CURRICULUM FOR MASTER OF PHILOSOPHY (M.Phil.) AND DOCTOR OF PHILOSOPHY (Ph.D.)

IN

GENETIC ENGINEERING AND BIOTECHNOLOGY

UNIVERSITY OF DHAKA

Session 2017-2018 onward

Curriculum for M.Phil. and Ph.D. in
Genetic Engineering and Biotechnology
University of Dhaka

Session 2017-2018 onward

The Department of Genetic Engineering and Biotechnology offering two (2) years M.Phil. and three (3) years Ph.D. program. In MPhil/Ph.D. program, students will conduct advanced research focusing a need-based problem as well as provide a broad base of knowledge in diverse areas of Genetic Engineering and Biotechnology. The knowledge and the research finding generated during M.Phil/Ph.D studies will contribute to the development of the society as a whole.

Besides their assigned research project, the M.Phil./Ph.D. students other than the graduates who obtained BS and MS degree from the Department of Genetic Engineering and Biotechnology, University of Dhaka, will require to take two theory courses from the list below:

Course Number	Course Name	Credit
GEB 601	Computational and Systems Biology	4
GEB 602	Recombinant DNA Technology	4
GEB 603	Medical Biotechnology	4
GEB 604	Industrial Biotechnology	4
GEB 605	Agricultural Biotechnology	4
GEB 606	Molecular Genetics	4
GEB-607	Viva-voce	4

Each 4-credit theory course will be of 100 marks comprising 60 lecture-hours, and 2-credit theory course will be of 50 marks comprising 30 lecture-hours. For the departmental students, standard university rules will be applied.

Course No.	**GEB 601**
Course Name	**Computational and Systems Biology**
Course Credit	**Four (4.0)**

Learning objectives:

The application of computer science in Biological data analysis and interpretation has made unprecedented impacts to reveal new information and make use of them. It has allowed looking at large datasets of complex biological systems which paved the way for Systems Biology. The department offers this course with the following objectives: i) introduce the students with the background and advancements of computational and systems biology ii) give the students in-depth understanding on the principles iii) tools and techniques in this field iv) make the students aware about the applications of computational and systems biology in discovery and v) innovation and critical analysis of the classic and latest works in this field and generate new ideas.

Course content: The course will cover the following aspects of Computational and Systems Biology:

The HGP Project and beyond: Genomes to life; Human Genome Project (HGP); Next-generation sequencing technologies; cloud computing; Beyond HGP projects: the 1000 genomes; Human epigenome, microbiome, connectome project.

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).

Computational Systems Biology: Introduction, areas, and challenges of computational systems biology; Databases: data representation and model exchange formats (XML and it XML-based format e.g. SBML,CellBL, BioPAX, PSI-MI; UML) database models and model storage.

Biological Networks: Review of basic principles of networks and network properties; 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; Metabolic networks: basic concept, network reconstruction models from genome and proteome information, metabolic network structural and functional analyses; Regulatory network: reconstruction, analysis and simulation; Gene Network: estimation, modeling and simulation, petri-net based modeling.

Developmental systems biology: General pattern formation models; Cell fate and cellular programming; Future of developmental and stem cell biology.

Image informatics: Basics of image informatics, imaging in the quantitative studies of systems biology; biomedical image informatics

Expected learning outcomes:

At the end of the course, students will i) learn about the historical background and progress in computational and systems biology ii) understand the current trends in the field iii) learn the applications of the tools and techniques of systems biology for discovery and innovation in biological sciences and iv) learn how to critically analyze literature in this fields and generate new research ideas of their own.

Evaluation methods:

 Course final examination

Suggested readings:

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.
9. Next-generation DNA sequencing methods. Mardis, E. R. Annu. Rev. Genomics Hum. Genet., 9, 387-402., 2008.
10. Networks: An Introduction. Newman, M.E.J. Oxford University Press., 2010.
11. Genome-wide genetic marker discovery and genotyping using next-generation sequencing. Davey, J. W., Hohenlohe, P. A., Etter, P. D., Boone, J. Q., Catchen, J. M., & Blaxter, M. L. Nature Reviews Genetics, 12(7), 499-510., 2011.
12. Discovering functions and revealing mechanisms at the molecular level from biological networks. Zhang, S., Jin, G., Zhang, X. S., & Chen, L. Proteomics, 7(16), 2856-2869., 2007.
13. Supporting SBML as a model exchange format in software applications. Keating, S. M., & Le Novere, N. *In Silico* Systems Biology, 201-225., 2013.
14. The systems biology markup language (SBML): a medium for representation and exchange of biochemical network models. Hucka, M., Finney, A., Sauro, H. M., Bolouri, H., Doyle, J. C., Kitano, H., & Cuellar, A. A. Bioinformatics, 19(4), 524-531., 2003.
15. In vitro organogenesis in three dimensions: self-organizing stem cells. Sasai, Y., Eiraku, M., & Suga, H. Development, 139(22), 4111-4121., 2012.

Addition reading material and learning resources will be suggested by the respective course teacher(s).

Course No.	**GEB 602**
Course Name	**Recombinant DNA Technology**
Course Credit	**Four (4.0)**

Learning objectives:

The advancement of recombinant DNA technology allows genetic manipulation of organisms by incorporating DNA from different sources into a single recombinant molecule. This technology has immense applications in the field of plant, environmental and clinical genomics. This course has the following objectives: i) introduce the concepts of recombinant DNA technology and its development ii) understanding tools and techniques in implementing and transferring genetic material at molecular and cellular levels iii) provide in-depth knowledge on tissue and protein engineering, and iv) understanding the potential applications of this technology.

Course content: The course will cover the following aspects of Recombinant DNA Technology:

Basic principles of rDNA technology: Introduction to gene cloning and rDNA technology; DNA manipulative enzymes; Linkers and adaptors; Cloning and expression vectors; Transformation and transfection; Selectable markers; other selection methods.

Manipulation of gene expression in prokaryotes: Prokaryotic gene expression system; Gene expression from constitutive and inducible promoters; Fusion proteins; Increasing protein stability; DNA integration into the host chromosome; Increasing extra-cellular secretion; Metabolic load; General problems with the production of recombinant eukaryotic proteins in prokaryotes.

Manipulation of gene expression in eukaryotic systems: Eukaryotic expression systems; Fungus-based expression systems; Baculovirus-insect cells expression systems; Mammalian cell expression systems; Biopharming; Methods to make transgenic animals; Application of transgenic model organisms; Cloning by nuclear transfer; Transgenic livestock, poultry and fish; Targeted gene modification; Gene Knock-out, Cre-LoxP and CRISPR in genome editing, knock-in technologies; Antisense RNA technology to control gene expression.

Directed mutagenesis and protein engineering: Site directed mutagenesis procedures; Error prone PCR; Random mutagenesis with nucleotide analogues; DNA shuffling; Adding disulfide bond; Increasing enzyme activity, specificity and protein stability; Modifying metal cofactor requirements; Decreasing protease sensitivity, etc.

Large-scale Protein production: Maximizing the efficiency of the fermentation process; Increasing plasmid stability; Increased protein secretion; Typical large-scale fermentation systems; Harvest of microbial cells; Disruption of cells and downstream processing; Protein solubilization.

Tissue engineering: 3-D cell culture; Organ culture; Significance of cell and tissue engineering; Challenges of tissue engineering, Embryonic and adult stem cells, Induced pluripotent stem cells, Trans-differentiation capabilities of cells.

Applications of rDNA technology: Synthesis of commercial products using rDNA technology- Antibiotics, Biopolymers, human insulin, growth hormones, Factor VIII, Amino acids, Enzymes, Recombinant vaccines, Small biological molecules; Gene therapy; Insect and pest resistant plants; Herbicide tolerance in plants; Plants with enhanced nutritional quality; Bioremediation and Biomass Utilization; Genetic engineering of biodegradable pathways.

Ethical and societal issues in biotechnology: Concerns about the safety of consuming genetically modified foods; Concerns about the impact of genetically modified organisms on the environment; Economic issues; Regulating recombinant DNA technology; Deliberate release of genetically modified microorganisms; Regulating GE food and food ingredients; Patenting rDNA technology derived products.

Expected leaning outcomes:

At the end of the course, students will i) be able to understand the basic principles of recombinant DNA technology. ii) learn the tools required for the transmission of genetic material from one source to another. iii) know the applications of this technology and can apply their knowledge in the practical field.

Evaluation methods:

 Course final examination

Suggested readings:

1. Molecular biotechnology: Principles and applications of recombinant DNA. (4th ed.). Glick, B.R., & Pasternak, J.J. 1752 N St. NW, Washington, DC: ASM press., 2010.
2. An introduction to genetic engineering. (3rd ed.). Nicholl, D.S.T. The Edinburgh Building, Cambridge CB2 8RU, UK: Cambridge University Press., 2008.
3. Biotechnology in medical sciences. Khan, F.A. 6000 Broken Sound Parkway NW, Suite 300: CRC Press., 2014.
4. Gene cloning and DNA analysis: An introduction. (6th ed.). Brown, T.A. The Atrium, Southern Gate, Chichester, West Sussex, PO19 8SQ, UK.: John Wiley & Sons Ltd., 2010.

Addition reading material and learning resources will be suggested by the respective course teacher(s).

Course No.	**GEB 603**
Course Name	**Medical Biotechnology**
Course Credit	**Four (4.0)**

Leaning objectives:

The biotechnology in the field of medicine has an immense impact on diagnostic and preventive purposes. Medical biotechnology has played a dynamic role in improving the obstacles regarding health and medicine as it has the flexibility to reduce global health differences by the provision of promising technologies. This course has the following objectives: i) this course provides an in-depth understanding of the core principles and methodologies underlying modern medical biotechnology, ii) provides a broad grounding in genetic diseases, with the emphasis on the molecular aspects of disease diagnosis and pharmacogenomics, particularly in relation to human disease iii) understanding the concepts of personalized medicine and gene therapy as a new mode of disease treatment and iv) enabling graduates with the relevant skills to pursue careers in medical biotechnology.

Course content: The course will cover the following aspects of Medical Biotechnology:

Introduction: Importance, scopes and applications of medical biotechnology.

Genetic diseases: Molecular basis of genetic diseases-Pathogenic mutations; Gain of function mutations; Loss of function mutations; Dynamic mutations; Copy number variations. Classification of genetic diseases- Chromosomal disorders; Numerical disorders e.g. trisomies and monosomies; Structural disorders e.g. deletions, duplications, translocations and inversions; Chromosomal instability syndromes; Gene controlled diseases – Autosomal dominant and recessive, X-linked disorders; Mitochondrial disorders.

Diagnosis of diseases using molecular techniques: Molecular diagnosis – past, present and future; Immunological approach to detect protein biomarkers -ELISA, Sandwich-ELISA, Indirect-ELISA, HLA typing; Karyotyping, FISH, KISH etc; PCR and its variants - PCR-Electrophoresis, PCR-RFLP, PCR-SSP, PCR-SSOP, QF-PCR, MLPA (multiplex ligation dependent probe amplification); Real time PCR-Qualitative and quantitative real-time PCR, multiplex real-time PCR; DNA sequencing – targeted sequencing, multiplex mini-sequencing (Sanger based), NGS based application in diagnosis.

Pharmacogenomics and personalized medicine: Drug development and drug targets -challenges of current drug discovery; Better and safer drugs, determining accurate drug dosage; Difference in drug response due to genetic variation and/or polymorphism of the drug metabolizing enzymes; Concept of personalized medicine.

Stem cell technology and gene therapy: Significance and importance of gene therapy, types of stem cells, stem cell based therapy, stem cell transplantation; Concept of gene therapy and types – *ex vivo* and *in vivo* gene therapy, importance of vectors in gene therapy; Applications of gene therapy – ADA-SCID, cancer, neurological and eye disorders; CRISPR and the future of gene editing.

Ethical issues: Bioethics; Ethical issues for mammalian cloning; Organ transplantation; Embryo screening; Xenotransplantation; Human embryonic stem cells.

Genetic Counseling: History and development of genetic counseling; Fundamental principles in prenatal, pediatrics and adult genetic counseling; Clinical aspects of human genetics with focus on single gene, chromosomal and multi-factorial genetic diseases; Underlying molecular and biochemical principles, mode of inheritance, determination of genetic risks.

Expected learning outcomes:

At the end of the course, students will i) understand the mode of genetic diseases and the ways to diagnose and prevent these diseases ii) learn the tools used for the diagnostic purposes of genetic diseases iii) equip with the knowledge on stem cell and gene therapy as a treatment opportunity and iv) can build up a career in the medical biotechnology field.

Evaluation methods:

 Course final examination

Suggested readings:

1. Medical Biotechnology. Glick, B.R., Patten, C.L., &Delovitch, T.L. Washington, DC: ASM Press., 2014.
2. Biotechnology in medical sciences. Khan, F.A. 6000 Broken Sound Parkway NW, Suite 300: CRC Press/ Francis Taylor Group., 2014.
3. Medical Biotechnology. Pongracz, J., & Keen, M. Elsevier Health Sciences. 2009.
4. Molecular Diagnostics. Patrinos, G.P. &Ansorge, W.J. (Eds.). Elsevier Ltd., 2016.

Addition reading material and learning resources will be suggested by the respective course teacher(s).

Course No.	**GEB 604**
Course Name	**Industrial Biotechnology**
Course Credit	**Four (4.0)**

Learning objective:

The applications of biotechnology in the fields of industrial production and process development have a very old history. However, the modern principles, tools, and techniques in molecular biology and its combination with technological development have revolutionized the whole field and it has huge impacts on our life. This course has the following objectives: i) guide students to follow historical breakthroughs in industrial biotechnology and how they impacted our social and personal life ii) introduce the applications of various tools and technologies in industrial biotechnology iii) in-depth understanding of the principles and processes of biotechnological product development at industrial scale and iv) understanding about protecting own discovery and innovations.

Course content: The course will cover the following aspects of Industrial Biotechnology:

Introduction: History and scope of industrial biotechnology; Nature of industrial biotechnology; Public perceptions of industrial biotechnology; Social and legal issues in industrial biotechnology; Hurdles and challenges for the smooth introduction of an acceptable sustainable industrial biotechnology product.

Pharmaceutical biotechnology: Biotechnology versus pharmaceutical biotechnology; Pharmaceuticals of animal, plant and microbial origin.

Drugs and diagnostic kit development: Transferring new molecular entities into drug; Application of biotechnologies in drug development; Drug approval, clinical and preclinical trials, and development of kit based diagnostic tools.

Production of therapeutics: Antibodies, hormones, interferon, antibiotics, enzymes, vaccine, blood products, nucleic acid therapies.

Immobilization of enzymes and cells: Rational of immobilization; Methods of immobilization of enzymes and cells and their application.

Fermented food products: Culture development for food fermentation**;** Principles of culture maintenance and preparation of bacterial, yeast and mold cultures; Production of bread, malt, beverage, dairy products, vinegar, oriental fermented food; Recovery and purification of fermented products.

Foods and enzymes from microbial origin: Microorganisms as food, SCP, probiotics, and prebiotics; Production of amino acids, production of food and feed additives; Source and production of enzymes required for food and feed processing.

Practices in industrial biotechnology: Good Manufacturing Practice (GMP), Good Laboratory Practice (GLP); Hazard Analysis and Critical Control Points (HACCP), Standard Operating Procedure (SOP); Quality management and standard operating procedures.

Intellectual Property: Patentable subject matter; Patent claims and ownership of intellectual property; Disclosure requirements; Procedural aspects of patent litigation; recent developments in the patent system and patentability of the biotechnological invention.

Expected outcomes:

At the end of the course, students will i) learn about the historical background and progress in industrial biotechnology ii) learn the applications of biotechnology tools and techniques used in industrial sectors iii) know about the latest discoveries in the field and understand current trends iv) learn how to protect their own IPs in the field of industrial biotechnology.

Evaluation methods:

 Course final examination

Suggested readings:

1. Industrial Biotechnology: Sustainable Growth and Economic Success. Soetaert, W., & Vandamme, E.J. WILEY-VCH Verlag GmbH & Co.KGaA, Weinheim., 2010.
2. Industrial Biotechnology. Yadav, P.R., & Tyagi, R. Discovery Publishing House, New Delhi., 2005.
3. Industrial Microbiology: An Introduction. Waites, M.J., Morgan, N.L., Rockey, J.S., & Higton, G. Blackwell Science Ltd., 2001.
4. Industrial Biotechnology. Nedwin, G.E., MoT., Walker, L.P. ISSN: 1550-9087. Mary Ann Liebert Inc Publisher., 2016.
5. Basic Industrial Biotechnology. Reddy, S.M. Newage International Publisher., 2010.
6. Industrial Biotechnology. Mathuriya, A.S. Ane Books private ltd., India., 2010.
7. The Coming Biotech Age: The Business of Bio-Materials. Oliver, R. McGraw-Hill Companies. ISBN-10: 0071350209., 1999.
8. Prescott & Dunn's Industrial Microbiology. Reed, G. CBS Publishers & Distributors, ISBN-10: 8123910010., 2004.
9. Biopharmaceuticals: Biochemistry and Biotechnology. Walsh, G. Wiley-Blackwell, ISBN-10: 0470843276., 2003.
10. Biotechnology and Biopharmaceuticals: Ho, R.J. Y., & Gibaldi, M. Wiley publisher, ISBN: 9780471206903., 2004.
11. Food Microbiology (5th ed.). Westhoff, D.C., Frazier, W.C. McGraw Hill Education publisher, ISBN 10: 1259062511., 2013.
12. Biotechnology and Intellectual Property Rights-Legal and Social Implications. Singh, K.K. Springer International Publishing AG, ISBN 978-81-322-2059-6., 2016.
13. Biotechnology and its applications in pharmacy. Kulkarni, G.T. Jaypee Brothers, New Delhi, ISBN 81-7179-776-8., 2002.
14. Pharmaceutical Biotechnology. Vyas S.P., Dixit V.K. CBS Publishers & Distributors Pvt. Ltd., ISBN 10: 8123906145., 2010.

Addition reading material and learning resources will be suggested by the respective course teacher(s).

Course No.	GEB 605
Course Name	Agricultural Biotechnology
Course Credit	Four (4.0)

Learning objectives:

Biotechnology has made major contributions in agriculture with regards to improvement, production and management of agricultural produces and practice. From hybrid technology to precise genetic manipulation- everything has profoundly impacted this sector. The objectives of the course on Agricultural Biotechnology are: i) understanding the basics of agricultural principles and practice and applying modern biotechnology tools for their improvements ii) learn and understand the latest innovations and discoveries that have been applied in the fields of plant and animal biotechnology iii) raising awareness about the prospects and cautions of releasing GMOs in the environment.

Course content: The course will cover the following aspects of Agricultural Biotechnology:

Plant growth and development: Plant growth regulators; Biological nitrogen fixation; Biofertilizers-types, production, VAM, *Rhizobium*, *Azotobacter*, *Mycorhiza*, Actinorhiza; Vermicomposting technology; Biopesticides.

Plant tissue culture techniques and their application: *In vitro* morphogenesis and totipotency of seedling eexplants; Effects of hormone balance on explants growth and morphogenesis; Establishment of suspension cultures, anther culture, microspore culture; Micropropagation; Meristem culture and production of virus-free plants; Embryo and ovary culture; Protoplast isolation, protoplast fusion; Somatic hybrids, hybrids; Soma clones; Synthetic seeds; Cryopreservation; Germplasm collection and conservation; Plant tissue culture certification.

Plant transformation techniques: Agrobacterium mediated gene transfer: Ti and Ri plasmids as vectors, design of expression vectors; 35S promoter, genetic markers, reporter genes; Binary vectors, plasmid vectors, viral vectors; Direct gene transfer methods; Transgene stability and gene silencing.

GM technology: Introduction, crop improvement, productivity, performance and fortification of agricultural products; Nutrient uptake efficiency; Genetic engineering for biotic stress tolerance; Golden rice and transgenic sweet potato; Genetic engineering for abiotic stress; Current status of transgenic plants; Ethical issues associated with GM crops and GM food; Labeling of GM plants and products; Importance of integrated pest management and terminator gene technology. Environmental impact of herbicide resistance crops and super weeds.

Genetic Engineering for quality improvement: Seed storage proteins, essential amino acids, vitamins and minerals; heterologous protein production in transgenic plants for agriculture, industry and pharmaceuticals uses; Plants as bioreactor, Extending shelf life of fruits and flowers , delay of softening and ripening of fleshy fruits; Post-harvest protection of cereals, millets and pulses.

Metabolic engineering of plants: Plant cell culture for the production of useful chemicals and secondary metabolites (Hairy root culture, biotransformation, elicitation); Pigments, flavanoids, alkaloids; mechanism and manipulation of shikimate pathway.

Biotechnology and its applications in aquaculture: Biotechnology in fish breeding; Transgenesis, chromosome engineering, surrogate brood stock technology. Biotechnology in fish health management; Cryopreservation of gametes or gene banking; Producing GM fish, Environmental and regulatory safety assessment of new fish variety produced via GM and conventional methods.

Agricultural biodiversity and Intellectual Property Rights (IPR): Historical and geographical causes for diversity; Genetic diversity , molecular diversity; Species and population biodiversity; Quantifying biodiversity maintenance of ecological biodiversity; Collection and conservation of biodiversity; Relevant types of IP for agriculture; Types of IP contributions to innovation in agriculture.

Agro economics: Finance, marketing and planning.

Expected learning outcomes:

At the end of the course, students will: i) learn about the available tools and technologies of modern biotechnology and their applications in the field of agriculture, ii) apply their knowledge to improve, conserve and maintain the integrity of the modern farming by minimizing negative impacts, ii) understand how to communicate the social and economic issues with relevant stakeholders of this field.

Evaluation methods:

 Course final exam

Suggested readings:

1. Plants, Genes and Agriculture. Chrispeels, M.J., &Sadava, D.E. Boston: Jones and Bartlett Publishers.1994.
2. Plant cell, tissue and organ culture: Fundamental methods. Gamborg, O.L., & Philips, G.C. Berlin: Springer-verlag., 2013.
3. Plant Biotechnology: New Products and Applications. Hammound, J., McGravey, P., &Yusibov, V. Berlin: Springer-verlag., 2012.
4. Plant Biochemistry and Molecular Biology. Heldt, H.W. Delhi: Oxford and IBH Publishing Co. Pvt. Ltd.1997.
5. Plants from test tubes. An introduction to Micropropagation. Kyte, L., &Kleyn, J.Portland: Timber Press., 1996.
6. Advanced methods in plant breeding and biotechnology. Murray, D.R. Panima Publishing Corporation., 1996.
7. Plant cell electroporation and electrofusion protocols. Nickoloff, J.A. USA: Humana press Inc., 1995.
8. Plant genetic transformation technology. Sawahel, W.A.Delhi:Daya Publishing House., 1997.
9. Hand book of Plant Biotechnology (Vol. I & II). Gistou, P., &Klu, H. John Publication., 2004.
10. The genetic manipulation of plant. Slater, A., Scott, N., & Fowler, M. Oxford University Press., 2008.
11. Recent Advances in Plant Biotechnology. Kirakosyan, A., & Kaufman, P.B. Springer Publishers.,2009.
12. Plant biotechnology: current and future applications of genetically modified crops.Halford, N.G. John Wiely Publishers., 2006.

13. Agricultural biotechnology innovations versus intellectual property rights. Boyd, S.L., W.A. Kerr and N. Perdikis, The Journal of World Intellectual Property, Vol. 6(2), pp. 211-232., 2005.

Addition reading material and learning resources will be suggested by the respective course teacher(s).

Course No.	**GEB 606**
Course Name	**Molecular Genetics**
Course Credit	**Four (4.0)**

Learning objectives:

The field of biotechnology and genetic engineering has been established on the foundation of molecular genetics. The discoveries and understandings about DNA, gene, RNA and protein have made possible the manipulation of these master regulators of living system.
The course on Molecular genetics is offered with the following objectives: i) advanced learning about the fundamentals of genetics and genetic materials, ii) learning about the mechanisms of genetic regulations and how they impact disease, developments etc. iii) learning about the principles and techniques of genetic manipulations.

Course content: The course will cover the following aspects of Molecular Genetics:

Basics of molecular genetics: Physical and chemical properties of DNA, RNA and proteins; Organization of the nuclear and organelle genomes, DNA replication**,** transcription**;** Translation; DNA recombination and repair; Mutation and evolution; Types and mechanism of mutation.

Regulation of gene expression: Transcriptional factors and regulatory sequences; Operon model of gene expression; Enhancers and repressors; Spatial and temporal controls; Post-transcriptional regulation, RNA splicing, translational and post-translational regulation; Epigenetics and genome imprinting; miRNA and other non-coding RNAs, RNAi.

Genetics of viruses and transposable elements: Classification of viruses based on DNA and RNA genomes; Genome of bacteriophages; Lytic and lysogenic cycles; Oncogenic viruses; Proto-oncogenes and tumor suppressor genes; Mobile genetic elements and their roles in evolution and diseases.

Molecular genetics of diseases: Genetics of diabetes; Genetic and epigenetic changes in tumor cells; Mechanisms of oncogenic viruses in tumor formation; Other genetic diseases-genetic disorders of lipoprotein metabolism; molecular basis of Phenylketonuria, Alkaptonuria, Maple syrup urine disease, Glycogen storage diseases, Gout, Alzheimer's, Parkinson's and Huntington's disease, Down's syndrome, Cystic fibrosis, Fragile-X syndrome, etc.

Techniques in molecular genetics: Isolation, detection and quantification of DNA, RNA and protein; Polymerase chain reaction (PCR); RFLP; Detection of SNPs; Agarose and polyacrylamide gel electrophoresis; Hybridization; Southern, Western and Northern blotting; DNA sequencing; Fluorescent in situ hybridization (FISH); Basics of DNA fingerprinting.

Developmental genetics: Universal mechanisms of animal development; Basic anatomical features of animal; Genes controlling developmental processes; Cell fate and determination, positional values, inductive interaction and morphogenic effects.

Basic principles of rDNA technology: Gene cloning and rDNA technology; DNA manipulative enzymes; Cloning and expression vectors, Methods of introducing DNA into prokaryotic and eukaryotic cells; Selectable markers; Commercial products developed using rDNA technology.

Expected learning outcomes:

At the end of the course, students are expected to have: i) deep understanding about genetics, genetic materials and central dogma of life, ii) knowledge about the tools and techniques used in genetic engineering, iii) understanding the molecular mechanisms of diseases and development.

Evaluation methods:

 Course final examination

Suggested Readings

1. Molecular Biology of the Gene (7th edition). James D. Watson, Tania A. Baker, Stephen p. Bell, Alexander Gann, Michael Levine & Richard Losick. Benjamin Cummings., 2013.
2. Molecular Biology of the Cell (5th edition). Bruce Alberts, Alexander Johnson, Julian Lewis, Martin Raff, Keith Roderts & Peter Walter. Garland Science. 2007.
3. Molecular Cell Biology (6th edition). by Harvey Lodish, Arnold Berk, Chris A. Kaiser & Monty Kreger. W. H. Freeman., 2007.
4. Principles of Genetics. Snustad, D, P. Simmons, M. J. and Jenkins & J. B. Jacaranda. Wiley.,1997.
5. Lewin's Genes XI. Jocelyn E. Krebs. Jones and Bartlett Learning., 2012.
6. Human Molecular Biology: An Introduction to the Molecular Basic of Health and Disease (1st edition). RJ Epstein. Cambridge University Press., 2002.
7. Molecular Basis of Human Disease (1st edition). William J. Tsongalis. Academic Press., 2009.
8. Handbook of Epigenetics (1st edition)..Tollefsbol, T.. Academic Press. 2010.
9. Principles of Molecular Virology (5th edition). Alan Cann, Acadamicpress., 2011.
10. Molecular Oncology (2nd Edition). H. Bronchud, M. A. Foote, G. Giaccone, O. Olopade, P. Workman(eds). Humana Press., 2004.

Addition reading material and learning resources will be suggested by the respective course teacher(s).

Course No.	**GEB 607**
Course Name	**Viva-voce**
Course Credit	**Four (4.0)**

Students will face viva and answer questions on the syllabus of studies. They will also be tested on their ability to answer analytical case study questions. Additionally, they are tested on their ability to relate information from various aspects of genetic engineering and biotechnology.