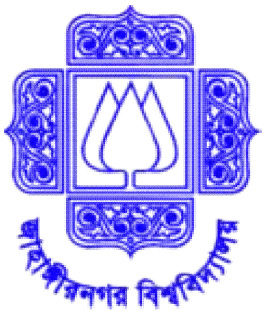
Curriculum

M.Sc. in Biotechnology and Genetic Engineering



DEPARTMENT OF BIOTECHNOLOGY AND GENETIC ENGINEERING

JAHANGIRNAGAR UNIVERSITY

Vision, Mission and Program objectives of the Department of Biotechnology and Genetic Engineering

Vision:

- To disseminate in-depth knowledge and skills in the field of Biotechnology, attaining new heights in research, shaping biotechnology into a premier precision tool for the welfare of human and society.

Mission:

- To provide quality education for developing potential graduates in Biotechnology and Genetic Engineering to contribute in various sectors including agriculture, research, healthcare, industry and environment.
- To facilitate a well directed effort for the expansion of scientists, entrepreneurs and policymakers towards nation building program.
- To disseminate knowledge and skills for the betterment of the society and promote meaningful collaboration with academia, industry and research organizations across the world.

Program objectives:

To facilitate a well directed effort with cutting-edge knowledge in Biotechnology and Genetic Engineering in order to connect the latest techniques, technologies and methodologies for the graduates in the field of:

- Medical and Pharmaceutical Biotechnology
- Molecular Biotechnology
- Microbial Biotechnology
- Industrial Biotechnology
- Environmental Biotechnology
- Plant and Animal Biotechnology
- Nutrition and Food Biotechnology

M. Sc. in Biotechnology and Genetic Engineering (2020-2021, 2021-2022, 2022-2023)

Theory courses (Five courses will be offered for both General and Thesis groups):

Course No.	Title	Credits	Marks
BGE 501	Advanced Agricultural Biotechnology	4	100
BGE 502	Vaccines and Immunotherapeutic	4	100
BGE 503	Enzyme Technology	4	100
BGE 504	Systems Biology	4	100
BGE 505	Biomaterials and Regenerative Medicine	4	100
BGE 506	Neurobiology	4	100
BGE 507	Industrial Biotechnology	4	100
BGE 508	Molecular Breeding	4	100
BGE 509	Oncology	4	100
Sub-total (For 5 courses)		**20**	**500**

General Group (Three courses will be offered from BGE 511 to BGE 514):

Course No.	Title	Credits	Marks
BGE 511	Advanced Agricultural Biotechnology Practical	2	50
BGE 512	Enzyme Technology Practical	2	50
BGE 513	Omics Practical	2	50
BGE 514	Biomaterials and Regenerative Medicine Practical	2	50
BGE 515	Seminar	2	50
BGE 521	Viva-voce	2	50
Sub-total		**10**	**250**
Total		**30**	**750**

Thesis Group:

Course No.	Title	Credits	Marks
BGE 516	Thesis	6	150
BGE 517	Seminar on Thesis	2	50
BGE 521	Viva-voce	2	50
Sub-total		**10**	**250**
Grand Total		**30**	**750**

Course: BGE-501	**Course Title:** Advanced Agricultural Biotechnology		**Offered year:** 5th
Minimum Course hour: 56h	**Credit hour:** 4	**Final exam duration:** 4h	**Total marks:** 100

Rationale: Advanced agricultural biotechnology course is designed to provide basic concepts and valuable insights of transgenic plants and animals as well as past, present and future of the agricultural biotechnology. This course facilitates the students with cutting-edge knowledge such as gene editing, molecular farming, plant metabolic engineering for the welfare of human and society.

Course Objectives:

- To provide detailed concepts of basic and advanced agricultural biotechnology.
- To facilitate advanced concepts for the production and application of transgenic plants and animals
- To provide basic in-depth knowledge on various techniques of gene editing and plant metabolic engineering.

Intended Learning Outcomes (ILOs): At the end of the course the students will be able to-

- Gain basic concepts and valuable insights of agricultural biotechnology.
- Learn the details about the transgenic plants and animals.
- Gather basic in-depth knowledge on editing techniques and its various applications.
- Acquire knowledge on the systems of important agro-biotechnology concepts.
- Learn about plant production, molecular farming, plant metabolic engineering, risk assessment and economic applications of plants.

Teaching Strategy: Lecture, Projector display, Animation, Hands on experiment, Visit, etc.

Assessment Strategy:
Tutorials: Q/A, Quiz, Assignment, MCQ, Presentation, Viva
Final exams: Q/A

Course Content

1.	**Introduction:** Past, present and future of the agricultural biotechnology, biotechnology for crop improvements and their socioeconomic benefits, nuclear and plastid transformation of plants, speed breeding for crop improvement, impacts of climate changes in crops, livestock, biodiversity and food systems, Emerging technologies for agricultural improvements, applications of gene editing in agriculture.
2.	**Genome Editing for agricultural improvement:** Background of genome editing technologies, the basic science of genome editing, mechanism of genome editing, reakage and repair of genomic-DNA, precursors of CRISPR/Cas-9 gene editing, programming of CRISPR/Cas-9, Genome editing without double stranded DNA breaks, delivery of genome editing nucleases into plant and animal cells, use of dead Cas9 (dCas9) to regulate epigenetic modifications, Zinc-Finger Nuclease and TALEN methods and their applications, challenges

	of genome editing technologies.
3.	**Molecular Farming:** Introduction to molecular farming, selection of plant types, sub cellular targeting, plant transformation methods, stability of recombinant DNA inside the plants, expression of multiple gene, purification and downstream processing of recombinant proteins, expression of synthetic human insulin in tobacco plant, expression of type 2 pneumococcal polysaccharide in transgenic tobacco, biosafety and monitoring.
4.	**Plant Metabolic Engineering:** Overview of cellular metabolism, The concept of secondary metabolites, historical and current views, importance of secondary metabolites in medicine and agriculture, Introduction to various pathways, flavonoid pathway, terpenoid pathway, polyketoid pathway. Genetic manipulation of flavonoid pathway, terpenoid and polyketoid pathways in plants and their value addition with significance in horticulture, agriculture and medicine. Metabolic Engineering to improve tolerance of plants to abiotic factors/climate change. Applications of plant metabolic Engineering, in pharmaceuticals (edible vaccines, plantibodies etc), production of biopolymers, bioethanol and biohydrogen production, engineered male sterility.
5.	**Risk assessment and economic applications:** Regulatory aspects of genome edited crops, Regulatory oversight and safety assessment of plants and animals with novel traits, GMO approval and import on a World-Wide scale, Public perceptions of modern biotechnology and the necessity to improve communication.
6.	**Micro propagation of industrially important plants:** Introduction to micro propagation, micro propagation of industrially important plants such as potato, orchid, Aloe Vera and Ginseng.

Recommended Text Books:

1. Agricultural Biotechnology, P.C. Trivedi; ISBN : 9788179103098, (2010).
2. Genetic Modification of Plants: Agriculture, Horticulture and Forestry F. Kempken, C. Jung; Springer Heidelberg Dordrecht London New York. ISBN 978-3-642-02390-3, (2009).
3. Biotechnology in Agriculture, Ramniwas Sharma; ISBN: 9788176221580, (2005).
4. Advances in Applied Biotechnology, Marian Petre; ISBN 978-953-307-820-5, (2012).
5. Molecular Farming in Plants: Recent Advances and Future Prospects, Editors: Wang, Aiming, Ma, Shengwu (Eds.) ISBN 978-94-007-2217-0, (2012).

Recommended References:

1. Human Genome Editing: Science, Ethics, and Governance. National Academies of Sciences, Engineering, and Medicine. 2017. Washington, DC: The National Academies Press. doi: https://doi.org/10.17226/24623.
2. Chauhan, B. S., Jabran, K., and Mahajan, G.. (2017). Rice Production Worldwide. Cham: Springer International Publishing.
3. Church, G. (2018). Genome Editing and Engineering: From TALENs, ZFNs and CRISPRs to Molecular Surgery. In K. Appasani (Ed.), Cambridge: Cambridge University Press.

Course: BGE-502	**Course title:** Vaccines and Immunotherapeutics		**Offered year:** 5th
Minimum course hour: 56 h	**Credit hour:** 4	**Final exam duration:** 4h	**Total marks:** 100

Rationale: Vaccines and Immunotherapeutics course is designed to offer basic and modern concepts of vaccine, its development and application for the welfare of human and animals. This course is intended to provide in-depth knowledge of vaccine ethics, vaccine economics and vaccine regulatory considerations.

Course Objectives:

- To provide the classical and modern concepts of vaccine and immunotherapeutics to combat diseases.
- To be familiar with various antigen, adjuvant, host cellular sensors and cancer specific markers.
- To provide in depth knowledge for the safety, ethical issues and regulatory considerations of vaccine development.

Intended Learning Outcomes (ILOs): At the end of the course the students will be able to-

- Understand the various approaches of classical and modern vaccines.
- Realize hypersensitivity, tolerance, auto immune diseases and the causes behind them.
- Identify and apply specific antigens and adjuvant for vaccine development.
- Be familiar with various kinds of vaccines such as DNA vaccine, Cancer vaccine etc.
- Be aware of the regulatory consideration and safety regarding vaccination and immune therapeutics.

Teaching Strategy: Lecture, Projector display, Animation, Hands on experiment, Visit, etc.

Assessment Strategy:

Tutorials, Q/A, Quiz, Assignment, MCQ, Presentation, Viva

Final exams: Q/A

Course Content

1.	**Introduction:** History of vaccine and immune therapeutics, review of immune responsive elements: B Cells, T cells, antibodies, structure and function of MHC class I and II molecules, humoral and cell mediated immune responses, non-peptide MHC ligands.
2.	**Hypersensitivity reaction**: Classification of hypersensitivity, immune suppression, immune tolerance, central and peripheral tolerance, negative and positive effect of tolerance, auto immune disorders.
3.	**Classical and Novel Vaccination Strategies:** Classical bacterial vaccines, inactivated vaccines, methods of inactivation , advantages and limitations of inactivated vaccines, live vaccines, attenuation, advantages and limitations of live vaccines, vaccines for human, vaccines for fish and animals.
4.	**Production of Antigen:** Basic concept of antigens, antigen recognition, identification and production of specific antigens, hybridoma technology, production of monoclonal and polyclonal antibodies.

5.	**Vaccination and Immune Response:** Activation of innate immunity, host cellular sensors, dendritic cells, mast cells, molecules involved in T and B cell differentiation, Th1-inducing cytokines, Th2-inducing cytokines.
6.	**Adjuvant Technology:** The two-signal model of adjuvant-induced immune activation, Th1 and Th2 Induction by vaccine adjuvants, antigen dose effects, the three-signal model of adjuvant-induced immune activation, human Th2 vaccines, human Th1 vaccines.
7.	**DNA vaccines:** Generations of DNA vaccine development, delivery Approaches of DNA vaccine, mechanisms of DNA vaccine, identification of T and B cell epitopes for vaccine preparation, recognition of epitope, HLA gene complex , immunodiagnostic techniques..
8.	**Cancer vaccines and immunotherapy:** Tumor antigen, properties of tumor antigen, immuno therapeutic and vaccination approaches for cancer treatment, construction of vectors for cancer immunotherapy, vaccines for various cancers.
9.	**Regulatory Considerations of Vaccine Production:** Safety regarding vaccination and immune therapeutics, challenges for the vaccine developer, vaccine ethics, regulatory and post marketing considerations for vaccine development.

Recommended Text Books and References:

1. Immunology, Richard A. Goldsby, Thomas J. Kindt. Barbara, A. Osborne, Janis Kuby 5th Edition, 2003. W. H. Freeman & Company.
2. Monoclonal Antibodies: Principles and Practice, J. W. Goding, 1983. Academic Press.
3. Hybridoma Technology in the Biosciences and medicine, T.A. Springer, 1985. Plenum Press NY.
4. Novel Vaccination Strategies, *Stefan H.E. Kaufmann,* Wiley-VCH Verlag GmbH & Co. KGaA, 2004, Weinheim, Germany.
5. Cancer vaccines and immunotherapy, Peter L. Stern, Peter C. L. Beverley, Miles W. Carroll, Cambridge University Press 2000, UK.

Course: BGE-503	**Course title:** Enzyme Technology		**Offered year:** 5th
Minimum course hour: 56h	**Credit hour:** 4	**Final exam duration:** 4h	**Total marks:** 100
Rationale: The course is designed to provide basic concepts and valuable insights of enzyme kinetics and also enzyme preparation and use. This course also offers the techniques of enzyme immobilization, large-scale application of free and immobilized enzymes, recent advances and future prospects for enzyme technology.			

Course Objectives:

- To provide detailed concepts of enzymes and function of the enzymes.
- To instruct in-depth knowledge on kinetics of free and immobilized enzymes.
- To offer various important techniques related to enzyme production, immobilization and application.

Intended Learning Outcomes (ILOs): At the end of the course the students will be able to-

- Learn the details about enzyme technology.
- Gather in-depth knowledge on kinetics of free and immobilized enzymes.
- Identify the sources, screening and preparation of specific enzymes.
- Know the recent advances and future prospects of enzyme technology.
- Acquire knowledge on the processes of important enzymes in biotechnology.

Teaching Strategy: Lecture, Projector display, Animation, Hands on experiment, Visit, etc.

Assessment Strategy:
Tutorials: Q/A, Quiz, Assignment, MCQ, Presentation, Viva
Final exams: Q/A

Course Content	
1.	**Review of enzyme kinetics:** Enzymes, Enzyme nomenclature, Enzyme units, The mechanism of enzyme action, Simple kinetic of enzyme action, Effect of pH and ionic strength on enzyme catalysis, Effect of temperature and pressure, Reversible reactions, Enzyme inhibition, Determination of V_{max} and K_m.
2.	**Enzyme preparation and use:** Sources of enzymes, Screening for novel enzymes, Media for enzyme production, Preparation of enzymes, Centrifugation, Filtration, Aqueous biphasic systems, Cell breakage, Ultrasonic cell disruption, High pressure homogenizers, Use of bead mills, Use of freeze-presses, Use of lytic methods, Preparation of enzymes from clarified solution, Heat treatment, Chromatographic separation of enzymes.
3.	**The preparation and kinetics of immobilized enzymes:** The economic argument for immobilization, Methods of immobilization, Kinetics of immobilized enzymes, Effect of solute partition on the kinetics of immobilized enzymes, Effects of solute diffusion on the kinetics of immobilized enzymes, Diffusional effects in porous supports.
4.	**The large-scale use of enzymes in solution:** The large-scale use of enzymes in solution, The use of enzymes in detergents, Applications of proteases in the food industry, The use of proteases in the leather and wool industries, The use of enzymes in starch hydrolysis, Production of glucose syrup, Production of glucose from cellulose, Production of syrups containing maltose, Applications of enzymes in various industries, Medical applications of enzymes.
5.	**Immobilized enzymes and their uses:** Enzyme reactors, Membrane reactors, Continuous flow reactors, Packed bed reactors, Continuous flow stirred tank reactors, Fluidized bed reactors, Immobilized-enzyme processes, High -fructose corn syrups (HFCS), Use of immobilized raffinase, Use of immobilized invertase, Production of amino acids, Use of immobilized lactase.

6.	**Recent advances in enzyme technology:** Enzymic reactions in biphasic liquid systems, The stabilization of enzymes in biphasic aqueous-organic systems, Equilibria in biphasic aqueous-organic systems, Enzyme kinetics in biphasic aqueous-organic systems, Use of aqueous 2-phase systems, Practical examples of the use of enzymes 'in reverse', Glycosidases used in synthetic reactions, Inter esterification of lipids.
7.	**Future prospects for enzyme technology:** Whither enzyme technology? Use of 'unnatural' substrates, Enzyme engineering, Artificial enzymes, Coenzyme-regenerating systems. Potential applications in Bangladesh perspective.
8.	**Enzymes used in Biotechnology:** Names, sources, uses and modification of enzymes used in Biotechnology.

Recommended Text Books and References:

1. Enzyme Technology by Martin Chaplin, Christopher Bucke, Cambridge University Press, (1990).
2. Enzyme Technologies for Pharmaceutical and Biotechnological Applications by Herbert A. Kirst, Wu-KuangYeh, Milton J. Zmijewski, (2001).
3. Novel enzyme technology for food applications by Robert Rastall, Woodhead Publishing Limited, UK, (2007).
4. Immobilization of Enzymes And Cells 2nd Ed., John M. Walker, Humana Press, New Jersy, (2006).
5. Fundamental of Enzymology, Nicholas C. Price and Lewis Stevens. 2nd edition. Oxford Science Publications, UK. (1990).
6. Lehninger Principle of Biochemistry, David L. Nelson, Michael M. Cox, 5th edition, W.H. Freeman.

Course: BGE-504	**Course title:** System Biology	**Offered year:** 5th

Minimum course hour: 56h	**Credit hour:** 4	**Final exam duration:** 4h	**Total marks:** 100

Rationale:

Recent advances in biology, including the human genome project, have created new opportunities to understand biological problems from a systems perspective. Systems Biology aims to explain how higher-level properties of complex biological systems arise from the interactions among their parts. The application of computer science in biological data analysis and interpretation has made unprecedented impacts to reveal new information and allow looking at large datasets of complex biological systems which paved the way for systems biology.

This course aims to introduce students to the new concepts and knowledge relevant to systems biology and to help them select important unsolved problems in biology and medicine that may now be possible to address using quantitative and theoretical approaches.

Course Objectives:

- Introduce the students to the background and advancements of computational and systems biology.
- Emphasize a deeper insight into the fundamentals of molecular network biology.
- Introduce tools and techniques in mathematical modeling of the biological processes .
- Make the students aware of the applications of computational and systems biology in innovation and critical analysis to generate new ideas.

Intended Learning Outcomes (ILOs):

Upon successful completion of this course, the student should be able to:

- Understand the goals and advancements through the Human genome project and beyond
- Explain how biological systems information relating to genes, proteins and cellular structures can be used to model living cells, and even to create new synthetic cells.
- Acquainted with the quantitative nature of the systems approach
- Understand mathematical model building of biological systems that link mechanistic information on the molecular function to systems-wide networks and interactions.
- Develop ideas about the current and future trends and techniques of systems biology for discovery and innovation.

Teaching Strategy:

Lecture, Projector display, Animation, Hands-on problem-solving, group discussions, etc.

Assessment Strategy:

Tutorials: Q/A, Quiz, Assignment, MCQ, Presentation, Viva

Final exams: Q/A

	Course Content
1.	**Introduction to Systems Biology:** Definition and Principle, Genomes to life, Human Genome Project (HGP) & Beyond, Review of Next-generation sequencing technologies, Cloud computing, Beyond HGP projects: the 1000 genomes; Human epigenome, microbiome, connectome project, Concepts of 'omics' and their networks and interactions.
2.	**Comparative and Functional Genomics:** Functional annotation; Gene ontology**,** Evolution of functional RNAs and their interactions**,** RNA interference (RNAi); Therapeutic possibilities of RNAi; CRISPR: gene editing technology**,** Genome analysis in identification of drug targets, Gene expression analysis by sequencing: RNA-seq basic principles, file format, bias detection and correction, quality control, read alignment, quantifications (count, FPKM), differential expression, functional enrichment analysis from count data. Single-cell RNA sequencing (scRNA-seq): principles, alignment, counting, clustering (PCA, ICA, tSNE).
3	**Translatomics:** Polysomal profiling, ribosome footprinting, RIPseq, tagged proteins (libraries).
4.	**Cellular and Molecular systems biology:** Construction and modeling of genetic, control theory and genetic networks; local activation and global inhibition models, gradient sensing systems.
5.	**Computational Systems Biology:** Introduction, areas, and challenges, Databases: data representation and model exchange formats (XML and XML-based format, e.g., SBML, CellBL,

	BioPAX, PSI-MI; UML) database models and model storage.
6.	**Biological Networks:** Basic principles of networks, network properties and biology**,** Understanding the cell's functional organization, reconstructing transcriptional regulatory modules and networks**,** Synthetic biology: Simple synthetic networks**,** Network construction from high throughput screen**,** Designer network, modeling of genetic networks and engineered gene circuits; Petri Nets (PN) for modeling biological networks, matrix notation of PN; Cell signaling networks. **Metabolomics:** Basic concept, structural properties, structural and functional analyses of Metabolic Networks (MN), Modeling MN - network reconstruction models from genome and proteome information; designer networks: Engineered Gene Circuits. Flux balance analysis, metabolic profiling, and transcription factors for metabolic engineering**.** **Regulatory network:** reconstruction, analysis, and simulation; Gene Network: estimation, modeling, and simulation**.** **Protein-Protein Interaction (PPI) networks:** Biological experiments, computational techniques and analyses databases.
7.	**Developmental systems biology:** General pattern formation models, Cell fate and cellular programming**,** Future of developmental and stem cell biology.
8.	**Image informatics:** Basics of image informatics**,** Imaging in the quantitative studies of systems biology, Biomedical image informatics.
	Recommended Text Books/References: 1. National Human Genome Research Institute. NIH, Educational Resources. 2. Anatomical structural network analysis of human brain using partial correlations of gray matter volumes. Joshi, A.A., Joshi, S.H., Dinov, I.D., Shattuck, D.W. Leahy, R.M., & Toga, A.W. IEEE International Symposium on Biomedical Imaging: From Nano to Macro., 2010. 3. Next-generation DNA sequencing Informatics. Brown, S.M. Cold Spring Harbor Press., 2013. 4. CRISPR: gene editing is just the beginning. Ledford, H. Nature News, 531(7593), 156. 5. An introduction to systems biology: design principles of biological circuits. Alon, U. CRC press., 2006. 6. Systems Biology. A Textbook. Klipp, E., Liebermeister, W., Wierling, C., Kowald, A., Lehrach, H., Herwing, R. ISBN 978-3-527-31874-2, 2009. 7. Cloud computing: a new business paradigm for biomedical information sharing. Journal of biomedical informatics. Rosenthal, A., Mork, P., Li, M. H., Stanford, J., Koester, D., & Reynolds, P. 43(2), 342-353, 2010. **8.** Sequencing technologies—the next generation. Metzker, M. L. Nature reviews genetics, 11(1), 31-46, 2010.

Course: BGE-505	**Course Title:** Biomaterials and Regenerative Medicine		**Offered year:** 5th
Minimum course hour: 56h	**Credit hour:** 4	**Final exam duration:** 4h	**Total marks:** 100

Rationale: The course provides theoretical knowledge to M.Sc. students in the area of bioengineering to design biomaterials for improved drug delivery and regenerative medicine.

Course Objectives:

- To provide the basic principles of bioengineering to design novel biomaterials for drug delivery, tissue engineering, and stem cell engineering.
- To explain modern techniques to characterize and design novel biomaterials for controlled and targeted release of drugs.
- To provide basic knowledge and techniques of advanced regenerative medicine research.

Intended Learning Outcomes (ILOs): After completion of the course, the students will be able to-

- Demonstrate knowledge and understanding of a range of concepts and issues in biomaterials and regenerative medicine.
- Show proficiency in designing novel biomaterials for controlled and targeted release of drugs (e.g., anticancer drugs, nucleic acids, and oligonucleotides (i.e., siRNA, mRNA and so on)).
- Gain expertise in designing biomaterial scaffolds for the growth of 3D cells/tissues from adult/embryonic stem cells.
- Demonstrate knowledge and techniques required to design state-of-the-art vaccine technology.
- Exhibit knowledge and techniques fundamental to regenerative medicine.
- Reveal an understanding of ethical standards in regenerative medicine research.

Teaching Strategy: Lecture, Projector display, Animation, Hands on experiment, Visit, etc.

Assessment Strategy:
Tutorials: Q/A, Quiz, Assignment, MCQ, Presentation, Viva
Final exams: Q/A

Course Content

1.	**Introduction to biomaterials:** Types and applications of biomaterials, issues of biocompatibility and its evaluation, surface characterization of biomaterials, biomaterial-blood (bio-fluid) interface, surface modifications for improved compatibility.
2.	**Biorheology:** Definition of biorheology, need for biorheology and rheological concepts; haemorheology: definition and clinical aspects; rheology of body fluids; application of rheology in diagnosis, treatment and fundamental understanding of diseases.
3.	**Review of drug delivery:** Fundamentals of drug delivery including physiology, pharmacokinetics, drug diffusion and permeation through biological barriers; various types of drug and gene delivery routes including oral, transdermal, implantable, targeted and pulmonary; controlled drug delivery,

	biomaterials used in drug delivery, particle targeting via receptor-ligand interactions, intracellular transport of colloidal particles, protein and peptide delivery, synthetic (nonviral) gene delivery vectors; microneedles for drug delivery.
4.	**Nano-biotechnology:** Introduction to bio-nanotechnology, cellular nanostructures, self-assembly of colloidal nanostructures of biological relevance, bioactive nanoparticles (respiratory surfactants, magnetic nanoparticles), types of nanoparticles: liposomes, solid lipid nanoparticles, synthetic and biopolymeric nanoparticles, inorganic nanoparticles, carbon nanotubes, polymeric nanofibers, implications in neuroscience, and environmental and 16 - DBB safety aspects of bio-nanotechnology.
5.	**Tissue engineering:** Cell-matrix interactions, receptor biology, cell culture, gene therapy and gene transfer techniques, protein and peptide engineering, tissue ablation, engineering angiogenesis, vascularization, material based immunotherapy and case studies involving skin, bone, liver, muscle tissue engineering.
6.	**Clinical application of biomaterials:** Applications of biomaterials for the human body: biomaterials in cardiovascular system, cardiovascular implant biomaterials, orthopaedic implant materials, and biomaterials in ophthalmology, biomaterials for coronary artery disease, stroke, pneumonia, COPD, diarrheal diseases, HIV/AIDS, tuberculosis, lung cancer, traumatic injuries, and prematurity.
7.	**Biomaterials for stem cell engineering:** Stem cell programming, engineering ECM complexity into biomaterials for directing cell fate; functional biomaterials for controlling stem cell differentiation; integration of biomaterials into 3D stem cell microenvironments; the nanofiber matrix as an artificial stem cell niche; micropatterned hydrogels for stem cell culture; microengineering approach for directing embryonic stem cell differentiation; biomaterials as stem cell niche: cardiovascular stem cells.

Recommended Text Books:

1. Bioengineered Nanomaterials; AtulTiwari, Ashutosh Tiwari; CRC Press, New York, USA, (2013).
2. Apapatite: Synthesis, Structural Characterization and Biomaterial Applications; Michele Iafisco, Jose Manuel Delgado-Lopez; Nova Publications, New York, USA, (2014).
3. Biomaterials for clinical applications; Sujata K. Bhatia; Springer Publishing group;
4. Biomaterials, Medical Devices & Tissue Engineering: An Integrated Approach, S. Fredrick, Chapman & Hall, (1994).
5. Biomaterial Science and Biocompatibility, S. Frederick, H. Chrstiansen, L. Devid: Springer Verlag, New York, (1999).
6. Rheology of Blood in Diagnostic and Preventive Medicine, L. Dintenfass, Butterworth, London, (1976).
7. Tissue Engineering, Saltzman WM, Oxford University Press (2004).
8. Principles of Tissue Engineering, Lanza RP, Langer R, Vacanti JP, Academic Press, 3rd Edition (2007).
9. Nanoscale Materials in Chemistry, Kenneth J. Klabunde, John Wiley & Sons, Inc., (2001).
10. Drug delivery principles and applications, Wang B, Siahaan T, Soltero R, WileyInterscience, (2005).

Recommended References:

1. Biomaterials as Stem Cell Niche (studies in Mechanobiology, Tissue Engineering and Biomaterials

(Volume 2); Krishnendu Roy; Springer Link Publisher.

Course: BGE-506	**Course Title:** Neurobiology		**Offered year:** 5th
Minimum course hour: 56h	**Credit hour:** 4	**Final exam duration:** 4h	**Total marks:** 100

Rationale: The course is designed to develop a conceptual understanding of the central and peripheral neural systems as well as brain development. This course also provide basic idea on the structure and chemistry of synapse, physiology and mechanism of nerve impulse, process of brain development and the impact of nutrition on brain growth.

Course Objectives:

- Provide a basic understanding of neurobiology research and approaches.
- Develop basic understanding of the central as well as peripheral neural systems, process of brain and memory development.
- Offer a broad understanding of several aspects of Neuroscience.

Intended Learning Outcomes (ILOs): At the end of the course the students will be able to learn-

- The gross and fine structure of the brain as well as its function.
- The process of brain development and the impact of nutrition on brain development.
- The mechanism of nerve impulse generation.
- The transmission of impulses between the CNS and the PNS.
- The chemistry of the myelin sheath and its significance in nerve conduction.
- The causes and treatments of neurological disorders.
- Memory biochemistry and intracellular trafficking.

Teaching Strategy: Lecture, Projector display, Animation, etc.

Assessment Strategy: Tutorials, Q/A, Quiz, Assignment, MCQ, Presentation, Viva
Final exams: Q/A

Course Content

1.	**Brain:** Structural and chemical specialties of the brain; Gross structure of the brain: cerebrum, cerebellum, diencephalon, brain stem. Fine structure of brain: structure and functions of neurons and glial cells, their classification and formation of neural tube. Formation of axon and dendrites, guidance of commissural axons.
2.	**Brain growth and development:** Species, structural and cell type differences, neurogenesis and gliogenesis, neuronal death and nervous system development, Neural stem cell differentiation; Adult neural stem cells; Development of the Human brain; Metabolism of the developing brain: lipid, protein, energy metabolism.

3.	**Nerve impulse:** Structure and chemistry of synapse; Physiology and mechanism of nerve impulse: action potential and its ionic basis, sodium channel, potassium channel and calcium channel, conduction of nerve impulse through myelinated and unmyelinated nerve fibers. Intracellular trafficking.
4.	**Neurotransmission:** Neurotransmitters, their metabolism, storage and release. Postsynaptic receptors and their modulation with agonists, antagonists and neuropeptides. Neural circuits, regeneration and repair of nerve tissue.
5.	**Myelination:** Myelin composition and maturation, cell adhesion molecule in myelination.
6.	**Neurological diseases and management:** Parkinson's, Wilson's, Huntington's chorea, and Alzheimer's disease, Schizophrenia, Dementia, Neurological diseases caused by viruses (Flaccid paralysis, Aseptic meningitis, Spongiform encephalopathies etc), Neurological drugs: classification, mechanism of action, drug interaction causing neurological problems.
7.	**Biochemistry of memory:** Synaptic plasticity, genetic and environmental basis of memory, location of memory, measurement of learning and memory, long-term potentiation (LTP), long-term depression (LTD), memory consolidation and reconsolidation, sensitization and fear-conditioning, short and long-term memory

Recommended Text Books:

1. Understanding the brain and its development - Harun K.M. Yusuf
2. Fundamental Neuroscience – Larry Squire, Darwin Berg, Floyd E. Bloom, Sascha Du lac, Anirvan Ghosh and Nicholas C. Spitzar
3. Basic neurochemistry: Molecular, cellular and medical aspects – George siegel, R. Wayne Albers, Scott Brady, Donald Price
4. Handbook of Neurochemistry and Molecular Neurobiology – Lajtha N.S. Abel, Mikoshiba, Katsuhiko
5. Neuroscience: Exploring the brain – Mark F. Bear, Barry W. Connors and Michael A. Paradiso
6. Netter's atlas of human neuroscience – David L. Felten, Ralph Jozefowicz
7. Biochemistry of Brain – S. Kumar. Pergamon Press.

Course: BGE-507	**Course title:** Industrial Biotechnology		**Offered year:** 5th
Minimum course hour: 56h	**Credit hour:** 4	**Final exam duration:** 4h	**Total marks:** 100
Rationale: The course is designed to enable the students to use micro-organisms for manufacturing products using less energy, reducing waste and still ensuring higher yields with cost benefit. It also provides fundamental biological and engineering principles for production of proteins, metabolites, cells and devices.			

Course Objectives:

- To provide fundamental biological and engineering principles for production of proteins, metabolites, cells and devices.
- To offer instructions for engineering modeling methods for the calculation of key process parameters.
- To instruct basic concepts of bioreactor design and its application in batch and fed-batch systems.

Intended Learning Outcomes (ILOs): At the end of the course the students will be able to-

- Understand the fundamental biological and engineering principles for production of proteins, metabolites, cells and devices.
- Know the principles for engineering design of key unit operations.
- Learn about other chromatographic separation of bioproducts and analytical instruments.
- Carry out engineering computations and simulations of bioprocesses.
- Know basic mathematical equations and models for biological processes.

Teaching Strategy: Lecture, Projector display, Animation, Hands on experiment, Visit, etc.

Assessment Strategy:
Tutorials: Q/A, Quiz, Assignment, MCQ, Presentation, Viva
Final exams: Q/A

Course Content	
1.	**Introduction:** Introduction: History of Industrial Biotechnology, the penicillin story, scope of industrial biotechnology, nature of industrial biotechnology, organizational set-up in an industrial microbiology establishment, the shift from antibiotics to pharmacological agents, the biopharmaceutical revolution.
2.	**Industrial media and the nutrition of industrial organisms:** The basic nutrient requirements of industrial media, criteria for the choice of raw materials used in industrial media, some raw materials used in compounding industrial media, some potential sources of components of industrial media, the use of plant waste materials in industrial microbiology media: saccharification of polysaccharides.
3.	**Metabolic pathways for the biosynthesis of industrial microbiology products:** The nature of metabolic pathways, industrial microbiological products as primary and secondary metabolites, trophophase-idiophase relationships in the production of secondary products, role of secondary metabolites in the physiology of organisms producing them, pathways for the synthesis of primary and secondary metabolites of industrial importance, carbon pathways for the formation of some industrial products derived from primary metabolism, carbon pathways for the formation of some products of microbial secondary metabolism of industrial importance.

4.	**Overproduction of metabolites of industrial microorganisms:** Mechanisms enabling microorganisms to avoid overproduction of primary metabolic products through enzyme regulation, derangement or bypassing of regulatory mechanisms for the over-production of primary metabolites, regulation of overproduction in secondary metabolites, empirical methods employed to disorganize regulatory mechanisms in secondary metabolite production; improvement in biotechnological organisms, selection from naturally occurring variants, manipulation of the genome of industrial organisms in strain improvement.
5.	**Industrial systems biology:** Introduction, industrial systems biology case studies, a mature and developed industrial biotechnology product: bioethanol, a recently launched and rapidly growing industrial biotechnology product: 1,3-propanediol, an in-development industrial biotechnology product: succinic acid.
6.	**Industrial biotechnology in the food and feed sector:** Introduction, food applications, starch transformation, dairy industry, baking industry, beer-making industry, fruit processing, food and feed applications: probiotics; prebiotics, insulin, fructo-oligosaccharides, galacto-oligosaccharides, gluco-oligosaccharides; resistant starch, phytate hydrolysis, carbohydrate hydrolysis, amino acid production.
7.	**Good manufacturing practice in industrial biotechnology:** definitions, requirements and historical background; quality assurance, quality management, design of quality systems, principles for documentation in GMP; site master file (SMF); monographs; protocols: production protocols, standard operating procedures, SOP; quality control, chemical and radiochemical identity and purity; risk analysis and risk assessment.
8.	**Societal issues in industrial biotechnology:** Introduction, impact of industrial biotechnology, public perceptions of industrial biotechnology, social Issues in industrial biotechnology, hurdles and challenges for the smooth introduction of acceptable sustainable industrial biotechnology.

Recommended Text Books:

1. Modern Industrial Microbiology and Biotechnology. Nduka Okafor, Benedict C. Okeke, CRC Press, (2021).
2. Industrial Biotechnology: Sustainable Growth and Economic Success. WimSoetaert and Erick J. Vandamme, WILEY-VCH Verlag GmbH &Co. KGaA, Weinheim, (2010).
3. Industrial Biotechnology by P.R. Yadav and Rajiv Tyagi, Discovery Publishing House, New Delhi, (2005).
4. Industrial Microbiology: An Introduction. Michael J. Waites, Neil L. Morgan, John S. Rockey, Gary Higton, Blackwell Science Ltd., (2001).

Course: BGE-508	**Course Title:** Molecular Breeding		**Offered year:** 5th
Minimum course hour: 56h	**Credit hour:** 4	**Final exam duration:** 4h	**Total marks:** 100

Rationale: The course is designed to offer basic and modern concepts of breeding, different genetic markers, molecular techniques etc. Molecular breeding intends to introduce various applications for marker assisted selection, marker assisted breeding for the welfare of human being.

Course Objectives:

- To provide the basic concepts of plant genetic variation and breeding.
- To be familiar with different tools for molecular breeding.
- To explain various biochemical and molecular markers, marker assisted selection and breeding techniques.

Intended Learning Outcomes (ILOs): At the end of the course the students will be able to-

- Gain in-depth knowledge of molecular breeding.
- Understand the classical and modern concepts of breeding.
- Realize the diversities and characteristics of genetic markers.
- Understand, select and apply various molecular techniques for marker assisted selection and breeding.
- Know the impact of genetic variation on different species of plants.

Teaching Strategy: Lecture, Projector display, Animation, Hands on experiment, Visit, etc.

Assessment Strategy:

Tutorials: Q/A, Quiz, Assignment, MCQ, Presentation, Viva

Final exams: Q/A

Course Content

1.	**Introduction**: Ancient efforts at Plant Breeding, History of plant breeding, Domestication of Crop Plants, Genetic variation, Quantitative traits, Molecular Breeding.
2.	**Tools of molecular breeding:** Genetic Markers, Molecular Maps, Molecular Techniques in Omics, Comparative genomics, Array technologies in Omics.
3.	**Molecular dissection of complex traits**: Single marker based approach, QTL for different traits, QTL mapping, Multiple QTL, Meta analysis, Multiple traits and gene expression. The application of QTL theory.
4.	**Marker assisted selection:** From genes to marker: exploiting gene sequence information to develop tools for plant breeding, Components of Marker-assisted selection, selection schemes for marker-assisted selection, genotype building strategies for multiple target genes, marker assisted gene pyramiding, marker assisted hybrid prediction.
5.	**Molecular marker and marker assisted breeding:** Morphological marker, biochemical marker, molecular marker (non PCR based, PCR based), targeted PCR and sequencing, fingerprinting, marker system selection. Application, advantages and limitations of molecular markers.
6.	**TILLING:** Introduction to Targeting induced local lesions in genomics, Relevance of TILLING in plant genomics, TILLING techniques, bioinformatics tools in the TILLING strategy, iTILLING, Application and Limitation of TILLING.
7.	**Case studies:** Plant genomics and its impact on wheat breeding, The impact of plant genomics on maize improvement, Genomics and molecular breeding for root and tuber crop improvement.

Recommended Text Books/ References:

1. Plant Molecular Breeding (Ed: H John Newbury). Blackwell Publishing, CRC Press. ISBN: 1-84127-321-X

2. Molecular Plant Breeding, Yunbi Xu, CAB International. ISBN: 978-1-84593-392-0
3. Crop Breeding (Eds; Delphine Fleury and Ryan Whitford). Humana Press, Springer NewYork Heidelberg Dodrecht London. ISSN: 1064-3745 (2014)
4. Advances in Applied Biotechnology, Marian Petre; ISBN 978-953-307-820-5, (2012).
5. Molecular Farming in Plants: Recent Advances and Future Prospects, Editors: Wang, Aiming, Ma, Shengwu (Eds.) ISBN 978-94-007-2217-0, (2012).

Course: BGE-509	**Course Title:** Oncology		**Offered year:** 5th
Minimum course hour: 56h	**Credit hour:** 4	**Final exam duration:** 4h	**Total marks:** 100

Rationale: The course is designed to provide basic knowledge on cancer. Oncology will emphasize on genetic and epigenetic changes involved in cancer, cell cycle regulation angiogenesis, diagnosis, and treatment options. Students will be introduced with relationship between virus and cancer.

Course Objectives:

- To demonstrate an understanding of basic oncology principles.
- To provide the concepts of oncogenes and tumor suppressor genes as well as their effect on cancer development.
- To instruct different mechanisms of cancer development, diagnosis and therapeutic strategies for cancer treatment.

Intended Learning Outcomes (ILOs): At the end of the course the students will be able to-

- Understand the major pathways involved in different stages of cancer development
- Know about the diagnosis and therapeutic strategies for cancer treatment
- Gain knowledge the concepts, etiology, and pathophysiology of cancer prognosis
- Learn the genetic, epigenetic and environmental factors for cancer development
- Learn about the roles various oncogenic viruses in cancer.

Teaching Strategy: Lecture, Projector display, Animation, etc.

Assessment Strategy:
Tutorials:Q/A, Quiz, Assignment, Presentation, Viva
Final exams: Q/A

Course Content

1.	**Concepts of cancer:** Symptoms, types of cancer, cell cycle, cell proliferation, cell differentiation, tumors arise from normal tissues and many cell types, benign and malignant tumor, cancers seem to develop progressively, tumors are monoclonal growths, dominance and recessiveness of tumorigenic phenotype, hall marks of cancer.
2.	**Cancer etiology:**

	Mutagenic carcinogenesis: An overview on mutagenic carcinogenesis. **Non-mutagenic carcinogenesis:** Toxic agents, mitogenic agents, inflammation (signaling in inflammation-dependent tumor progression). V**iral carcinogenesis:** DNA and RNA oncogenic viruses, mechanism of viral oncogenesis.
3.	**Cellular oncogenes:** Product of proto-oncogenes and their functions, mechanism of proto-oncogene activation, Functions of Src protein and EGFR as tyrosine kinase, Ras-regulated signaling pathways (Akt/PKB), Wnt–β-catenin pathway, GPCRs drive normal and neoplastic proliferation.
4.	**Tumor suppressor genes:** Introduction to cancer suppressor genes, identification of LOH, elimination of suppressor genes, inactivation of tumor suppressors (mutations, promoter methylation), pRb and cell cycle check points, p53 and apoptosis, BRCA1/2, PTEN.
5.	**Angiogenesis, invasion, and metastasis:** Hall marks of vessel formation, angiogenic switch for tumor expansion (role of VEGFR). Travelling, colonization, role of E-cadherin, extracellular proteases, small GTPases in invasion process, mechanism of metastatic tropisms, influence of RhoC on metastasis.
6.	**Cancer diagnosis and treatment:** Biochemical and molecular techniques for cancer detection (Histologic and cytogenic methods, Immunocytochemistry, molecular diagnosis, ultrasonic scanning, nuclear medicine approaches), Treatment of cancer (Limitation of Radiotherapy, Chemotherapeutics (GFR antagonists, Proteosome inhibitor, chaperon inhibitor, mTOR target, p53basedtherapeutics), Nuclear medicine, Immunotherapy-antibody and biphasic antibody therapeutics).

Recommender Text Books:

1. The Biology of Cancer, Robert A. Weinberg (2nd Edition)
2. The Molecular Biology of Cancer, Pelengaris S, Khan M
3. Cancer Medicine, Holland
4. Cancer Biology, Raymond W. Ruddon
5. Cancer Biology, Roger John Benjamin King

References:

1. Biology of Microorganisms. Brock, T.D.
2. Review of medical microbiology. Jawetz, E. J. *et al.*

Course:BGE-511	**Course title:** Advanced Agricultural Biotechnology Practical	**Offered year:** 5th

Minimum course hour:	**Credit hour:**	**Final exam duration:**	**Total marks:**
28h	2	As per requirement	50

Rationale: The course is designed to provide basic laboratory techniques to measure water and nutrient uptake in plants and also morphological marker, biochemical marker, molecular marker system in agriculture. This course is also intended to instruct various techniques of chloroplast purification, SDS-PAGE analysis of chloroplast proteins, differential centrifugation, RNA extraction, agarose gel electrophoresis of RNA, RT-PCR and toxin production, extraction, purification and bioassay.

Course Objectives:

- To provide detailed concepts of laboratory techniques for agricultural biotechnology.
- To explain various techniques to measure water and nutrient uptake in plants and estimation of plant products.
- To instruct various important aspects and techniques of agro-biotechnology.

Intended Learning Outcomes (ILOs): At the end of the course the students will be able to-

- Know the details about the laboratory techniques of agricultural biotechnology.
- Gather in-depth knowledge on different laboratory techniques for estimation of plant products.
- Carry out special techniques such as SDS-PAGE, differential centrifugation, chloroplast fusion.
- Perform RNA extraction, agarose gel electrophoresis of DNA/RNA, RT-PCR of plant genomes.
- Acquire knowledge on the system of extraction, purification, analysis of proteins, RNA and toxin.

Teaching Strategy: Lecture, Projector display, Animation, Hands on experiment, Visit, etc.

Assessment Strategy:
Tutorials: Q/A, Quiz, Assignment, MCQ, Presentation, Viva
Final exams: Q/A, Viva, and practical exam.

Course Content

1.	Laboratory techniques to measure water and nutrient uptake in plants.
2.	Morphological marker, biochemical marker, molecular marker (non PCR based, PCR based), targeted PCR and sequencing, fingerprinting, marker system selection. Application, advantages and limitations of molecular markers in agriculture.
3.	Rapid screening tests for abiotic stress tolerance (drought, salinity - PEG, Mannitol & NaCl).
4.	Estimation of antioxidants and antioxidant enzymes - Ascorbate, Superoxide dismutase, Catalase, and Peroxidase.
5.	Major insect, nematode pests and diseases of crop plants – study of phytotoxaemia and other categories of insect damage in crop plants.
6.	Polymerase chain reaction to amplify a plant gene.
7.	Homogenization of leaves, sub-cellular fractionation by differential centrifugation, chloroplast purification, SDS-PAGE analysis of chloroplast proteins.
8.	RNA extraction, agarose gel electrophoresis of RNA, RT-PCR analysis of a plant gene.
9.	Toxin – production - extraction - purification - selection of toxin resistant calli- assay of toxins to

	pathogens - bioassay for PR protein - culturing and isolation of Bt – bioassay techniques

Recommended Text Books / References:

1. Introduction to Plant Biotechnology. H.S Chawla. Oxford & IBH Publishing Co. Pvt. Ltd. New Delhi. 2002.
2. Molecular Plant Biology: A Practical approach, Gilmartin and Bowler, (Vol. I and II)
3. Practical Biotechnology and Plant Tissue Culture. Madhavi Adhav, Rajendra Ravindra Printers Pvt. Ltd. New Delhi.2009.
4. Plant cell culture (advance in biochemical engineering/biotechnology) by Anderson LA.Springer.1st edition. 1985.
5. Handbook of Plant Biotechnology by Chistou P, Klee H. Wiley. 1 st edition. 2004.•
6. Plant Biotechnology and Agriculture: Prospects for the 21st Century by Altman A, Hasegawa P. Academic Press. 1st edition. 2011

Course: BGE-512	**Course title:** Enzyme Technology Practical		**Offered year:** 5th
Minimum course hour: 28 h	**Credit hour: 2**	**Final exam duration:** As per requirement	**Total marks:** 50

Rationale: This course provides the practical knowledge about enzymes including fundamental properties of enzymes, enzyme catalytic mechanisms and enzyme production.

Course Objectives:

- Provide the fundamentals of enzymes, offer hand on training of enzyme production, purification and characterization.
- Explain various enzyme assay techniques such as enzyme purity assay by SDS-PAGE and 2-D gel electrophoresis.
- Demonstrate Enzyme immobilization techniques using alginate beads and gel.

Intended Learning Outcomes (ILOs): At the end of the course the students will be able to-

- Know the fundamentals of enzymes, its nomenclatures, characteristics and mechanisms of action
- Understand the techniques employed in enzymes purification and characterization.
- Apply enzyme technology in food, medical, and household industries.
- Learn the current and possible future applications of enzyme technologies.
- Develop attitude and capability to work in a group and gather information on the related field for lifelong learning.

Teaching Strategy: Lecture, Projector display, Animation, Hands on experiment, Visit, etc.

Assessment Strategy:
Tutorials: Q/A, Quiz, Assignment, MCQ, Presentation, Laboratory problem, Viva
Final exams: Q/A

Course Content	
1.	**Enzyme production:** (i) Enzyme production in submerged fermentation. (ii) Enzyme production in fed batch fermentation. (iii) Enzyme production using industrial wastes.
2.	**Enzyme purification:** (i) Preparation of cell-free lysates. (ii) Ammonium Sulfate precipitation. (ii) Chromatographic purification.
3.	**Enzyme assay:** (i) Assessing enzyme activity. (ii)Assessing enzyme purity by SDS-PAGE. (iii) Assessing enzyme purity by 2-D gel electrophoresis. (iv) Estimation of Enzyme Kinetic Parameters: K_m, V_{max} and $K_{cat.}$
4.	**Enzyme immobilization:** (i) Enzyme immobilization by gel entrapment. (ii) Enzyme immobilization in alginate bead.

Recommended Text Books:

1. Laboratory Exercises in Microbiology, Fifth Edition, Harley, J.P. and Prescott, L.M. The McGraw-Hill Companies.
2. Enzyme Technology by Martin Chaplin, Christopher Bucke, Cambridge University Press, (1990).
3. Enzyme Technologies for Pharmaceutical and Biotechnological Applications by Herbert A. Kirst, Wu-KuangYeh, Milton J. Zmijewski, (2001).
4. Novel enzyme technology for food applications by Robert Rastall, Woodhead Publishing Limited, UK, (2007).
5. Immobilization Of Enzymes And Cells, 2nd Ed., John M. Walker, Humana Press, New Jersy, (2006).

Course: BGE-513	**Course title:** Omics Practical		**Offered year:** 5th
Minimum course hour: 28h	**Credit hour:** 2	**Final exam duration:** As per requirement	**Total marks:** 50

Rationale:

This is a laboratory course designed to enable the students to apply and investigate theoretical and conceptual knowledge about System Biology to generate knowledge and make informed interpretations and enhance their research skills.

Course Objectives:

- To introduce Unix commands, with a focus on the topics that will be taught in the course
- To provide the concepts of metagenomics, and whole metagenome sequence analysis, assembly, and annotation.
- To offer the concepts related to comparative genomics and visualization of comparative genomic data.

Intended Learning Outcomes (ILOs): After completion of the course, the students will be able to-

- Carry out basic experiments of System Biology and interpret the results
- Design a strategy to circumvent potential experiments
- Analysis and interpretation of gene ontology terms and pathways
- Learn basic commands for different operating systems
- Analysis of mutational landscape in different samples.

Teaching Strategy: Lecture, Projector display, Animation, Hands-on experiment, etc.

Assessment Strategy:

Tutorials: Q/A, Quiz, Assignment, Presentation, Viva

Final exams: Q/A

Course Content

1.	**An introduction to Unix:** Unix commands. Files and directories. Viewing, creating, copying and deleting. Permissions. Pipes.
3.	**Transcriptomics:** RNA-Seq theory. Raw data QC. Mapping data with Tophat and viewing with Seqmonk. Differential expression analysis with Deseq. Reviewing and visualizing differential expression hits. Isoform analysis with Cuffdiff. Pathway analysis with IPA, GOseq and DAVID.
4.	**Metagenomics:** Introduction. 16S analysis. Whole metagenome sequence analysis. Data normalization. Metagenome assembly using SOAPdenovo. Metagenomics annotation.
5.	**Comparative genomics:** Genome alignment. Protein clustering. Visualization of comparative genomic data.

Recommended Text Books:

1. Bioinformatics: Sequence and Genome Analysis. David W. Mount. Cold Spring Harbor Laboratory Press.
2. Essential Bioinformatics. JinXiong. Cambridge University Press, (2006)
3. Bioinformatics: From Genomes to Drugs. Edited by Thomas Lengauer. Wiley-VCH. (2002).
4. Lecture Notes on Biological Sequence Analysis. Martin Tompa. (2000)
5. Bioinformatics. A Practical Guide to the Analysis of Genes and Proteins. Andreas D. Baxevanis. 2nd Edition. Wiley Interscience. (2002).

References:

1. Bioinformatics Computing. Bryan Bergeron. Prentice Hall PTR. (2002)
2. Developing Bioinformatics Computer Skills. Cynthia Gibas, Per Jambeck. O'reilly. (2001)

3. Discovering Genomics, Proteomics, and Bioinformatics. Campbell andHeyer (2003) Pearson Education, ISBN: 0-8053-4722-4
4. Bioinformatics, Methods of Biochemical Analysis Series Vol. 43, Baxevanisand Ouellette (2001) John Wiley and Sons, ISBN 0-471-38391-0
5. Computational Molecular Biology. Pevzner, P.A. (2000) MIT Press, ISBN: 0262161974
6. Bioinformatics: A Lab. Guide to the Analysis of Genes and Proteins. Andreas D.
7. Baxevanisand B. F. Francis Ouellette (2004). 3rd Edition. Wiley and Sons, ISBN: 0-471-47878-4

Course: BGE-514	**Course title:** Biomaterials and Regenerative Medicine Practical		**Offered year:** 5th
Minimum course hour: 28h	**Credit hour:** 2	**Final exam duration:** As per requirement	**Total marks:** 50

Rationale: The course provides hands on training to M.Sc. students to design, characterize, and evaluate biomaterials for improved drug delivery and regenerative medicine.

Course Objectives:

- To provide the basic principles of bioengineering to design novel biomaterials for drug delivery, and tissue engineering.
- To demonstrate modern techniques to characterize novel biomaterials.
- To offer hands on training on the synthesis, characterization, and biological evaluation (antibacterial activity, and biocompatibility) of apatite, silver and gold nanoparticles..

Intended Learning Outcomes (ILOs): After completion of the course, the students will be able to-

- Design, synthesize, and characterize liposomes, apatite nanoparticles, Au nanoparticles and biogenic silver/gold nanoparticles.
- Evaluate antibacterial activity of Au, and biogenic Ag/Au nanoparticles.
- Encapsulate anticancer drugs, nucleic acids, oligonucleotides (e.g., mRNA, and siRNA) and investigate their release profile.
- Perform biocompatibility assay *in vivo*.
- Culture 3D cells/tissues *in vitro*.
- Culture adult/embryonic stem cells.

Teaching Strategy: Lecture, Projector display, Animation, Hands on experiment, Visit, etc.

Assessment Strategy:
Tutorials: Q/A, Quiz, Assignment, MCQ, Presentation, Viva
Final exams: Q/A

Course Content

1.	Synthesis, characterization, and biological evaluation (antibacterial activity and biocompatibility) of gold nanoparticles.
2.	Synthesis, characterization, and biological evaluation (antibacterial activity, and biocompatibility) of apatite nanoparticles.
3.	Preparation/formulation, characterization, and biological evaluation (drug encapsulation, release, and biocompatibility) of liposomes.
4.	Synthesis, characterization, and biological evaluation (antibacterial activity, and biocompatibility) of iron oxide nanoparticles.
5.	Synthesis, characterization, and biological evaluation (antibacterial activity and biocompatibility) of biogenic silver/gold nanoparticles.
6.	Culturing 3-D cells/tissues using animal cell lines.
7.	Culturing adult/embryonic stem cells and their characterization.
8.	Differentiation of stem cells and their characterization.

Recommended Text Books:

1. Bioengineered Nanomaterials; AtulTiwari, Ashutosh Tiwari; CRC Press, New York, USA, (2013).
2. Apapatite: Synthesis, Structural Characterization and Biomaterial Applications; Michele Iafisco, Jose Manuel Delgado-Lopez; Nova Publications, New York, USA, (2014).
3. Biomaterials for clinical applications; Sujata K. Bhatia; Springer Publishing group;
4. Biomaterials, Medical Devices & Tissue Engineering: An Integrated Approach, S. Fredrick, Chapman & Hall, (1994).
5. Biomaterial Science and Biocompatibility, S. Frederick, H. Chrstiansen, L. Devid: Springer Verlag, New York, (1999).

References:

1. Biomaterials as Stem Cell Niche (studies in Mechanobiology, Tissue Engineering and Biomaterials (Volume 2); Krishnendu Roy; Springer Link Publisher.
2. MM Hossain, SA Polash, M Takikawa, RD Shubhra, MA Hasan, S Takeoka, SR Sarker,Investigation of the antibacterial activity and *in vivo* cytotoxicity of biogenic silver nanoparticles as potent therapeutics. Frontiers in Bioengineering and Nanotechnology, 7 (2019), 239.
3. SR Sarker, SA Polash, J Boath, AEKandjani, A Poddar, C Dekiwadia, R Shukla,Y Sabri, SK Bhargava, Functionalization of elongated tetrahexahedral Au nanoparticles and their bioactivity assay. ACS Applied Materials and Interfaces, 11 (2019): 13450-13459.