St. Xavier's College, Ahmedabad
BSc. Voc. Biotechnology
Effective from 2020 (period2020-2023)

Programme Outcomes

PO1. Create a strong knowledge domain
PO2. Develop critical thinking, Problem solving and research aptitude
PO3. Skill development
PO4. Encouraging social interaction, service learning and develop equity centred national development (Social Extension work)
PO5. Self-directed and lifelong learning
PO6. Developing employability and entrepreneurial skills
PO7. Promoting Ecological sustainability development
PO8. Nurturing creativity and humane values

Programme Specific Outcomes for Vocational Biotechnology

PSO1 Comprehending applications of concepts in basic subjects of Biochemistry and Biotechnology
PSO2 Experience nuances of entrepreneurship, work ethics of an industry/ Research organization in Biochemistry and Biotechnology
PSO3 Acquire technical skill set related to research and employability in Biotechnology
PSO4 Acquire ability to impart training in techniques related to the subject
PSO5 Evaluate the ethical, legal and social issues pertaining to use of biological systems

Overall structure

Semester I

BT – 1401 Plant Biotechnology
BT – 1402L Lab: Plant tissue culture

Semester II

BT – 2401 Biostatistics and Entrepreneurship
BT – 2402L Lab: Mini Projects (in-house)
Summer Trainings

Semester III

BT - 3401 Animal Biotechnology
BT – 3402L Lab: Basic techniques in animal cell culture and immunology

Semester IV

BT - 4401 Environmental and Industrial Biotechnology
BT – 4402L Lab: Basic Environmental & Industrial BT techniques
Summer Trainings

Semester V

BT - 5401 Medical Biotechnology
BT- 5402L Lab: Mini Project

Semester VI
BT - 6401 Recombinant DNA Technology
BT- 6402L Lab: Techniques of Recombinant DNA technology

Detailed syllabus of Vocational Biotechnology

Semester I

CORE Paper: Plant Biotechnology
Course Code: BT 1401
No. of Credits: 02
Learning Hours: 30 hrs

I. Course Outcome

The main objective of the course will be to build the basic foundation for micropropagation and plant biotechnology

By the end of the paper, a student should be able to:

CO 1: To explain the basic concepts and techniques in plant biotechnology, especially the importance of standard operating procedures for successful culture establishment.
CO 2: To comprehend the pros and cons of the various techniques in Agriculture, Environment and Industry/ Commercial set up.
CO 3: To assess how crops have been improved and evolved due to specialized techniques like hybridization, mutagenesis and transgenics
CO 4: To be aware and be sensitive to ethical concerns related to genetic modifications in plants
CO 5: To appraise how industry has been able to scale up the production of commercially important plant based products

Thus, the knowledge from this course can help in the following:

a) The students could pursue a career in Agriculture sector, Environment Sector and Biotech industries related with plant products
b) The students can carry out basic research that can be translated to the field or industry, thereby going for higher studies in this field
c) Due to knowledge of techniques, they can proceed to study further and be part of teams that are involved in policy making related to the field
d) Plant Proteomics is an area that can be explored as a career option.
e) Comprehend beginning entrepreneurship ventures in plant based products

Unit-1: Basic concepts in Plant Tissue Culture

Basics terms and definitions in plant tissue culture; Introduction to *in vitro* cultures; Laboratory set up; Sterilization techniques; Media: Various kinds of media, Composition and significance of media components; Plant growth regulators; Micropropagation: Axillary bud, Shoot tip, Meristem culture

Unit-2: Types of Plant Tissue Culture

Introduction to organogenesis, Production of haploid plants and their applications ; Ovary and ovule culture, *In vitro* pollination and fertilization, Pollen culture, Anther culture, Embryo culture: History and methodology, Embryo rescue after wide hybridization, Applications, Somatic embryogenesis

Unit-3: Types of Plant Tissue Culture

Endosperm culture and production of triploids, Single cell suspension cultures, Mutant Selection, Scale up of cell cultures and bioreactors, Protoplast isolation and culture, DNA transformation methods in plants

Unit-4: Applications

Somaclonal variation and applications, Somatic Hybridization and its applications, Virus free plants, Germplasm conservation, Synthetic seeds, Applications of plant DNA transformation. Hairy root culture, Secondary metabolite production, Transgenics in crop improvement, Plant Proteomics

CORE Paper: Plant Biotechnology
Course Code: BT 1402L
No. of Credits: 02
Learning Hours: 30 hrs

I. Course Outcome

The main objective of the course will be to build the basic foundation for micropropagation and plant biotechnology

By the end of the paper, a student should be able to:

CO 1: To present the basic concepts and techniques in plant biotechnology, and experimentally establish

CO 2: To assess how crops have been improved and evolved due to specialized techniques like hybridization, mutagenesis and transgenics

CO 3: To appraise how industry has been able to scale up the production of commercially important plant based products

Laboratory sessions

1. Study of laboratory equipments
2. Stocks and Media preparation
3. Sterilization techniques in plant tissue culture
4. Explant selection, treatment and inoculation
5. Subculture of initiated cultures
6. Acclimatization of cultures
7. Extraction of proteins from plants and its estimation
8. Extraction of DNA/RNA from plants and its estimation
9. Estimation of peroxidase activity in plants
10. Study of β – amylase enzyme from germinated pulses.

References

1. Plant Tissue Culture, Theory and Practice, Rev Ed.,S. S. Bhojwani, M.K. Razdan
2. Biotechnology, B.D. Singh
3. Introduction to Plant Biotechnology, 3rd Ed., H. S. Chawla
4. Plant Tissue Culture, development and Biotechnology, Edited by Robert N. Trigiano and Dennis J Gray.
5. Plant Propagation: Principles and Practices – Hartmann, H.T and Kester D. E.
6. Introduction to Practical Biochemistry. T. Plummer.

Semester II

CORE Paper: Biostatistics and Entrepreneurship
Course Code: BT 2401
No. of Credits: 02
Learning Hours: 30 hrs

I. Course Outcome

The main objective of the course will be to build the basic foundation for Biostatistics and Entrepreneurship

By the end of the paper, a student should be able to:
CO 1: To know the basic concepts and importance of statistics in biology
CO 2: To compare the various nuances of sampling techniques
CO 3: To plan and execute basic research
CO 4: To analyze and interpret data using the learned concepts
CO 5: To assess the journey of successful entrepreneurs and gauge one's own potential
CO 6: To crystallize a business idea and develop a business plan

Thus, the knowledge from this course can help in the following:

a) The students will be adept to carrying out basic research and pursue doctoral studies
b) Improve prospects of being in Public Health Domain, Clinical Research, Research and Development divisions of companies.
c) Being an interdisciplinary subject, Biostatistics can enable students to be part of collaborative projects
d) Entrepreneurship can enable Critical thinking, creative and innovative thinking, becoming independent, improve management skills and networking
e) The students can begin their own startups in incubation centres or by initially working with a team developing a product

Unit-1: Basic concepts in Statistics

Terms and Definitions in Statistics, Population and Sample, Raw Data, Types of variables, Numerical variable (Continuous and discrete), Categorical variables (Nominal and ordinal), Outcome and exposure variables, Display of data for 1 variable, For categorical data: Bar Chart and Pie Chart, For numerical data: Histogram (different shapes) and Frequency Polygon

Measurements of central tendency: Mean, Median, quartiles, percentiles, Mode
Measures of spread: Range, Variance and Standard Deviation and its interpretation
Normal deviation and its characteristics

Unit-2: Probability, Permutations and combinations

Probability: Definition and basic formula, Probability of an event not occurring, Multiplicative rule to calculate the probability of occurrence of both of two events. Independent events, Non-independent events (conditional probability), Additive rule to

calculate the probability of occurrence of at least on of two events, mutually exclusive events, Non-exclusive events, Concept of odds, Applications of probability in biology

Permutations: Definition and basic formula (${}_nP_r = n!/(n-r)!$), Permutations with repetition, Application of permutations in biology (The genetic code), Combinations: Definition and basic formula (${}_nC_r = n!/r!(n-r)!$), Application in biology (pedigree analysis), Problems involving Permutations, Combinations and Probability

Unit-3: Sampling, Hypothesis and significance

Sampling Variation, Population mean and standard error, Concept of Hypothesis test and null-hypothesis, t-test (concept and calculation), ANOVA, One way Anova (concept and calculation), SPSS and its application

Unit-4: Basics of Entrepreneurship

Starting an enterprise: Entrepreneur, Stages in setting up an enterprise:

a. Business idea,
b. Setting up a business plan: Executive summary, Vision statement,
c. Mission statement, Product offering and SWOT analysis,
d. Management team,
e. Marketing: Analysis of the market and competition – Market
f. research, Choosing target market, Marketing strategy: 4P strategy,
g. Financial planning: Balance sheet, Profit and loss statement,
h. Breakeven analysis, Sources of capital.
i. Intellectual Property rights.

CORE Paper: Biostatistics and Entrepreneurship (mini-Project)
Course Code: BT 2402L
No. of Credits: 02
Learning Hours: 30 hrs

I. Course Outcome
The main objective of the course will be to build the basic foundation for Biostatistics and Entrepreneurship

By the end of the paper, a student should be able to:
CO 1: To compare the various nuances of sampling techniques
CO 2: To plan and execute basic research
CO 3: To analyze and interpret data using the learned concepts

Laboratory Sessions
1. Mini project on
   a. Collecting data,
   b. Sampling
   c. Proposing a null hypothesis and analyzing using t-test.
2. Mini project on setting up a small scale industry related to biological products

References:

1. Fundamentals of Biostatistics , 2006 – Bernard A Rosner
2. Fundamentals of Biostatistics, Khan and Khanum
3. Methods in Biostatistics, 2010, B.K. Mahajan
4. Fundamentals of Biostatistics, 2009 , V.B. Rastogi
5. The Biotech Age , Richard Oliver; Tata McGraw –Hill Edition

Semester III

CORE Paper: Animal Biotechnology
Course Code: BT 3401
No. of Credits: 02
Learning Hours: 30 hrs

I. Course Outcome

The main objective of the course will be to understand the concepts of Animal Biotechnology and its applications

Thus, the knowledge from this course can help in the following:
CO1: To describe the concept of growing animal cells *in vitro*
CO2: To explain the importance of specifications in design of laboratory and working to avoid contamination
CO3: To assess how transfection studies enable production of cloned products necessary for medical and pharmaceutical applications
CO4: To spell out experimental designs by scientists to develop techniques for production of vaccines, monoclonal antibodies etc.
CO5: To evaluate how animal cell culture has been instrumental in basic research

Thus, the knowledge from this course can help in the following:
a) Become a skilled personnel in animal cell culture
b) Work in biotech and pharmaceutical industries that commercialize cloned products such as erythropoietin, factor VIII etc
c) Carry out basic research in understanding mode of action of drugs, chemicals etc
d) Work in clinical research laboratories
e) Work in hospitals involved in research especially cancer research

Unit-1: Basics of Animal Cell Culture

Terms and definitions; History of development of cell culture; Laboratory set up; Sterilization and maintenance of cultures; Simulating natural conditions for growth of animal cells; Media: Significance of media components; Importance of growth factors like EGF, PGDF, FGF, IL -1, IL – 2, NGF, erythropoeitin and serum; Metabolic capabilities of animal cells; Anchorage dependence and contact inhibition.

Unit-2: **Types of animal cell culture**

Types of Animal cell culture; Organ culture; Primary explant cultures; Secondary cultures and Established cell lines; commonly used cell lines: origin and characteristics; Growth kinetics and cells in culture; Cell – cell interactions, aggregations and extracellular matrix; Cell suspensions

Unit-3: Specialized techniques

Cell fusion studies; Transplantation of cultured cells; Transfection in animal cells; Expressing cloned products in animal cells: The need to express in animal cells, over production and processing of chosen protein; Bioreactors for large scale culture of cells; *In vitro* fertilization

Unit-4: Applications

Transgenic animals; therapeutic cloning; Production of special secondary metabolites/ products (insulin, growth hormone, interferon, t – plasminogen activator, factor VIII etc); Production of vaccines using animal cell culture; Production of monoclonal antibodies and its applications; Limitations and ethical issues

Practical: Animal Biotechnology
Course Code: BT 3402L
No. of Credits: 02
Learning Hours: 30 hrs

I. Course Outcome

The main objective of the course will be to understand the concepts of Animal Biotechnology and its applications

Thus, the knowledge from this course can help in the following:
CO1: To describe the concept of growing animal cells *in vitro*
CO2: To spell out experimental designs by scientists to develop techniques for production of vaccines, monoclonal antibodies etc.
CO3: To evaluate how animal cell culture has been instrumental in basic research
CO4: To carry out immunological experiments

Lab Sessions
1. Laboratory set up of animal cell culture
2. Demonstration of use of Biosafety Cabinet and importance of clean rooms
3. Media preparation and sterilization by membrane filtration
4. Peripheral Blood Lymphocyte Culture
5. Cell suspension studies using cell lines
6. Rocket Immunoelectrophoresis
7. Immunoelectrophoresis
8. Purification of IgG and quantification
9. Rh typing
10. Agglutination tests

References

1. Animal Cell Culture and Technology– M Butler, 2nd Ed., 2004, BIOS Scientific Publishers
2. Freshney's Culture of Animal Cells: A Manual of Basic Technique and Special Applications, 6th Ed, Wiley online
3. Biotechnology – B.D. Singh, 2010, Kalyani Publishers

Semester IV

CORE Paper: Environmental and Industrial Biotechnology
Course Code: BT 4401
No. of Credits: 02
Learning Hours: 30 hrs

I. Course Outcome

The main objective of the course will be to understand the concepts of Environmental and Industrial Biotechnology and its important applications.

By the end of the paper, a student should be able to:

CO 1: To narrate the importance of requirement of alternate fuels and its production
CO 2: To explain the reclamation of contaminated water and soil by bioremediation
CO 3: To demonstrate how some microbes are able to degrade xenobiotics and how some microbes enable assimilability of nutrients
CO 4: To evaluate using biological systems to recover trace elements, to control growth of weeds, pests etc., Clean the environment by waste water and solid waste management.
CO 5: To summarize how industries have used bioprocessing techniques
CO 6: To formulate the importance of quality control, assurance and regulatory policies in industries

Thus, the knowledge from this course can help in the following:

a) Carry out research to enable reclamation of polluted soil, water to maintain the natural flora and fauna
b) Develop biosensors or technology to assess levels of pollutants
c) Develop technology to increase production and use of biofuels
d) Understand carbon credit and its effect on the environment
e) Work to develop better policies for environment conservation and industry
f) Can work in industries that develop products based on fermentation
g) Can begin industries based on fermentation

Unit-1: Alternative fuels

Introduction to Environmental Biotechnology; Biofuels – definition, benefits and prospects; Biogas production using methanogenic bacteria; Microbial hydrogen gas production; Ethanol production and its use as fuel, eg. Gasohol; Cellulose degradation for combustible fuel; Photosynthetic pigments as solar energy convertors; Plant based petroleum industry.

Unit-2: Biodegradation and Bioremediation

Xenobiotic degradation – pesticide degradation, herbicide degradation etc. by microbes; Biopesticides, thuringiensis toxin as a natural pesticide, Bt plants etc.

Biofertilizers: Nitrogen fixing microorganisms enriching the soil with assimilable nitrogen; Phosphate solubilizers; Vermicompost; Plant growth promoting rhizobacteria

Bioremediation and phytoremediation; Bioleaching: Enrichment of ores by microorganisms; Wasteland reclamation

Unit-3: Fundamentals of Fermentation

Introduction of Industrial Biotechnology; Types of fermentation processes: Batch culture, fed-batch culture, continuous culture. Isolation and improvement of industrially important micro-organisms. Preservation and activation of industrially important microbial cultures. Overview of sterilization processes.

Unit-4: Downstream Processing

Downstream processing: Introduction; Importance; Processes: Removal of insolubles, Product isolation, Product purification and Product polishing. Quality Control and Assurance, Regulatory policies.

Practical: Basic Environmental & Industrial BT Techniques
Course Code: BT 4402L
No. of Credits: 02
Learning Hours: 30 hrs

I. Course Outcome

The main objective of the course will be to understand the concepts of Environmental and Industrial Biotechnology and its important applications.

By the end of the paper, a student should be able to:

CO 1: To demonstrate how some microbes are able to degrade xenobiotics and how some microbes enable assimilability of nutrients

CO 2: To evaluate using biological systems to recover trace elements, to control growth of weeds, pests etc., Clean the environment by waste water and solid waste management.

CO 5: To carry out the importance of quality control, assurance and regulatory policies in industries

Laboratory session

1. Estimation of total hardness of water samples
2. Determination of pH, carbonates and nitrates in soil
3. Estimation of Dissolved oxygen and Biological oxygen demand
4. Estimation of chemical oxygen demand
5. Alcoholic fermentation, purification and estimation
6. Bioremediation
7. Strain development

References:

1. Principles and Techniques of Biochemistry and Molecular Biology, Wilson and Walker, 7th Edition, 2010, Cambridge University Press
2. Microbial Biotechnology, Glazer et al, 2nd edition, 2007, Cambridge University Press
3. Principles of Fermentation, Whitaker et al, 2nd Edition, 1999, Butterworth – Heinemann publishers
4. Biotechnology – B.D. Singh, 2010, Kalyani Publishers

Semester V

CORE Paper: Medical Biotechnology
Course Code: BT5401
No. of Credits: 02
Learning Hours: 30 hrs

I. Course Outcome

The main objective of the course will be to understand how biotechnology is an important part of the medical field

By the end of the paper, a student should be able to:

CO 1: To explain the basic mechanism of RNA interference and how RNAi has been developed to be used in therapeutics
CO 2: To assess the use of stem cells for treatment of various disorders
CO 3: To comprehend the ethical issues related to use of stem cells
CO 4: To appreciate how understanding of molecular mechanisms has enabled therapeutic progress towards customized and target specific regimes
CO 5: To perceive the challenges in RNAi technology, stem cell therapy and cancer therapy
CO 6: To evaluate the role of mechanics and engineering in enabling diagnosis and treatment
CO 7: To recognize how Bioinformatics as a tool is leading to drug discovery and analysis of medical conditions

Thus, the knowledge from this course can help in the following:

a) Opt for drug development research and basic research that can translate to use in medical sciences
b) Progressing to train as a Medical Lab Technician
c) Become skilled personnel as Counsellors for regimes using stem cells and cancer therapeutics
d) Students can progress to the Omics field
e) Be part of Ethics Committees and Policy drafting related to this field

II. Course Content

Unit-1: RNAi Interference Technology in Therapy

Introduction to RNA interference; its features: DNA – directed RNAi; Mechanism of gene regulation by RNAi; Designing siRNAs; RNAi treatment for genetic diseases;

RNAi as defence against viral infections eg. HIV; Use of RNAi for cancer treatment; Knockdown by RNAi as a mechanism to study diseases in model organisms; Limitations and disadvantages of RNAi technology.

Unit-2: **Stem Cell Therapy**

Introduction to stem cells; Sources of stem cells and their uses; Somatic cell nuclear transfer (Therapeutic cloning); Induced pluripotent stem cells; Development of regenerative treatment models; Stem cells and neurodegenerative diseases; Potential of hematopeotic stem cells in treatment of autoimmune diseases; Ethical issues and disadvantages of stem cell therapy

Unit-3: Biotechnological Interventions in Cancer Therapy

Introduction to different types of cancer therapy; Hormonal therapy; Targeted therapy against surface molecules; Microtubule targeting plant based drugs; p53 protein as a target; Targeting angiogenesis; Introduction to oncogenomics.

Unit-4: Specialized Instruments and Bioinformatics in Medical Sciences

Biophysical concepts of Ultrasound Imaging techniques; CT Scan; PET Scan; ElectroCardiogram; Electro encephalogram; Endoscopy.

Introduction to Bioinformatics; Biological databases, data retrieval and pitfalls; Database Similarity Searching; BLAST and FASTA and their comparison

Practical: Basics of Bioinformatics
Course Code: BT 5402L
No. of credits 02
Learning Hours: 30

I. Course Outcome

The main objective of the course will be to understand how biotechnology is an important part of the medical field

By the end of the paper, a student should be able to:

CO 1: To learn to use various bioinformatics softwares

CO 2: To appreciate how understanding of molecular mechanisms has enabled therapeutic progress towards customized and target specific regimes

CO 3: To carry out various bioinformatics tools to analyse genome

CO 4: Recognize how Bioinformatics as a tool is leading to drug discovery and analysis of medical conditions

Lab Sessions

1. Introduction to NCBI and other biological databases
2. Sequence retrieval from biological databases
3. BLAST of DNA
4. BLAST of RNA
5. BLAST of protein
6. Visit to a Diagnostic Centre to see MRI, CT Scan etc. (Optional)

References

1. Krishnarao Appasani. RNA Interference Technology. Cambridge University Press. 2009
2. Al – Rubeai et al. Stem Cells and Cell Therapy. Springer. 2014
3. Bruce Alberts. Molecular Biology of the Cell. 4th edition. Garland Science. 2002
4. Xiong J. Essential bioinformatics. Cambridge University Press. 2006
5. Ramsden J. Bioinformatics: An Introduction; Third Edition. Springer. 2015.

Semester VI

CORE Paper: Concepts in recombinant DNA Technology
Course Code: BT6401
No. of Credits: 02
Learning Hours: 30 hrs

I. Course Outcome

The main objective of the course will be to understand the concepts of recombinant DNA technology

By the end of the paper, a student should be able to:

CO 1: To explain the basic tools required in recombinant DNA technology especially in eukaryotic systems
CO 2: To explore the methods used to study gene location and structure
CO 3: To know the various techniques used to study the gene expression and regulation
CO 4: To describe the techniques used in analyzing transcripts and proteins
CO 5: To clarify the problems associated with production of recombinant molecules
CO 6: To explore the use of recombinant DNA technology in betterment of the society
CO7: To appreciate experiments carried out by scientists to enable understand various molecular mechanisms

Thus, the knowledge from this course can help in the following:

a) To chose a career in molecular biology and genetic engineering
b) Exploit the basic understanding of the subject to create something that can help society
c) Equip oneself with skills to grow in the biotech sector
d) Work in biotechnology industries in Research and Development/Production/ Quality Assurance
e) Carry out basic research in understanding many more molecular mechanisms inside a cell

II. Course Content

Unit-1: Cloning Vectors for Eukaryotes

Vectors for yeast and other fungi: 2μ plasmid, YEPs, YIPs, YRPs, and YACs; Vectors for higher plants: Ti plasmid, Binary vector and Cointegrate Ti plasmids, Ri plasmids, Limitations of agrobacterium plasmids, Direct gene transfer into protoplasts, Plant viruses as cloning vectors; Vectors for animals: Cloning vectors for insects, Cloning vectors for mammals

Unit-2: **Obtaining Clone of a specific gene**

Direct method and Marker rescue; using hybridization to select clones: colony and plaque hybridization; Synthesis of probes: Abundancy probing, Probe synthesis from protein

sequence, Heterologous probing; Methods of labelling of probes; Non – probe selection of clones; Studying location of genes by *in situ* hybridization

Unit-3: Studying gene expression and function

Studying the RNA transcript of a gene: Introns, splice sites; Studying regulation of gene expression: Gel retardation, DNA footprinting, Modification Interference Assay, Deletion Analysis; Identifying and studying the translated product of gene: HRT and HART; Analysis of proteins by *in vitro* mutagenesis; Site directed mutagenesis; Studying protein – protein interaction.

Unit-4: Production of proteins from cloned genes

Special vectors for expression of foreign genes in *E.coli;* Cassettes and gene fusions; Problems associated with production of recombinant protein in E.*coli;* Production of recombinant protein by eukaryotic cells; Pharming; Production of recombinant insulin, human growth hormone, factor VIII; Gene subtraction using antisense RNA technology; *In vitro* transcription and *in vitro* translation

Practical: Techniques of Recombinant DNA Technology
Course Code: BT 6402L
No. of credits 02
Learning Hours: 30

I. Course Outcome

The main objective of the course will be to understand the concepts of recombinant DNA technology

By the end of the paper, a student should be able to:

CO 1: To explore the methods used to study gene location and structure

CO 2: To carry out the various techniques used to study the gene expression and regulation

CO 3: To explore the use of recombinant DNA technology in betterment of the society

CO 4: To appreciate experiments carried out by scientists to enable understand various molecular mechanisms

1. Genomic DNA isolation
2. Plasmid DNA isolation
3. Assessment of quality and quantity of DNA
4. Agarose gel electrophoresis to visualize DNA
5. Restriction digestion
6. DNA ligation
7. DNA transformation
8. PCR - Demonstration

References

1. Molecular Biology of the Gene (2008) 6th ed., Watson, J.D., Baker, T.A., Bell, S.P., Gann, A., Levine, M. and Losick, R., Cold Spring Harbor Laboratory Press, Cold Spring. Harbor (New York), ISBN:0-321-50781 / ISBN: 978-0-321-50781-5.
2. Gene Cloning and DNA Analysis (2010) 6th ed., Brown, T.A., Wiley-Blackwell Publishing (Oxford, UK), ISBN: 978-1-4051-8173-0.
3. Principles of Gene Manipulation and Genomics (2006) 7th ed., Primrose, S. B., and Twyman, R. M., Blackwell publishing (Oxford) ISBN: 13: 978-1-4051-3544-3.
4. Molecular Biotechnology: Principles and Applications of Recombinant DNA (2010) 4th ed., Glick B.R., Pasternak, J.J. and Patten, C.L., ASM Press (Washington DC), ISBN: 978-1-55581-498-4 (HC).