St. Xavier's College (Autonomous)
Mumbai

Syllabus
For 5th Semester Courses in
LIFE SCIENCE
(June 2020 onwards)

Contents:
Syllabus (theory and practicals) for Courses:

Percent revision:
2015-16: No revision
2016-17: No revision
2017-18: 8.33% (0501) and 8.33% (0502)
2018-19: 40 - 50%
2019-20: 3% (0502) and 1% (0504)
2020-21: No revision

LIFE SCIENCE

T.Y.B.Sc. **Course No.: SLSC0501**

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 and repair **(10)**

a. Forms of recombination: Homologous, site-specific and illegitimate
b. Model for homologous recombination: Holliday Model
c. Gene conversion
d. Recombination repair in *E.coli*- REC- BCD pathway
e. Repair systems in *E.coli*: Excision repair and Error - Prone repair
f. Non -homologus end joining repair

2**. Mobile genetic elements** **(5)**

a. Overview of mobile genetic elements
b. Transposable elements in bacteria: IS element, Composite and Non-composite transposons
c. Transposable elements in eukaryotes: Ac/ Ds element in maize
d. Transposable elements in humans: LINES, SINES
e. Evolutionary significance of transposable elements

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

1. Molecular techniques for cloning genes **(9)**

a. Restriction endonucleases Type II enzymes
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

References:

1. *Principles of Genetics* (2005) 4th Edition, Snustad, D.P. and Simmons, M.J. John Wiley and Sons
2. *Introduction to Genetic Analysis* (2015) 11th Edition, Griffiths, A.J., Wessler, S.R., Lewontin, R.C. and Caroll, S.B. W.H. Freeman and Co.
3. *iGenetics: A Molecular Approach* (2009) 3rd Edition, Rusell, P. Benjamin Cummings Publication.
4. *Genetics: A Conceptual Approach* (2017) 4th Edition, Pierce, B. McMillan Publishers.
5. *Lewin's Genes XII* (2018) 12th Edition, Krebs, J.E., Goldstein, E.S., Kilpatrick, S.T. Jones and Bartlett Learning.

LIFE SCIENCE

T.Y.B.Sc. **Course No.: SLSC0502**

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. Mechanisms of development: Asymmetric cell division, Inductive signals, Lateral inhibition and Positional value **(1)**
3. Model organisms in Developmental Biology and their significance: *C.elegans*, Drosophila, Zebrafish, Xenopus, Mouse, *Arabiposis* and *Dictyostelium* **(3)**
4. Fertilization **(2)**
5. Avian Embryology: **(8)**
   a. Cleavage
   b. Gastrulation
   c. Axis Specification and the Avian 'Organizer'
   d. Neurulation:
   e. Somite formation
   f. Organogenesis

UNIT II: **(15 lectures)**

1. Totipotency, Pluripotency, Determination and Differentiation **(2)**
2. Differentiation as a change in gene expression. **(3)**
3. Cell cell communication in development **(3)**
4. Cell cycle and its regulation **(3)**
5. Programmed cell death: apoptosis **(2)**
6. Stem cell biology - basic concepts, stem cell niche, Induced Pluripotency, Transdifferentiation **(2)**

UNIT III: **(15 lectures)**

1. Drosophila Development **(12)**
   a. Early development
   b. Generation of body plan
   c. Genes that pattern the body plan: anterior-posterior polarity, dorsal-ventral patterning
      i. maternal genes
      ii. segmentation genes
      iii. Homeotic genes

iv. Realiasator genes

2. Patterning of Flower development in Arabidopsis **(3)**

UNIT IV: **(15 lectures)**

1. Metamorphosis and regeneration **(4)**
2. Ageing and Senescence: cellular and molecular changes **(2)**
3. Abnormal Developmental Programs: **(5)**
   a. Teratogenesis: Alcohol, Retinoic acid, Endocrine disruptors
   b. Cancer as a disease of development
4. Sex Determination and dosage compensation **(2)**
5. Evolutionary Developmental Biology **(2)**

References:

1. *Developmental Biology* (2016) 11th Edition, Gilbert, S. and Barresi, M. Sinauer Associates, USA.
2. *Principles of Development* (2011) 3rd Edition, Wolpert, L. Smith, J., Jessell, T., Lawrence, P., Robertson, E. and Meyerowitz, E. Oxford University Press.
3. *Molecular Biology of the Cell* (2015) 6th Edition, Alberts, B., Johnson, A., Lewis, J., Morgan, D., Raff, M., Roberts, K. and Walter, P. Garland Science.
4. *Molecular Cell Biology* (2016) 8th Edition, Lodish, H., Berk, A., Kaiser, C., Krieger, M., Bretscher, A., Ploegh, H., Amon, A., and Martin, K. W.H. Freeman and Company.
5. *The Coiled Spring – How Life Begins* (2000) Bier, E. Cold Spring Harbor Laboratory Press.

LIFE SCIENCE

T.Y.B.Sc. **Course No.: SLSC0503**

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.

References:

1. *Bioprocess Engineering: Basic Concepts* (2008) 2nd Edition, Shuler, M. and Kargi, F. Prentice-Hall.
2. *Principles of Fermentation Technology* (2007) 3rd Edition, Stanbury, P., Whitaker, A. and Hall, S. Elsevier.
3. *Culture of Animal Cells: A Manual of Basic Technique and Specialised Applications* (2011) 6th Edition, Freshney, R. John Wiley and Sons.
4. *Industrial Microbiology* (1982) Prescott, S., Dunn, C. and Reed, G. AVI Publication Company.
5. *Industrial Microbiology* (1968) Casida, L. John Wiley and Sons.
6. *Plant biotechnology* (1999) Hammond, J., McGarvey, P. and Yusibov, V. Springer.
7. *Introduction to Nanoscience* (2008) Hornyak, G., Dutta, J., Tibbals H. and Rao, A. CRC Press.
8. *Biotechnology: Applying the genetic revolution* (2009) Clark, D. and Pazdernik, N. Academic Press.
9. *Biopharmaceuticals: Biochemistry and Biotechnology* (2003) Walsh, G. John Wiley and Sons.
10. *A Textbook of Modern Toxicology* (2010) Hodgson, E. John Wiley and Sons.

LIFE SCIENCE

T.Y.B.Sc. **Course No.: SLSC0504**

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. Mate location, Mating systems and Parental care

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).

References:

1. *Payment for Ecosystem Services* (2008) Pushpam, K. and Muradian. UNDP
2. *A Text Book on Ecology and Environmental Science* (2008) Prasanthrajan, P. and Mahendran, P. Agrotech.
3. *Trees – An Ecology Book* (1995), Asian/Pacific Cultural Centre for UNESCO, Tokyo. National Book Trust, India
4. *Ecological Education in Action - On Weaving Education, Cultural and the Environment*. (1999) Smith, G., and Williams, D. State University of New York. Press, USA.
5. *Ecosystem Ecology: A New Synthesis* (2012) Raffaelli, D. and Frid, C. Cambridge Univ. Press.

Practical: SLSC05PR

Genetics

1. Isolation of a pure culture from natural habitat:
   a. Identification up-to species level (Gram nature, basic biochemical tests, Bergey's manual)
   b. Culture maintenance
2. Viable count of overnight culture from the isolate
3. T4 plaque assay
4. Growth curve of *E. coli*
5. Genomic DNA extraction from chicken liver and quantification
6. Molecular biology
   a. Plasmid isolation and visualization on agarose gel after electrophoresis
   b. Competent cell preparation and transformation of *E. coli* DH5 with plasmid DNA

Developmental Biology

1. Study of a developing chick embryo using permanent slides
2. Study of different developmental stages of a developing chick embryo by preparing temporary mounts
3. Study of differential development at regions within a chick embryo using a mitochondrial marker enzyme (cytochrome c oxidase)
4. Study of different developmental stages of zebra fish by preparing temporary mounts
5. Whole mount staining of zebrafish embryo - Alcian blue staining to study fin development
6. Study of the morphology and life cycle of *C. elegans*
7. Behavioural assay using *C. elegans* as a model system
8. Project

Industrial Biotechnology and Nanotechnology

1. TLC of lipids
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 bioprocess products by PAGE
5. Immobilization of Amylase/yeast cells using sodium alginate
6. Bioassay of ampicillin
7. Projects (any one/ two)
   a. Wine production
   b. Mushroom cultivation

Ecology and Biodiversity

1. Quadrat and Transect Analysis
2. Estimation of hardness in a given water sample
3. Estimation of chlorinity and salinity in a given water sample
4. Isolation of *Rhizobium* from fenugreek
5. Cladistics – construction of a simple cladogram using principle of parsimony
6. Project

Template of Theory Question paper

T.Y.B.Sc. LIFE SCIENCE

Courses 0501, 0502, 0503, 0504

CIA I – 20 marks, 45 mins.

Objectives/Short questions

CIA II – 20 marks

Test (*45 mins.*)/ Survey/Assignment/ Presentation/ Poster/ Essay/ Review

End Semester exam – 60 marks, 2 hours

Question 1: Unit I: maximum marks per sub-question - 12 marks

15 marks to be answered out of 22-30 marks

Question 2: Unit II: maximum marks per sub-question - 12 marks

15 marks to be answered out of 22-30 marks

Question 3: Unit III: maximum marks per sub-question - 12 marks

15 marks to be answered out of 22-30 marks

Question 4: Unit III: maximum marks per sub-question - 12 marks

15 marks to be answered out of 22-30 marks

Mark-distribution pattern for Practical

Course: SLSC05PR

CIA & End Semester Practical Examination	**Total marks: 200**
CIA per course	
Q1. Any one / two practicals	15 marks
Q2.Journal	05 marks
End semester Practical Examination (0501, 0502 & 0503)	
Q1. Any two / three practicals	20 marks
Q2. Identification/project report/viva	10 marks
End semester Practical Examination (0504)	
Q1. Project	20 marks
Q2. Practical	10 marks

DEPARTMENT OF LIFE SCIENCES AND BIOCHEMISTRY

T.Y.B.Sc. Life Science Exam Grid Semester 5					
Course	**Exam**	**Knowledge and Information**	**Understanding**	**Application/Analysis**	**Total**
0501	CIA I	10	3	7	20
	CIA II	10	3	7	20
	End semester	30	15	15	60
Course	**Exam**	**Knowledge and Information**	**Understanding**	**Application/Analysis**	**Total**
0502	CIA I	12	8		20
	CIA II	12	8		20
	End semester	30	20	10	60
Course	**Exam**	**Knowledge and Information**	**Understanding**	**Application/Analysis**	**Total**
0503	CIA I	12	8		20
	CIA II	12	8		20
	End semester	30	20	10	60
Course	**Exam**	**Knowledge and Information**	**Understanding**	**Application/Analysis**	**Total**
0504	CIA I	12	8		20
	CIA II	12	8		20
	End semester	30	20	10	60