St. Xavier's College – Autonomous Mumbai

Syllabus
For 5th Semester Courses in
LIFE SCIENCE
(July 2014 onwards)

Contents:

Syllabus (theory and practicals) for Courses:

LIFE SCIENCE

T.Y.B.Sc.: **Course No. S.LSC.5.01**

Title: Genetics

Learning Objectives:

The course must enable the student to:

1. Understand the concepts of linkage, recombination and gene mapping in phage, bacteria and eukaryotes.
2. Understand gene recombination and DNA transposition.
3. Understand cellular and molecular changes caused in cancer.
4. Describe the basic principles of gene manipulation and its application.

Number of lectures: 60

UNIT I: Principles of bacterial and phage genetics **(15 lectures)**

1. Overview of a prokaryotic genome (1)
2. Gene mapping of bacteria

I. Conjugation (4)

a. Discovery of conjugation
b. F plasmid & Hfr strains
c. F' plasmids
d. Mapping of bacterial genomes – Jacob & Wollman's Interrupted Mating Experiment
e. Numerical problems

II. Transformation (3)

a. Discovery
b. Genome mapping using transformation
c. Numerical problems

III. Transduction (3)

a. Generalized transduction
b. Specialized transduction: production of λdgal
c. Mapping phage genomes using co-transduction frequency
d. Numerical problems

3. Mapping of bacteriophage genomes (4)

a. Benzer's fine structure mapping of phage genomes
b. Recombination mapping
c. Concept of "genes within genes", "alternate splicing" and "terminal redundancy" in phage genomes
d. Numerical problems

UNIT II: Principles of Eukaryotic genetics **(15 lectures)**

1. Overview of eukaryotic genome (3)

a. Structural organisation
b. Sequence complexity
   i. Unique sequences, repetitive sequences and satellite DNA

ii. Denaturation kinetics

2. Genetic recombination in yeast (4)
a. Life cycle of yeast
b. Constructing a linkage map using tetrad analysis
c. Numerical problems

3. Genetic mapping in eukaryotes (8)
a. Life cycle of *Drosophila*
b. Linkage analysis – sex-linked and autosomal genes
c. Recombination mapping with two-point and three-point crosses
d. Interference and coefficient of co-incidence
e. Mapping of human genes
i. Somatic cell hybridization, radiation hybrids
ii. Mapping with molecular markers
f. Numerical problems

UNIT III **(15 lectures)**

1. DNA recombination (5)
a. Forms of recombination: site-specific and illegitimate
b. Model for homologous recombination: Holliday Model
c. Gene conversion

2. Mobile genetic elements (5)
a. Overview
b. Transposable elements in bacteria: IS element
c. Transposable elements in eukaryotes: Ac element in maize
d. Transposable elements in humans: LINES, SINES
e. Evolutionary significance of transposable elements

3. Cancer genetics (5)
a. Overview of cancer cells – characteristics of cancer cells
b. Types and causes of cancer
c. Viruses and cancer
d. Proto-oncogenes and Oncogenes-Ras
e. Tumour suppressor genes – p53

UNIT IV: Genetic Engineering **(15 lectures)**

1. Molecular techniques for cloning genes (9)
a. Restriction endonucleases Type II
b. Cloning vectors: plasmids, cosmids
c. Construction of recombinant DNA molecules: Insulin gene cloning
d. Selection of recombinant clones: antibiotic and lacZ selection
e. Construction of DNA libraries: genomic and cDNA libraries
f. Screening DNA libraries: nucleic acid hybridization, immunochemical
g. Amplification of DNA by PCR

2. Molecular analysis of cloned sequences (4)
a. Analysis of DNA: Southern blot
b. Analysis of RNA: Northern blot
c. Analysis of protein: Western blot
d. DNA sequencing: Sanger's method
e. Restriction mapping

3. Application of recombinant DNA technology (2)
   a. Human genome project
   b. Human gene therapy

Practicals
Course S.LSC.5.01 PR:

1. Viable count of *E. coli*
2. T4 plaque assay
3. UV dark repair to isolate mutants
4. Conjugation in *E. coli* (kits)
5. Yeast/ Neurospora/ *C. elegans* genetic crosses and recombination
6. Restriction enzyme digest of plasmid DNA and agarose gel electrophoresis
7. PCR of a gene (demo)
8. DNA fingerprinting/ restriction mapping
9. Projects (any one):
   i. Clone a gene (blue white selection)
   ii. Use PCR to amplify and clone genes
   iii. Isolate auxotophic mutants of *E. coli*/ yeast
   iv. Map genes on the *E.coli* genome using Hfr strains

References

1. Principles of Genetics by Snustad and Simmons
2. Genetics by Griffith
3. Genetics by Russell
4. Genetics by Pierce
5. Problems in Genetics by Suzuki
6. Genetics by Goodenough

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T.Y.B.Sc.: **Course No. S.LSC.5.02**

Title: Developmental Biology

Learning Objectives:

The course must enable the student to describe/ discuss:

1. Model systems commonly used in the study of embryonic development.
2. Embryonic development in avian (chick), amphibian (*Xenopus*) and plant (*Arabidopsis*) systems.
3. Cellular and molecular mechanisms controlling development in *Drosophila*.
4. The process of morphogenesis, regeneration and ageing.
5. The role of environmental agents in teratogenesis.
6. Advances in stem cell biology and its applications.

Number of Lectures: 60

Unit I: **(15 lectures)**

1. History and basic concepts in Development (1)
2. Universal mechanisms of animal development: (2)
   a. Positional value of cells
   b. Inductive signals
   c. Asymmetry in cell division
   d. Lateral inhibition
3. Model organisms in Developmental Biology: (7)
   a. Significance of model organisms
   b. Sea Urchin: mosaic vs regulative development
   c. Dictyostelium: chemotactic-induced aggregation
   d. *C. elegans*: single cells die as part of apoptosis
   e. Zebrafish: in situ hybridization
   f. Drosophila: genes in early development
   g. Chick and amphibians: fate maps
4. Plant development: Dicotyledons (eg. Arabidopsis) (5)
   a. Overview of embryo development in plants
   b. Dormancy
   c. Vegetative growth: meristem, root and shoot development
   d. Floral signals

Unit II: **(15 lectures)**

1. Sexual Reproduction: (5)
   a. Sex determination, dosage compensation
   b. Fertilization, acrosome reaction, prevention of polyspermy, cortical reaction.
2. Embryology: eg. Birds (chick) (8)
   a. Cleavage
   b. Gastrulation
   c. Axis Specification and the Avian 'Organizer'
   d. Neurulation: Neural induction, Neural tube formation, Neural crest cells and their migration
   e. Somite formation
   f. Organogenesis of the limb and eye

3. Evolutionary Developmental Biology (2)

Unit III: (15 lectures)

1. Cellular aspects of development: (one example of each) (6)
   a. Totipotency: plant cells and animal cell nucleii
   b. Pluripotency
   c. Determination
   d. Transdetermination
   e. Differentiation
   f. Introduction to stem cells and their applications
2. Differentiation as a change in gene expression (2)
3. Molecular basis of growth: (Maintenance of tissues) (7)
   a. Cell cell communication in development
   b. Cell cycle and its regulation
   c. Programmed cell death: apoptosis

Unit IV: (15 lectures)

1. Developmental genetics: eg. Drosophila (7)
   a. Generation of body plan
   b. Maternal effect genes
   c. Segmentation genes
   d. Homeotic genes
2. Post Embryonic Development (4)
   a. Metamorphosis eg amphibian and insects
   b. Ageing and senescence: cellular and molecular changes
3. Abnormal Developmental Programs: (4)
   a. Congenital abnormalities: radiation, virus, retinoic acid, and alcohol-induced abnormalities (any two)
   b. Cancer: cellular changes

Practicals:

Course S.LSC. 5.02PR:

1. Study of permanent slides of a developing chick embryo.
2. Study of different developmental stages of a developing chick embryo / zebra fish by preparing temporary mounts.
3. a. Study of differential development at different regions within a developing chick embryo using a mitochondrial marker enzyme (cytochrome c oxidase).
   b. Study of morphogenetic movements in a developing chick embryo.
4. Study of the morphology and life cycle of *C.elegans*
5. a. Study of the pollen tube length under different growth conditions (Boron, Calcium).
   b. Diameter measurements (using ocular) of pollens of different types.
6. Screening of a movie on Development in *C. elegans* / zebra fish / amphibian / chick

   OR

   Journal club.
7. Group Projects (Any One):

a. Regeneration in Hydra
b. Regeneration in earthworm
c. Plant tissue culture - callus formation from different plant tissues.

d. Fate mapping in a chick embryo
e. Maintenance of a model system – Each group of 5-8 students to maintain any one model system eg. zebra fish, *C.elegans,* earthworm, Chironomous, Dictyostelium etc.

References:

1. Developmental Biology by Scott Gilbert, 9th edition.
2. Principles of Development by Lewis Wolpert, 3rd edition, Oxford Univ Press
3. Molecular Biology of the Cell by Alberts, Johnson et al 5th edition, Garland Sc , 2008.
4. Cell Biology by Lodish, Baltimore, et.al 6th edition, W.H. Freeman and Co, 2007.
5. Principles of Developmental Biology, W.Muller, Springer International, 1997.

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T.Y.B.Sc.: **Course Code: S.LSC.5.03**

Title: Industrial Biotechnology and Nanotechnology

Learning Objectives:

The course must enable the student to:

1. Understand the basics of industrial fermentation processes – strain improvement, media formation, design of bioreactors and downstream processing of products.
2. Describe bioprocess technology involved in industrial production of fermented beverages, antibiotics, recombinant insulin and enzymes.
3. Explain the steps involved in discovery and development of a lead molecule.
4. Understand the concept of business development and bioentrepreneurship.
5. Understand the concept and applications of nanotechnology.

Number of lectures: 60

Unit I: Fundamentals of Industrial Biotechnology **15 lectures**

1. History and overview of fermentation process
2. Source of Industrial Biocatalysts – microbial cells, animal & plant tissues
3. Batch and Continuous process
4. Primary & Secondary Screening of Microorganisms, Strain improvement of Industrial Microorganisms (selection of auxotrophic and analogue resistant mutants)
5. Media requirements & optimization, Criteria for good fermentation medium.
6. Types and design of Bioreactors
    a. Types of fermentation process: suspended and solid substrate.
    b. Basic bioreactor design, overview of bioreactor types-stirred tank bioreactor, bubble column bioreactor, air-lift reactor,
    c. Schematic overview of a bioreactor with control systems

Unit II: Downstream processing in industry **15 lectures**

1. Role and importance of downstream processing in biotechnological processes.
2. Separation and Recovery of products:
    a. Methods in cell harvesting – filtration and centrifugation
    b. Cell disruption methods for intracellular products – mechanical & non-mechanical methods
    c. Separation of Insoluble Products - flocculation and sedimentation, centrifugation and filtration
    d. Separation of Soluble Products - Precipitation & liquid-liquid extraction
    e. Membrane-based separations - micro- & ultra-filtration, dialysis.
    f. Chromatography techniques – ion-exchange, adsorption, HPLC, Affinity, Gel filtration

Unit III: Bioprocess Technology - Industrial Production **15 lectures**

1. Food – Wine and Vinegar
2. Antibiotics – Penicillin
3. Recombinant human insulin
4. Enzyme - Amylases
5. Concept of immobilization – Biosensors (Principle, types, advantages and uses)
6. Plant Tissue Culture – Micropropagation (Clonal propagation), Plant secondary metabolites (anticancer drugs)
7. Animal Tissue Culture : Vaccines - Polio, HBV

Unit IV: Discovery & Development of Industrial Product and Bio-nanotechnology
15 lectures

1. Discovery and Development of Industrial Product (7)
   a. High content screening to identify lead molecules and High throughput screening
   b. *In vitro* and *In vivo* toxicity studies
   c. Clinical trials – Phase I , Phase II Phase III
   d. GMP and GLP – Regulatory issues in Industrial Bioprocess
   e. Business Development and Bio-entrepreneurship

2. Bio-nanotechnology (8)
   a. Introduction and the scope of Bionanotechnology
   b. Nanomaterials used in medicine
   c. Fields of Application
      i. Nanoparticles for delivery of Drugs, DNA, RNA
      ii. Cancer Therapy
      iii. Biomolecular motors.

Practicals
Course S.LSC.5.03 PR

1. TLC of sugars/amino acids
2. Estimation of Alcohol
3. Purification of Amylase by ammonium sulphate precipitaion
4. Electrophoresis- a. Activity staining of Amylase in agarose gels
   b. Separation of post fermentation products by PAGE
5. Separation of components in industrial broth by ion exchange/ affinity/gel filtration chromatography
6. Immobilization of Amylase/yeast cells using sodium alginate
7. Bioassay of Penicillin
8. **Projects (any one / two):**
   a. Wine production
   b. Animal tissue culture
   c. Plant tissue culture
   d. Mushroom cultivation
   e. Vaccine Production
   f. Isolation of Analogue resistant / auxotrophic mutants
   g. Isolation of antibiotic/vitamin B12 synthesizers
   h. Any other relevant topic

References:

1. Bioprocess Engineering*:* Basic Concepts - Michael L Shuler and Fikret Kargi, , Prentice-Hall of India Pvt Ltd, 2008.
2. Principles of Fermentation Technology - Stanbury P.F.,Whitaker A. and Hall S.J,. Elsevier India Pvt Ltd, 2007.
3. Culture of Animal Cells Freshney, R. I Wiley-Liss.
4. Industrial Microbiology – Prescott and Dunn
5. Industrial Microbiology – Casida,L.E, Wiley Eastern Ltd, 1968
6. Plant biotechnology - J Hammond, *et. al* ,Springer Verlag.
7. Introduction to Nanosciene - G.L. Hornyak, Joydeep Dutta, Harry R. Tibbals,nil. K. Rao., CRC Press,2008.
8. Biotechnology – Applying the genetic revolution. – David P. Clark and Nanette J. Pazdernik, Academic Press, 2009.
9. Biopharmaceuticals- Biochemistry and Biotechnology – 2nd edition, GaryWalsh, John Wiley and sons,2003.
10. A textbook of modern toxicology,4th Ed , Ernest Hodgson, John Wiley and sons, 2010.
11. Advances in Pharmaceutical Biotechnology- S.P.Vyas and H.D.Kumar, 2011.

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T.Y.B.Sc.: **Course Code: S.LSC.5.04**

Title: Ecology and Biodiversity

Learning Objectives:

The course must enable the student to:

1. Discuss the concepts of ecology and inter-relations of abiotic and biotic factors
2. Elucidate the fundamental laws of energy transfer and efficiency in ecosystems
3. Elaborate on various intra-species and inter-species interactions
4. Understand biodiversity – qualitatively and quantitatively
5. Identify and weigh out the threats that damage ecosystems and endanger biodiversity

Number of Lectures: 60

UNIT I: Ecology and Ecosystems **(15 lectures)**

1. History and scope of ecology.
2. Physiological Ecology:
   a. Ecological niche, tolerance range, optima, acclimation
   b. Limiting factors: temperature, water, light, soil, fire, nutrients.
3. Biogeochemical cycling of Carbon, Nitrogen and Phosphorus.
4. Population Ecology: -
   a. Concept of an ecosystem
   b. Carrying capacity
   c. Population Dynamics: Growth, Density, Age distribution, Mortality, Natality
   d. Intrinsic rate of natural increase
   e. Population Fluctuations and cyclic oscillation, Population regulation;
   f. Density dependent and independent mechanisms, r- and k Selection.
5. Behavioral Ecology
   a. Development of behavior
   b. Behavioral adaptations for Survival, Foraging and feeding behavior
   c. Parental care and Mate location.

UNIT II: Community and Ecosystem Ecology. **(15 lectures)**

1. Community Ecology - Species interaction with communities and ecosystems:
   a. Relationships- Predation, Competition, Mutualism,
   b. Antagonism.
2. Community Change
   a. Succession: Primary and Secondary
   b. Models of Succession.
   c. Climax community and types of climax.
3. Concept of ecosystem:
   a. Classification of ecosystem.
   b. Trophic structure of ecosystem.
4. Energy Transfer in an Ecosystem
   a. Fundamental concepts of energy.

b. Laws of thermodynamics.
c. Concept of production.
d. Primary production, limits and Efficiency of Primary production.
e. Secondary production, limits and Efficiency of secondary production.
f. Energy flow in the ecosystem.

5. Trophic structure
   a. Food chains: - components and types.
   b. Food Web
   c. Ecological pyramids.

UNIT III: Biodiversity and Cladistics (15 lectures)

1. Biodiversity: - Distribution of flora and fauna and factors affecting this distribution.
2. Levels of biodiversity.
3. Status and importance of biodiversity.
4. Measurement of biodiversity: - a) classical methods and b)using genetic tools.
5. Assessment of global and local biodiversity, making an inventory.
6. Evolution of biodiversity (with one example).
7. Loss of biodiversity.
8. Basic principles and methods of cladistic analysis.
9. Introduction to Cladograms.
10. Construction of a simple cladogram.

UNIT IV: Impact of human activities on ecosystems (15 lectures)

1. Impact on Biological diversity: (8)
   a. Deforestation: Land use for mining, housing projects, dams.
   b. Threats associated with Intensive agricultural practices.
   c. Mono culturing of plant species and loss of diversity.
   d. Impact of exotic species on local biodiversity.
   e. Exploitation of aquatic plant and animal species.
   f. Emergence of new and resistant species, bacteria and pests.
2. Toxicology: (7)
   a. Basic principles of toxicology
   b. Concepts of LD50, LC50 and dose-response relationship.
   c. Classification of Pesticides and their mode of action.
   d. Pesticides / xenobiotics and public health programs eg diclofenac.
   e. Toxicokinetics: - Absorption, Distribution, Metabolism and Excretion of Xenobiotics.
   f. Bio accumulation and bio magnification of pesticides and industrial chemicals (Dioxins, heavy metals and halogenated compounds).

Practicals

Course S.LSC.5.04 PR

1. Quadrat and Transect Analysis
2. Cladistics – construction of a simple cladogram using principle of parsimony
3. Estimation of Nitrite in Water
4. Estimation of Hardness of Water
5. Estimation of Carbonates in Soil
6. Estimation of Salinity of water
7. Dissolved Oxygen (DO) / Biological Oxygen Demand (BOD)
8. Chemical Oxygen Demand (COD)
9. Isolation of *Rhizobium* from root nodules of fenugreek.
10. Visit to Mahim Nature Park to study plant diversity

References:

1. Payment for Ecosystem Services, Pushpam Kumar, Roldan Muradian, December 2008
2. A Text Book on Ecology and Environmental Science, M Prasanthrajan and P P Mahendran, Agrotech, 2008
3. National Book Trust of India (1995). Trees – An Ecology Book. Asian/Pacific Cultural Centre for UNESCO, Tokyo. National Book Trust, India
4. Smith G. A., Williams D. R. (1999). *Ecological Education in Action - On Weaving Education, Cultural and the Environment*. State University of New York. Press, USA.
5. Ecosystem Ecology: A New Synthesis - By David G. Raffaelli, Christopher L. J. Frid
6. National Book Trust of India (1995). Trees – An Ecology Book. Asian/Pacific Cultural Centre for UNESCO, Tokyo. National Book Trust, India

T.Y.B.Sc. LIFE SCIENCE Courses 5.01, 5.02, 5.03, 5.04
Template of Theory Question paper

CIA I – 20 marks, 45 mins.
Unit I: Objectives/Short questions
CIA II – 20 marks, 45 mins.
Unit II: Objectives/Short questions

End Semester exam – 60 marks, 2 hours

Mark-distribution pattern for Practical
CIA & End Semester Practical Examination of T.Y.BSc.
5.01, 5.02, 5.03, 5.04

CIA per course

Q1. Any one / two practicals	15 marks
Q2.Journal	05 marks

End semester Practical Examination

Q1. Any two / three practicals	20 marks
Q2. Identification/project report/viva	05 marks
Q3.Viva / Identification	05 marks