St. Xavier's College – Autonomous Mumbai

Syllabus
For 6th Semester Courses in
LIFE SCIENCE
(June 2015 onwards)

Contents:

Syllabus (theory and practicals) for Course:

Template for theory and practical question paper

LIFE SCIENCE

T.Y.B.Sc. **Course No. S.LSC.6.01**

Title: Immunology

Learning Objectives:

The course must enable to student to:

1. Understand the concept and role of innate and adaptive immunity and the factors that contribute towards immunity
2. Be able to describe the organization and the role of the various cells and organs of the immune system
3. Understand the structure-function relationship of immunoglobulins
4. Know the structure and role of antigen receptors in immunity
5. Describe the role of the MHC molecules in adaptive immunity
6. Study the various disorders related to the immune systems

Number of lectures: 60

UNIT I **(15 lectures)**

A. Overview of the immune system (1)

B. Cells and organs of the immune system (5)

1. Cells:
   - i. Hematopoiesis of leukocytes
   - ii. Myeloid cells – structure and function
   - iii. Lymphoid cells
   - iv. NK cells
2. Primary and secondary lymphoid organs
   - i. Bone marrow and Bursa of Fabricus
   - ii. Thymus
   - iii. Spleen
   - iv. Lymph node
   - v. MALT

C. Principles of innate immunity (7)

1. External barriers
   - i. Skin and mucous membranes
   - ii. Chemical secretions
   - iii. Normal microflora
2. Inflammation
3. Complement
   - i. Classical pathway
   - ii. Alternative pathway
   - iii. Lectin pathway
   - iv. Functions
4. Pattern recognition in innate immune system
   - i. PAMP's
   - ii. PRR's
   - iii. TLR's

D. Ontogeny and phylogeny of immune cells: (2)
Immune response in the neonate
Evolution of the immune system

UNIT II **(15 lectures)**

A. Structure of a typical antibody molecule (5)
1. Five classes of immunoglobulins
2. Structure and function of Ig classes

B. Genetics of antibody diversity (5)
1. Heavy chain gene rearrangement
2. Light chain gene rearrangement
3. Somatic hypermutation

C. Humoral immune response (5)
1. B-cell receptors
2. B-cell ontogeny
3. Role of APC's and T-cells in B-cell response

UNIT III **(15 lectures)**

A. Cell mediated immunity (5)
1. T-cell receptors
2. T-cell ontogeny
3. Role of TH1, TH2 and Treg cells
4. Cell mediated cytotoxicity of T cells

B. MHC complex and development of immunity (4)
1. MHC-I and MHC-II molecules – structure and function
2. MHC polymorphism
3. MHC restriction
4. Antigen processing and presentation in endogenous pathways
5. Antigen processing and presentation in exogenous pathways

C. Transplantation (2)

D. Hypersensitivity (4)
1. Anaphylactic hypersensitivity (type I)
2. Antibody dependent cytotoxic hypersensitivity (type II)
3. Immune complex mediated hypersensitivity (type III)
4. Cell-mediated (delayed-type) hypersensitivity (type IV)

UNIT IV **(15 lectures)**

A. Immune tolerance (3)
1. Mechanism of T and B cell tolerance
2. Immunology of pregnancy
3. Role of T-regulatory cells

B. Autoimmunity (4)
1. Mechanism of induction

2. Types of autoimmune diseases
   i. Systemic: systemic lupus erythromatosus, multiple sclerosis
   ii. Organ-specific: Grave's, Myasthenia Gravis

C. Immunodeficiency diseases (3)

1. Primary: X-linked aggamaglobulinemia, SCID, CGD
2. Secondary: AIDS

D. Vaccines (5)

1. Passively acquired immunity
2. Killed organisms as vaccines
3. Live attenuated organisms as vaccines
4. Subunit vaccines
5. DNA vaccines
6. Monoclonal antibody as vaccines

Practicals
Course: S.LSC.6.01 PR

1. Agglutination reactions:
   a. Study of blood groups
   b. Isohemagglutinin titre in blood
   c. Quantitative Widal test
2. Precipitation reaction: Ouchterlony test
3. Separation of mononuclear cells (lymphocytes) using a gradient and the determination of viable count of the same
4. Electrophoresis of serum proteins/ subfractionation of Igs
5. ELISA as a diagnostic tool (demonstration)
6. Innate immunity:
   a. Prevention of colonization of skin by *E. coli*
   b. Testing the effects of saliva, tears, lysozyme on *Staphylococcus*, *Streptococcus*, etc.
7. Advanced techniques in immunology to be covered in practicals by reading research paper on it (principle, technique and applications):
   a. Fluorescence Activated Cell Sorter (FACS)
   b. Radionimmuno Assay (RIA)

References

1. Kuby Immunology by Kindt, Goldsby, Osborne; 6th edition, W. H. Freeman, 2007
2. Immunology by Roitt, Brostoff, Male; 6th edition, Blackwell Publishing, 2001
3. Immunobiology by Janeway and Travers, et al, 7th edition , Garland Sc. 2005
4. Immunology by Ian Tizzard , 4th ed., SaundersCollege Publishing, 1995.
5. Roitt's Essential Immunology – P.Delves, S. Mastin et al, Blackwell Pub., 11th ed., 2006.
6. Immunology by Kalus Elgert, 2nd ed., Wiley Blackwell, 2010
7. The Immune response to infection by S.Kaufmann et al, ASM Press,2011
8. Cellular and Molecular Immunology by A.K. Abbas et al, 5th ed, Saunders, 2003.

LIFE SCIENCE

T.Y.B.Sc. **Course No. S.LSC.6.02**

Title: Neurobiology

Learning Objectives:

On completion of the course, the student must be able to:

1. Know the structural and functional organization of the nervous system.
2. Understand the cellular and molecular mechanisms that underlie neuronal signaling.
3. Comprehend the structure-function relationships in the sensory components of the nervous system.
4. Elucidate the cellular and molecular processes that contribute to the development, maintenance and modification of neural circuitry.

Number of lectures: 60

UNIT I: Organization and physiology of the nervous system (15 lectures)

1. Evolution of the nervous system (1)
2. Cellular organization of the nervous system (2)
   a. A typical nerve cell
   b. Cellular diversity of the nervous system
3. Vertebrate nervous system (4)
   a. Organization of the nervous system
   b. Central nervous system: brain and spinal cord, lobes of the brain and their functional role, motor areas, somatosensory areas
   c. Peripheral nervous system: cranial and spinal nerves, autonomic nervous system, structural organization and functional role
4. Ionic basis for nerve potentials (8)
   a. Resting membrane potential –ionic basis: Donnan's equilibrium experiments, Nerst' potential, Goldman's equation
   b. Action potential and its propagation –Hodgin and Huxley's voltage clamp experiment, propagation of an action potential along a myelinated and non-myelinated axon, ion channels and sodium-potassium pump

UNIT II: Communication in the nervous system (15 lectures)

1. Types of synapse: structural organization of chemical and electrical synapses, n-m junction, types of channels (3)
2. Neurotransmitters: metabolism receptors, second messenger systems, physiological role and pharmacological significance: (8)
   a. Acetylcholine (nicotinic and muscarinic receptors)
   b. Norepinephrine, dopamine (D1 and D2 receptors)
   c. GABA
   d. Glutamate
3. Synaptic potentials: chemical synapses –excitatory post synaptic potential (EPSP), inhibitory post synaptic potential (IPSP), neuro-muscular junctions –miniature end plate potentials (MEPPs) (3)
4. Receptor potentials (phasic and tonic receptors), generator potentials (1)

UNIT III: Signal transduction and processing in the sensory nervous system (15 lectures)

1. Mechanotransduction: skin, muscle stretch receptors, hair cells in the auditory and vestibular systems (6)
   a. Auditory system: structure of the ear, cochlea and organ of Corti, receptors and mechanism of transduction, auditory pathway (diagrammatic representation only)
   b. Vestibular system: structure of the vestibular labyrinth, maculae and cristae, receptors, mechanisms of transduction
2. Temperature and pain transduction (1)
3. Phototransduction –visual system: structure of the eye, retina, photoreceptors (rods and cones), mechanism of phototransduction, binocular vision, visual pathway (retina –Lateral Geniculate Nucleus –visual cortex; diagrammatic representation only) Light and dark adaptation (5)
4. Chemotransduction: olfactory and gustatory systems, receptors –structure, mechanism of transduction (3)

UNIT IV: Cognitive functions of the brain and neurological disorders (15 lectures)

1. Embryological development of the vertebrate nervous system: (comparison with invertebrate, *Drosophila*, whenever possible) (6)
   a. Pattern formation –axes of symmetry
   b. Nerulation: formation of neuroectoderm, neural tube and neural crest cells and their derivatives, induction as the basis of neurulation
   c. Formation of the major sub-divisions of the brain: fore brain, mid brain and hind brain
   d. Differentiation: into neuronal and glial cell types, neuronal migration, synapse formation, synapse competition, maturation and cell death
   e. Circuit formation: critical periods in development, effect of neuronal activity in development of neural circuits
2. Emotions (4)
   a. The limbic system: amygdala, physiological changes associated with emotions (e.g., fear, pleasure), addiction-role of neurotransmitters, serotonin as a mood enhancer.
3. Memory (5)
   a. Qualitative and temporal categories of memory, molecular mechanisms of short and long term memory, e.g.: behaviour test in Aplysia.
4. Neurological diseases and disorders (assignments for continuous internal assessment-II)

Practicals
Course: S.LSC.6.02 PR

1. Dissection & display of nervous system of invertebrates –earthworm / prawn / cockroach or any other suitable animal
2. Dissection & display of brain of vertebrates –chick brain/ or any other suitable system
3. Dissection and observation of the retina from a 10 day old chick embryo (demonstration)
4. Temporary mounts of any three of the following:
   a. Cornea of prawn/cockroach

   b. Statocyst of prawn
   c. Striated/ smooth muscle fibre
   d. Methylene blue staining of earthworm nerve cord or any other suitable nerve cord or brain to observe organization of neuronal cell bodies in invertebrates
5. Study of Permanent slides of:
   a. Medullary nerve fibre
   b. TS of spinal cord
   c. Mammalian retina
6. Stroop test, Blind spot test
7. Cognitive function tests (using COGLAB): Attention Blink, Memory Span, Irrelevant Speech effect.
8. Study of human brain and human nervous system using models/ charts/ videos/ photographs
9. Screening of the film, "Lorenzo's Oil".

References

1. Neuroscience: Exploring the brain, M.F.Baer, B.W.Connors & M.A.Paradiso, William & Wilkins, Baltimore, 2007
2. Neurobiology 3rd edition G.M. Shepherd Oxford University Press.
3. Principles of Neural Science. E.R.Kandel, J.H.Schwartz and T.M. Jessel. Prentice Hall International.
4. Instant Notes –Neurosciences, A.Longstaff Viva Books Pvt Ltd., New Delhi, 2002
5. Text Book of Medical Physiology A.C.Guyton and J.E.Hall Saunders College Publishers.
6. Elements of Molecular Neurobiology C.U.M. Smith J Wiley and Sons Publishers, N.Y.
7. An Introduction to Molecular Neurobiology Z.W. Hall Sinauer Associates Inc. Publishers.
8. Ion Channels –Molecules in Action D. J. Aidley and P.R. Stanfield Cembridge University Press.
9. Fundamentals of Neuroscience, Larry Squire et al 2006
10. From Neuron to Brain, John Nicholls, Fifth edition, 2010
11. Neuroscience, Dale Purves et al, Fourth edition, 2008
12. Physiology of a nerve cell, Katz
13. Comparative Neurobiology, J.P. Mill

Life Science

T.Y.B.Sc. **Course No. S.LSC.6.03**

Title: Recombinant DNA Technology and Bioinformatics

Learning Objectives:

The objective of the course is to:

1. To describe the use of restriction endonucleases in gene cloning.
2. To describe the different vectors(prokaryotic and eukaryotic) that can be used in gene cloning experiments, including the advantages and disadvantages of each.
3. Describe the essential steps involved in gene cloning with relavant examples.
4. To describe the various strategies of cloning, screening and selction methods.
5. To understand the various metods used in DNA sequencing.
6. To explain the general principles of generating transgenic plants, animals.
7. To describe the applications of recombinant DNA technologies is medicine, agriculture and industry.
8. To introduce the use of bioinformatics in biology.

Number of lectures: 60

UNIT I **(15 lectures)**

A. Introduction to Genetic Engineering (1)

B. Restriction Endonucleases (4)

1. Restriction Endonuclease: Type I, Type II, Type III
2. Restriction mapping

C. DNA Joining Strategies (2)

1. DNA ligase
2. Homopolymer tailing
3. Adaptors

D. Cloning Vectors: (8)

1. Basic properties of plasmids
2. pBR322 as vector
3. pUC as vector
4. Transcription vectors (pGEM3Z)
5. Expression vectors (GST fusion)
6. Cosmid vectors
7. P element as a vector
8. Mammalian vectors

UNIT II **(15 lectures)**

A. Cloning strategies: (5)

1. Shotgun Cloning: Genomic DNA libraries
2. cDNA cloning
3. Positional cloning
4. PCR cloning
5. Cloning eukaryotic genes (insulin / somatostatin)

B. Screening and selection strategies: (4)

1. Direct Selection eg antibiotic resistance, GFP, LacZ
2. Immunochemical screening
3. Nucleic acid hybridization method
4. Subtraction cDNA cloning

C. Sequencing Genes and Genomes: (6)

1. Chain termination method of DNA sequencing
2. Next generation sequencing
3. Shotgun approach to genome sequencing
4. Clone contig approach

UNIT III **(15 lectures)**

A. Cloning in Yeast: (2)

1. Vectors for use in Yeast
2. Cloning large DNA molecules in YAC

B. Transgenic Plants (6)

3. *Agrobacterium* mediated transformation
4. Ti plamid
5. Transgenic tobacco expressing luciferase gene
6. Bt Cotton
7. Herbicide-resistant plants
8. Plant viruses as vectors (eg CaMV virus)

C. Transgenic Animals (7)

1. Selectable markers for animal cells eg HAT, methotrexate
2. Reporter genes for promoter analysis (Lac Z, GFP)
3. Viruses as gene-transfer vectors (Baculoviruses)
4. Methods for production of transgenic mice (Pronuclear microinjection, retroviruses, Embryonic stem cells)
5. Transgenic mouse / Super mouse – (MT promoter fused to human growth hormone)
6. Transgenic Goats (isolation of cloned proteins from goat milk)
7. Whole animal cloning eg Dolly

Unit IV **(15 lectures)**

A. Advanced Transgenic Technology: (4)

1. Knock-out, knock-down, knock-in technology
2. Site-specific recombination using Cre-recombinase LOX system
3. Gene therapy eg SCID

B. Gene cloning and DNA analysis in : (one example each) (2)

1. Medicine and Agriculture,
2. Forensics and Archaeology

C. Ethics of Cloning : GM foods, Animal Cloning (1)

D. Bioinformatics: (8)

1. Databases
2. Analyses programs (FASTA, BLAST, CDD, CLUSTALW, RASMOL, SWISSPROT, PDB, SignalP)

3. Sequence annotation
4. Molecular phylogeny and evolution
5. Gene expression Omnibus, OMI: (how a gene is altered in different diseases)

Practicals:
Course: S.LSC.6.03 PR

1. Cloning and expression of an eukaryotic gene in *E.coli*/Yeast (Practicals/Projects)
    i. Genomic DNA extraction
    ii. Plasmid DNA extract and isolation
    iii. Restriction enzyme digest of plasmid and genomic DNA
    iv. Restriction Mapping of different vectors
    v. Ligation and competent cells
    vi. *E.coli*/Yeast transformation
    vii. Antibiotic / lac Z Selection
    viii. Expression of a gene (GST fusion)
2. Bioinformatics problems
3. PCR of genomic DNA using specific primers
4. Problems on DNA fingerprinting
5. Use of NEB catalogue: comparison of different restriction enzymes and vectors.

References:

1. Principles of gene manipulation by S.B. Primrose and Twyman, 7th Ed, Blackwell Sc., 2006
2. Principles of gene manipulation by R.W. Old and S.B. Primrose, 6th edition, Blackwell Sc., 2004
3. Recombinant DNA by Watson, 3rd ed. ASM Press, 2001.
4. Gene cloning and DNA analysis by T.A. Brown, 2nd ed. 2009
5. Bioinformatics-Methods and Applications by S.C. Rastogi et al 2nd edition, 2006
6. Integrated Genomics by A. Caldwell et al, Wiley Publishers, 2006
7. Molecular Biotechnology- Principles and application of recombinant DNA, 4th ed., B. Glick et al, ASM Press, 2010.
8. Biotechnology- Applying the genetics to revolution, D. Clark, N. Pazdernik, Academic Press, 2009.

LIFE SCIENCE

T.Y.B.Sc. **Course No. S.LSC.6.04**

Title: Sustainable Development and Carbon Management

Learning Objectives:

The course aims to sensitize the students towards the current issues related to environment management. At the end of the course the students are expected to:

1. Understand conservation of biodiversity and legal frameworks available for its implementation.
2. Identify the consequences of Global warming and Climate change and be informed of the various National and International Policies governing these issues.
3. Familiarize themselves with the basic tenets of sustainability.
4. Understand the concept of carbon currency in International Trade.

Number of lectures: 60

UNIT I: Conservation of Biodiveristy (15 lectures)

1. Valuation of biodiversity / living resources for active conservation.
2. National Parks and Sanctuaries (establishment, designing and management).
3. The importance of Sunderbans and wetlands in India.
4. Provisions for inventorying and monitoring the conservation process.
5. Ex-situ conservation: (Zoos, aquariums, botanical gardens, herbariums and arboretums).
6. Eco tourism.
7. Earth Summits
8. Man and Biosphere program.
9. Overview of Indian Legislation - Wild life Protection Act, Environment Protection Act, CITES and CBD.
10. Intellectual property and status of India.

UNIT II: Global warming and Climate change (15 lectures)

1. Greenhouse Gases, Global Warming Potential (GWP), Greenhouse Gas Effect and Global Warming
2. Causes of Climate Change
3. Impact of Climate Change on Ecology and Biodiversity
4. Effects of Climate Change – on agriculture, human health and economy.
5. Adaptations to Climate Change - Indicators
6. International Protocols and National policies: Montreal, Kyoto, COP, CDP, GHG, GRI, NAPCC, PAT and REC
7. Concept of Carbon Footprint

UNIT III: Concept of Sustainable Development (15 lectures)

1. Introduction to sustainability- theory and principles.
2. Practices for sustainable agriculture.
3. Importance of local and indigenous varieties.
4. Remote sensing technologies for monitoring.
5. Sustainability in Urban Development and Planning – LEEDS & GRIHA rating of buildings.

6. Principles of market demand and supply- green products.
7. Principles of enterprise- greening supply chains.
8. Economic Evaluation of eco-system goods and services

UNIT IV: Carbon Management **(15 lectures)**

1. Carbon markets and international climate change mitigation mechanisms.
2. Carbon foot printing and Greenhouse gas auditing (GHG protocols under Scope 1, Scope 2 and Scope3).
3. National Action Plan on Climate Change: a) National Solar Mission, b) National Mission for enhanced Energy Efficiency, c) National Water Mission, d) National Mission on Sustainable Habitat, e) National Mission for Sustainable Agriculture, f) National Mission for Sustaining the Himalayan Ecosystems, g) National Mission for Green India, h) National Mission on Strategic Knowledge of Climate Change.
4. EIA case studies- National and International.
5. Carbon Footprint Reduction Strategies & the Abatement Curve

Practicals
Course: S.LSC.6.04 PR

1. Carbon Footprint of the College or Department or Malhar using available Carbon Tools
2. Creating and Marketing a Green Product or Service
3. Calculating a Carbon Footprint or Emissions from a particular source – Life Cycle Analysis (LCA) of products.
4. Estimation of chromium from water samples.
5. Estimation of lead from water samples.
6. Estimation of, copper from water samples.
7. Estimation phosphorus from water samples.
8. Use of *Daphnia* / any other suitable model system for doing toxicological studies.
9. Projects:
   a. Vermiculture
   b. Water quality assessment before and after Ganpati immersion
   c. Any other suitable project

References:

1. Gadgil M. (2002). *Diversity the cornerstone of life.* Edited by Bittu Sahgal . NCSTC-HORNBILL. Natural History Series
2. Sathasivam K. & WWF-India (2004). *Marine Mammals of India*. Universities Press (India) Private Limited, India.
3. Menon S. (2000). *Trees of India*. Timeless Books (New Delhi), India
4. Biodiversity in India, Volume 4, T. Pullaiah, Daya Books, 2006
5. Biodiversity in India: issues and concerns, Sadasivam Kannaiyan, A. Gopalam, Associated Pub. Co., 2007
6. Biodiversity and ecological economics: participation, values, and resource management, Luca Tacconi, Earthscan, 2000

T.Y.B.Sc. LIFE SCIENCE
Template of Theory Question paper
Courses 6.01, 6.02, 6.03, 6.04

CIA I & II – 20 marks, 45 mins. (Any one option will be selected)

Objective/Short questions, not more than 3 marks each

Essay question of 10-20 marks

Combination of an essay question with short/objective questions

CIA II - assignment/ presentation

End Semester exam – 60 marks, 2 hours

Unit I - IV: 15 marks per Unit with Internal choice. Total choice in the paper 50-100%

Mark-distribution pattern for Practical
CIA & End Semester Practical Examination
6.01, 6.02, 6.03 & 6.04
C.I.A. per course

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

End semester Practical Examination

For 6.01 & 6.03

Q1. Any two / three practicals	20 marks
Q2. Identification/project report/viva	10 marks

For 6.02

Q1. Major	12 marks
Q2. Minor	08 marks
Q3. Identification	10 marks

For 6.04

Q1. Any one practical	10 marks
Q2. Identification	05 marks
Q3. Project	15 marks