SYLLABUS OF
M.Sc. INDUSTRIAL BIOTECHNOLOGY

2009

DEPARTMENT OF BOTANY, UNIVERSITY CAMPUS
CH.CHARAN SINGH UNIVERSITY, MEERUT-250004

INDUSTRIAL BIOTECHNOLOGY

Industrial **biotechnology** (known mainly in Europe as **white biotechnology**) is the application of biotechnology for industrial purposes, including manufacturing, alternative energy (or "bioenergy"), and biomaterials. It includes the practice of using **ce**ll (biology) or components of cells like enzymes to generate **in**dustry useful products. According to Biotechnology Industry Organization (BIO) of USA there are three "waves" of biotechnology. The first wave, Green Biotechnology, refers to agricultural biotechnology. The second wave, Red Biotechnology, refers to pharmaceutical and medical biotechnology. The third wave, White Biotechnology, refers to industrial biotechnology. In actuality, each of the waves may overlap. Industrial biotechnology, particularly the development of large-scale bioenergy refineries, will likely involve dedicated genetically modified crops as well as the large-scale bio-processing and fermentation as is used in some pharmaceutical production. In coming future industrial biotechnology might significantly impact the chemical industry might also enable economies to become less dependent on **fossil** fuels.

Industrial Biotechnologists can be of great help in the following fields.

- Bioenergy and Biofuels
- Biomass and Biorefineries
- Food, Beverage, and Feed Processing
- Agricultural sciences and Agronomics
- Nanobiotechnology
- Synthetic Biology and Genome Engineering
- Bioremediation
- Bioprospecting and Marine Biotechnology
- Cosmeceuticals and Personal Care
- Biomaterials: Bioplastics, Biofilms
- Pulp and Paper
- Textiles
- Detergents
- Industrial Enzymes
- Biodefense
- Automotive

Ch. Charan Singh University, Meerut –250004

DEPARTMENT OF BOTANY

M.Sc. INDUSTRIAL BIOTECHNOLOGY, 2009

Distribution of Marks in different courses:

I Semester	Course Title	Theory External	Theory Internal	Total Marks
Course I	General Microbiology & Microbes of industrial Importance	50	50	100
Course II	Molecular Cell Biology	50	50	100
Course III	Concepts in Biochemistry, Metabolism and Bioenergetics	50	50	100
Course IV	Biotechnology of Fermentation and Biotransformation I	50	50	100
Practical I (4 hours)		100	100	200
Total Marks		300	300	600

II Semester	Course Title	Theory External	Theory Internal	Total Marks
Course V	Molecular Biotechnology	50	50	100
Course VI	Biotechnology and Environment.	50	50	100
Course VII	Genetics and Genomics.	50	50	100
Course VIII	Biotechnology of Fermentation and Biotransformation II.	50	50	100
Practical II (4 hours)		100	100	200
Total Marks		100	300	600

III semester	Course Title	Theory External	Theory Internal	Total Marks
Course IX	Biopharmaceuticals, Medical Biotechnology and Health care	50	50	100
Course X	Immunotechnology	50	50	100
Course XI	Animal Biotechnology.	50	50	100
Course XII	Plant Biotechnology.	50	50	100
Practical III (4 hours)		100	100	200
Total Marks		300	300	600

IV Semester	Course Title	Dissertation, presentation, viva-voce	Total Marks
	Project	400	400
Grand Total of Marks		2200	2200

A minimum of 30% marks separately in internal and external assessment of each course and an aggregate of 40% marks in all the courses is required for passing. In case of failing to obtain 30 % marks in internal assessment of any paper, the candidate will not be eligible to appear in external examination of that course.

CURRICULUM: M.Sc. INDUSTRIAL BIOTECHNOLOGY (2009)

I Semester

1. General Microbiology & Microbes of industrial Importance.
2. Molecular Cell Biology.
3. Concepts in Biochemistry, Metabolism and Bioenergetics.
4. Biotechnology of Fermentation and Biotransformation I

Lab.: Biochemistry, Microbiology, Microbial cell cultures and Biochemical Identification.

II Semester

5. Molecular Biotechnology.
6. Biotechnology and Environment.
7. Genetics and Genomics.
8. Biotechnology of Fermentation and Biotransformation II.

Lab.: Recombinant DNA, , Fermentation, Environmental studies, Research Methods in Statistics, Computation & Bioinformatics.

III Semester

9. Biopharmaceuticals, Medical Biotechnology and Health care
10. Immunotechnology
11. Animal Biotechnology.
12. Plant Biotechnology.

Lab.: Bioseparation Technology, Plant, Animal Cell and Tissue Culture, Immunotechnology

IV Semester

Project : 1. Report of work
2. Presentation of work.
3. Viva-voce test.

M.Sc. Industrial Biotechnology

Teaching Hours:50

CourseI: General Microbiology and Microbes of Industrial Importance

Unit -I (a) Development of microbiology as science; important contributions of pioneer microbiologists; golden eras of microbiology; present trends; types of organisms studied by microbiologists.

(b) Methods in microbiology: sterilization, culture media, pure culture techniques, isolation of microbes, maintenance of microbial cultures; microbial culture collection centres

(c) Important criteria used for classification (morphological, ecological, biochemical, molecular and numerical criteria) of microorganisms.

(d) Evolutionary relationships among taxa; three domain concept

Unit -II (a) Ultrastructure of bacteria in general; important differences between archaebacteria and bacteria; features of special interest of cyanobacteria.

(b) Classification of bacteria based on Bergey's manual of systematic bacteriology.

(c) Viruses: characteristics and ultrastructure of viruses; isolation and purification of viruses; chemical nature; multiplication of animal viruses, plant viruses and bacteriophages; transmission of viruses.

(d) Viroids: structure and multiplication; general structure, reproduction and importance of mycoplasma, phytoplasma and rickettsiae; actinomycetes and actinorhizae.

Unit -III (a) Nutritional requirements of bacteria, nutritional uptake and transport; growth yield and characteristics, stress response.

(b) Methods of genetic transfer; transformation, conjugation, transduction and sexduction, mapping genes by interrupted mating, fine structure analysis of genes.

(c) Regulation of gene expression in phages and viruses; a comparison of gene expression between prokaryotic and eukaryotic microbes; viroids and gene silencing.

(d) Host-parasite interaction: a brief idea of recognition and entry processes of bacteria, viruses into animal and plant-host cells, alteration in host cell; virus-induced cancer; bacteria and plant two-component signalling systems; bacterial chemotaxis and quorum sensing.

Unit - IV (a) Microbiology of air.

(b) Microbiology of water.

(c) Microbiology of soil.

(d) Microbes for control of pollution.

(e) Microbial enzymes and their application.

(f) Microbes in nanobiotechnology.

Unit - V Food and Microorganisms: microorganisms in food industry; contamination and spoilage of different kinds of food : milk and milk products, sugar and sugar products, vegetables and fruits, cereals and cereal products, meat, fish, eggs and poultry, sea food and canned food; food-borne illnesses due to bacterial food poisoning, disease investigation; material and equipments, laboratory testing, field analysis and preventive measures; food hygiene and hazard analysis critical control points (HACCP).

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M.Sc. Industrial Biotechnology

Teaching Hours:50

Course II: Molecular Cell Biology

Unit I : - Microscopy—Principles, parts, types and functioning of Light and Electron Microscope, Scanning tunneling microscope.

Unit II : - Light and Ultra- microscopic structure of cell.
- Cell cycle; Biochemical and Genetic mechanism.
- Morphological, Biochemical and Ultra- structural organization of Chromatin and Chromosomes.

Unit III : - Biochemical and Ultra- structural organization of Cytoskeleton with emphasis on Spindle apparatus.
- Biochemical and Ultrastructural organization of Biological Membranes.
- Biochemical and Ultrastructural organization of Cell Organelles.
- Ultrastructural organization of Nucleus.

Unit IV: - Molecular organization of DNA.
- Types of RNA and their Molecular Organization.
- DNA replication and Biosynthesis.
- DNA damage and repair.
- Transposable Genetic Elements.
- Genetic Code.

Unit V : - Mechanistic details of –
- Transcription.
- Reverse- transcription.
- RNA processing.
- Translation.

M.Sc. Industrial Biotechnology

Teaching Hours:50

CourseIII: Concepts in Biochemistry, Metabolism and Bioenergetics

Unit I :- Water, Aqueous solutions.

- Laws of Thermodynamics.
- Concept of Free Energy, Redox Potentials and their application.
- Basic Biochemical Techniques-Centrifugation, Chromatography, Electrophoresis, Radioisotopic techniques.

Unit II :- Structure and Biochemical organization of Amino acids, Carbohydrates, Fatty acids and Nucleotides.

- Secondary Metabolites- Hormones, Alkaloids, Porphyrins,

Unit III :- Enzymes, Elementary kinetics, Mechanism of Enzyme Action, Assay types, Reaction rates,
Extremozymes, Engineering Enzyme Activity and Substrate Specificity
Non-aqueous Enzymology, Solvent Engineering v/s Protein Engineering
Coenzymes and Vitamins, Isoenzymes, Allosteric Enzymes

Unit IV :- Major Intermediary Metabolic Pathways. Biosynthesis and Catabolism of Saturated and Unsaturated Fatty Acids, Nucleotides.

- Ramachandran's plot and protein catabolism

Unit V:- ETS of Respiration and Oxidative Phosphorylation, Substrate level Phosphorylation.

- Anaplerotic pathways.

M.Sc. Industrial Biotechnology

Teaching Hours:50

Course IV: Biotechnology of Fermentation and Biotransformation-I

UNIT I:- (a) Screening, detection and assay of fermentation products (physical, chemical and biological assay) and inoculation; stock culture.

(b)Strain development: mutant selection, recombination, metabolic regulation, gene technology and genetic methods.

(c) Use of substrate as C-source and N-source.

UNIT II:-(a) Methods and types of fermentation; dual/multiple fermentation; continuous fermentation and late nutrient addition.

(b) Growth kinetics of microorganisms.

(c) Fermenter systems and fermentation.

(d) Stirring and mixing (Reynolds number and Power number kinetics).

(e) Oxygen concentration and oxygen transfer, Scale up processes through power consumption/volume and O2 transfer rate.

(f) Methods of gas and nutrient sterilization, instrumentation.

UNIT III:- (a) Product recovery and unit operations in product recovery yields, kinetics of product yield; Commercial and economic considerations and evaluations.

(b) Fermentation economics, market potential, fermentation and recovery costs.

UNIT IV:- (a) Organic feed stock production by fermentations; general methodology.

(b) Ethanol, acetone/ butanol and glycerol fermentations.

(c) Vitamin production, B_{12}, Riboflavin and β-carotene: occurrence, economic significance, biosynthesis, production process.

UNIT V:- (a) Alkaloid fermentation, Ergot production through fermentation and regulation.

(b) Fermentation processes in dairy and other food products.

(c) Biotechnology of food and feed: fermented food products– toffu, kaffir, cheese, buttermilk, yogurt, sour cream etc.

(d) Feed production, SCP, fats, amino acid, food additives.

M.Sc. Industrial Biotechnology

Teaching Hours:50

Course V: Molecular Biotechnology

Unit I :- Recombinant DNA Technology- Emergence of Technology.
- Restriction Endonucleases.
- Cloning Vectors- Plasmids, Phages, Cosmids, YACs, BACs
- Construction and screening of Genomic Library, cDNA Library.
- Genetic Transformation of Cells.

Unit II :- Manipulation of Gene Expression in Prokaryotes.
- Isolation of Functional Promoters.
- Expression through Strong and Regulatable Promoters.
- Fusion Protein Strategy.
- Translation Expression Vectors.
- Increasing Protein Stability.
- Increasing Secretion.

Unit III - Heterologous Protein Production in Eukaryotic cells.
- *Saccharomyces cerevisae* as Expression Systems with direct expression and Secretion of Heterologous Proteins.
- Other Yeast Expression System (for HBVSAg & BL c_2)
- Cultured Insect Cell Expression Systems.(Baculovirus Transfer Vector and Scale up problems).
- Mammalian Cell Expression Systems.
- Human Papova BK Viral Shuttle Vectors and other important vectors.
- Plant Expression Vectors.

Unit IV :- Molecular Research Procedures.
- DNA Sequencing Techniques.
- Chemical Synthesis of DNA and Gene Synthesis, Gene Machines.
- Polymerase Chain Reaction and Gene Amplification.
- Molecular Marker technique. RAPD RFLPs, AFLP, FISH and FACHS.

Unit V :- Regulating the use of Biotechnology.
- DNA
- Food and Feed Ingredients.
- Release of GMOs
- Human Gene Therapy – Concerns, Policy and Future.
- Patenting Biotechnological inventions.
- Patents, Patenting procedures for Technology, Microbes, Multicellular Organisms and Fundamental research.

M.Sc. Industrial Biotechnology

Teaching Hours:50

CourseVI: Biotechnology and Environment

Unit I : - Principles and nature of Environment. Organisms and Environment, Holocoenotic Environment, Biotic potentials of Environment.

- System analysis- Tools of System analysis, Ecomodelling, Application and Limitations.

Unit II :- Environment and energy, Energy resources- Renewable and Non-renewable.

- Natural resources, loss of Diversity, causes and consequences, Environmental Auditing, Preservation of Biodiversity.

Unit III :- Pollution –Types, Causes, Prevention and Control, Methods of Reducing, Environmental impacts of Chemicals, Weedicides, Pesticides and Fertilizers. Biotechnological advances in pollution control through GEMs.

- Sewage treatment, Newer approaches to sewage treatment, treatment of Solid Waste, Energy production- Bioenergy, Biofuels and Biofertilizers.

Unit IV :- Bioremediation and Pollution control through Microbes and Plants, Biodegradation of Natural products, Microbes and Heavy metal Pollution control, Microbes in Desulphurization.

- Biotechnology of transformation of Xenobiotics, Hydrocarbons, Cannabinoids, Pesticides.

Unit V :- Environmental protection through Genetically Engineered Microbes.

- Methylotrophs and Methanogenesis.
- Biotechnology of Biofuels.

CourseVII: Genetics and Genomics

Unit I : - Genetics:

- Mendel's Laws of Inheritance and Modified Ratios.
- Linkage, Crossing over, Molecular mechanism , Chromosome Mapping and mechanism of Chromosome Pairing, Synaptonemal complex.
- Extra - nuclear Inheritance.

Unit II : - Biochemical Genetics, Concept of Gene.

- Types of Mutations, Induction and Detection.
- Duplication and Deficiency : Classification, Meiotic pairing.
- Inversions: Classification, Meiotic pairing and Crossing over in different regions.

Unit III : - Translocations: Classification, Meiotic pairing, Chromosome disjunction.

- Types of Numerical changes and Haploidy.
- Polyploidy: Classification, Production, Utility in Crop Improvement.
- Aneuploidy: Trisomics, Tetrasomics, Monosomy, Multisomy.

Unit IV : - Genomics :-

- Structural Genomics: Genetic and Physical maps, Automated DNA sequencing and assembly.
- Functional Genomics :High through put chip Technology, Genetic knockouts, Approaches to define function of unknown genes.

Unit V : - Biostatistics and Bioinformatics:

- Data presentation, Frequency Distribution, Graphical representation/
  Frequency polygon and curve, Cumulative frequency curve, Central tendency measures and dispersion, Mean, Mode, Median, Mean deviation, Coefficient of Variance, Correlation, ANOVA.
- Basic knowledge of computers and its Application in biology, Internet Search of Literature and web Analysis, Basic information about major Databases related to Genes, Proteins, Biotechnology and its Application.

Course VIII. Biotechnology of Fermentation and Biotransformations -II

Unit I :- Fermentation of Antibiotics :-

- Organisms, Cultures, Procedures of Fermentation Penicillins, □□ Lactams, Cyclosporine and their derivatives, Streptomycin, Erythromycin, Gentamycin, Tetracyclines.
  Biotechnology of Antibiotic production :-
- Cloning of Antibiotic- Biosynthesis genes by Complementation and other methods.
- Synthesis of Novel Antibiotics.
- Improving Antibiotic productions.

Unit II :- Fermentation of Organic acids and Amino acids :-

- Organic acids- Acetic acid, Lactic acid, Gluconic acid and Citric acid.
  Amino acid: Glutamic acid, Tryptophan, Phenylalanine
- Biotechnological advances in Organic and Amino acid production (via recombinant DNA technology especially L-ascorbic acid (Vit.C) Glutamic acid and Tryptophan.

Unit III :- Fermentation and Microbial enzymes :-

- Bacterial and Fungal Cellulases, Amylases, Lipases, Proteases, Lysozyme, β-lactamases.
- Biotechnological advance in production of Cellulase, Amylases, Lipases and Proteases. Engineered enzymes (Adding and reducing disulfidebonds, changing sour amino acids, Asparagine, Glutamine) to other Amino acids, increasing Enzyme Activity modifying enzyme specificity

Unit IV :- Enology :-

- Alcohol and Alcoholic beverages- Microbes and Biotechnology of Alcoholic Fermentation.

Unit V :- Biotransformations :-

- Processes :-
  Immobilization of Enzymes and Cells, Techniques and Applications
  with special reference to Matrices and Methods of Immobilization.
- Transformation - Steroids, Alkaloids and Polysaccharides.
  Recent advances - in Biotransformation (Indigo, Xanthan, Malanins,
  Adhesive protein Biopolymer (Byssal adhesive), Rubber polymerase).

Course IX: Biopharmaceuticals, Medical Biotechnology and Health Care

Unit I :- Disease diagnosis :-

- Technology, Probes, construction of Probes, Hybridization , Ligase chain reaction and Diagnosis; Diagnosis through Monoclonal Antibodies, Immunological Assay, lmmuno PCR, Auto-antibodies.
- Genetic analysis of diseases, Neoplastic disease diagnosis, Human genetic predisposition to diseases.
- Genetic analysis methodology -Direct and Indirect with specific examples of Sickle Cell Anaemia, Duchene/Backer Muscular Dystrophies. Fragile X Syndrome, Heritable Cancer, Susceptibilities, Limitations and Imprinted genes. Genetic diseases, Molecular Mechanism.

Unit II :- Prophylaxis:-

- Disease prevention through Vaccines, Conventional Vaccines, Purified antigen Vaccines.
  Vaccine Biotechnology:-
- Vaccine production through recombinant DNA - Various approaches for Novel Vaccine production. Recombinant polypeptide Vaccines, DNA vaccines, Edible Vaccines, Strategies and Development (Vaccinia virus recombinants, Baculo virus expression Vector Vaccines, Recombinant vaccines for HIV, Genetic immunization).

Unit III :- Therapeutics :-

- Disease treatment by products of normal organisms - Microbes Plant cell/Animal cells; Products from Recombinant Organisms /Cells/Plants/ Animals, and their advantages; Interferons, Growth factors, Hormones, Antisense nucleotides, Monoclonal antibodies.
  Biotechnological Techniques of development of Drugs; Therapeutic agents.
- Drug synthesis - Natural products, Endogenous hormones, Random screening, Computer modeling; Molecular principles of Drug Targetting and Drug Delivery. General principles; Controlled release systems; Site specific delivery: Adopting different techniques.

Unit IV : Molecular basis of human diseases: AIDS, Cancer, Leukaemia, Thallasaemia,Sickle cell anaemia, Cystic Fibrosis, Muscular Dystrophy, Cancer diagnosis, Genetic analysis of Breast cancer, Oncogenes, Tumour diagnosis- Solid tumours and Hematological malignancies.

Unit-V : Molecular genetic medicine:-

Gene therapy, Gene targetting by Homologous Recombination, Embryonic Stem cell technology, Animal models for Human Diseases, Correction of Mutated Genes, Future directions.

Course X: Immunotechnology

Unit I :- Basics of Immunology.

- Immunity, types of Immunity, Cells of Immune system , Mediator of Immunity to Immune-response, Antibody repertoire.
- Differentiation of cells involved in Immune Response, Lymphoid system,
- Antibodies - types and structure, Effector Functions and their receptors

Unit II :- Generation of Antibody Diversity.

- Organization of Genes coding for Antibodies and T-cell receptors, Mechanisms of Antigen recognition, T-cell receptors, MHCs, Hyper-sensitivity
- Antigens and antigenicity -Humoral and Cellular, Haptens, Antigen - Antibody reactions, Application in Molecular Biology and Biotechnological techniques.

Unit III :- Biotechnology of Immunity :-

- Genetic Engineering of Antibody molecule. Ab structure and Antibody Engineering, Expression systems for Ab fomation *In vitro* Libraries for Antibody Identification, Chimeric antibodies.
- Auto-antibodies and Auto-immunity- responsible Effector mechanisms, Auto Antibodies as Diagnostic Markers, Molecular and Cellular probes.

Unit IV :- Combinatorial phage Antibody Library, Construction of Ab Library on Phage.Affinity based Selection from Phage Display libraries, Abs from immune and non- immune libraries.

- Cytokines (Interleukins, Lymphokines, and Monokines) General properties and functions, role in Pathology and Therapy, their Molecular biology, role in Signal Transduction and Regulation of Gene expression.

Unit V :- Immunological techniques in Biotechnology, Hybridoma technology, Production and Utility of Monoclonal antibodies

Course XI: Animal Biotechnology

Unit I :- Animal tissue and Organ culture

- Plasma clot method, Raft method, Agar-gel method, Grid method, etc.
- Cyclic exposure to Medium and Gas phase, Advantages, limitations and applications, artificial skin.

Unit II :- Cell cultures:-

- Substrate and Suspension culture
- Culture media, Natural and Artificial
- Initiation of Cell culture- Explant isolation, Desegregation of explants, Sub- cultures.
- Evolution and Maintenance of Cell culture lines, Large scale culture of Cell lines, Monolayer, Suspension culture, Immobilized cultures.
- Somatic cell fusion, Mechanism and Applications; Cell culture Products and their Applications
- Vaccines; Interferons; Recombinant protein; Hybrid Antibodies.
- Monoclonal Antibodies.

Unit III :- Genome Analysis :-

- Human Genome Project.
- Molecular Marker.
- Chromosome - jumping.
- Chromosome - walking.
- Microsatellite - mapping.
- Chromosome Region Specific Library.
- DNA fingerprinting and Application of technique.

Unit IV :- Transgenic animals

- Objectives, Vectors, Gene Construct, (Promoters and Reporter or Marker genes)
- Transfection methods, Embryonic Stem Cell Transfer, Targetted Gene Transfer.
- Transgene integration, Detection of Transgenics through Transgene function.
- Transgenic animals:-Mice, Rabbits, Cattle, Goat, Sheep, Pigs and Fish.

Unit V :- *In vitro* Fertilization and Embryo Transfer.

- Human beings.
- Embryo transfer in cattle.
- Application of Embryo Transfer Technology.
- Animal cloning.
- Ethical and Social issues relating to Human cloning,
- Transgenics and Prospectives.

M.Sc. Industrial Biotechnology

Teaching Hours:50

Course XII: Plant Biotechnology

Unit I :- Principles and methods of preparation of Culture Media.

- Nutritional aspects of Plant Cell and Tissue culture.
- Techniques of organ (Shoot, Root, Flower, Ovary, Ovules, Endosperm, Embryo and Fruit), Tissues, free cells and Protoplast cultures, and their Applications.
- Somaclonal Variation, Causes and Consequences; Induced variation and their Applications.

Unit II :-- Gene transfer methods in plant cells:- Via virus vector, Via ***Agrobacterium***,

- Chemically mediated DNA uptake, Microinjections, Microprojectile bombardment, Electroporation,
- Genetic Engineering of Insect Control Agents; Production of Insect Resistant plants, Proteinase Inhibitor Gene Technology, Bt Gene Technology, Other related Technology.

Unit III :- Engineering Herbicide Resistant Plants:-

Direct and Indirect strategies for developing Herbicide Resistance.

Direct strategy : - Mutant Psb A gene; Microbial and Plant mutant Al s gene; EPSPS and Mutant genes.

Indirect Strategy:- Gene Amplification and Overexpression

- Herbicide Detoxifying Enzymes / Genes
- Bacterial Detoxifying Genes

Engineering Plants for Viral Disease Resistance:-

- Strategies for Engineering Genes for Plant Protection through:-
- Coat Protein Expression System; Satellite DNAs; Antisense RNA.

Unit IV :- Improvement of Nutritional quality of plants:-

- Through Seed Storage Protein e.g. Glycinin, Conglycinin, Legumin, Phytohaemaglutinin, Phaseolin, Prolamins, Albumins and Designer-proteins,

  Engineering for vitamins and iron-deficiency
- Engineering Traits related to Hybrid Seed Production (e.g. Male Sterility); Terminator technology.

Unit V:- Plant Genome Programs.-

- Impact of Genetically Modified crops and Genomics Research in Agriculture.
- Evaluation of Transgenic plants as to their Commercial Value, Efficacy and Environmental concerns.
- Legislations for Transgenic plants.
- Economic viability of Transgenic plants.
- Production of 2 s Albumins.