques of Biochemistry and Molecular Biology by Wilson and Walker
5. Laboratory Manual of Biotechnology by S. K. Bhatnagar and DeepikaAbrol, S. Chand &Co.

Semester: IV, Course No: BOTA C402

Course Name: Plant Biotechnology and Tissue culture

Credits: 4 **Core/Elective: Core**

Course details

Chapter	Contents	Hours
Unit- I	**Plant nutrition, plant cell and tissue culture:** General introduction, history, scope, concept of cellular differentiation, totipotency. Plant micro and macronutrients, vitamins and growth hormones (auxins, gibberellins, cytokinins): physiological effects and mechanism of action, Media for plant tissue culture. Fundamental aspects of morphogenesis, micropropagation techniques, organogenesis somatic embryogenesis, androgenesis, gynogenesis and adaptive embryogenesis.	**12**
Unit- II	**Protoplasm culture:** Somatic hybridization, protoplast isolation, fusion and culture, hybrid selection and regeneration. Possibilities, achievements and limitations of protoplasm research. Applications of plant tissue culture: clonal propagation, artificial seed production of hybrids, somaclones, production of secondary metabolites/natural products, cryopreservation and germplasm storage.	**12**
Unit- III	**Plant genomics:** Introduction to plant genomics, functional genomics, transcripteomics and proteomics, comparative genomics, organelle genomes (Mitochondria and Chloroplast). **Studying genomes:** shotgun approach, clone contig approach, chromosome walking and jumping, c-DNA, genome and gene libraries. Analysis of genome through application of DNA fingerprinting techniques: RFLP, RAPD, AFLP, SSR, SNP, DNA micro array. Expressed sequence tags (ESTs).	**12**
Unit- IV	**Recombinant DNA, Transgenic and genome editing technologies:** Methods of r-DNA technology and genetic manipulation; restriction endonucleases, vectors: plasmid, cosmid, BAC, YAC, *Agrobacterium* - the	**12**

	natural genetic engineer of Ti and Ri plasmid, mechanism T-DNA transfer to plant; Insect-, pathogen- and herbicide-resistant plants, stress tolerant plant; Genome and gene editing (CRISPR Cas-9) technologies for plant improvement. Regulatory, biosafety and ethical issues relating to transgenic and gene-editing.	
Total		**48**

Referred Text books:

1. Molecular Biotechnology: Principles and Applications of Recombinant DNA by Glick, B. R. and Pasternak, ASM Press, Washington, D. C., USA.
2. Plants from Test Tube: An Introduction to Micropropagation by Kyte, L. and Kleyn, J.3rd Ed. Timber press, Port land, USA.
3. Plant Cell and Tissue Culture Vol VI by Pollard, W. J. and Walker, Humana press Clifton, USA.
4. Gene Cloning and DNA Analysis by Brown T. A. Blackwell Science, London.
5. Biotechnology and Plant Genetic Resources by Callow, J. A., Ford-Lloyed, B. V. and Newbury, H. J., Conservation and Use, CAB International, Oxon UK
   Practical Applications of Plant Molecular Biology by Henry, R. J., Chapman & Hall, London, UK
   Proteomics in Functional Genomics by Jolles, O. and Jornvall, H. (eds). Birkhauser Verlag, Basel, Switzerland.

Semester: IV, Course No: BOTA P403

Course Name: Practical
Credits: 4 **Core/Elective: Core**

Course details

Chapter	Contents	Hours
Microbial and Molecular Bio-techniques **Tissue culture techniques**	1. Microbial culture techniques: Preparation culture media (solid and liquid media) for Bacteria, Cyanobacteria, algae and fungi. 2. Agar-agar extraction from red algae 3. Paper Chromatography 4. Thin Layer Chromatography 5. Isolation of DNA, RNA, proteins from plant/ algae / microbes 6. Purification of DNA &RNA 7. Agarose Gel electrophoresis, 8. SDS-PAGE 9. Native gel electrophoresis 10. PCR for amplification of DNA 11. Primer design for PCR 12. Plant explant and callus culture 11. Artificial seed production	**100**
Total		

Referred practical books/ manuals:

1. Molecular Cloning by M.R. Green and J. Sambrook
2. Gene biotechnology by S. N. Jogdand
3. Caluculation in Molecual Biology and Biotechnology by F.H. Stephenson
4. Molecular Biology Principles and Methods a practical approach by P.Nagaranjan and N. Senthil kumar
5. Plant tissue culture: Techniques and Experiments by R.H. Smith, Elsevier
6. Microbiological Applications (A Laboratory Manual in General Microbiology) by Benson, H.J., W.C.B., Wim C. Brown Publishers

Semester: III, Course No: BOTA D404

Course Name: Dissertation
Credits: 4 **Core/Elective: Core**

Course details

DISSERTATION/PROJECT WORK

Each student is required to carry out a project work on a particular problem related to Botany/Biosciences with one of the faculty members of the P.G. department of Botany or from other department of Berhampur University or from any reputed Universities/Institutes/Organizations duly approved by the Head of the Department to fulfill the Master's degree. Students in advance may contact the respective researchers/scientists from around the country to carry out the work for the project work much before the start of the 4th Semester (beginning/mid of the 3rd semester) to avail sufficient time for the planning and execution of the work.
Dissertation carries 200 marks. The dissertation will be evaluated jointly by both internal (supervisor) and external examiners for 150 marks. Seminar presentation carries 50 marks. The seminar presentation will be evaluated by the board of examiners consisting of the department faculty members and an external examiner from outside the University duly approved by the authority. The student has to submit their dissertation before the commencement of the practical examination (Paper No: BOTA P403) for evaluation and the dissertation must be certified with Turnitin for Plagiarism/similarity index certificate, signed by the Internal (supervisor) and the candidate. The UGC-2019 plagiarism rules are recommended by Berhampur University 2019-2020 prior to acceptance of M.Sc. dissertation for evaluation.

Format of M.Sc. Dissertation:

Title Page

Declaration certificate from the Candidate

Certificate from the supervisor

Plagiarism certificate, signed by supervisor and the candidate

Abstract/summary

Materials and Methods

Results

Discussion

Conclusion

References