St. Xavier's College (Autonomous)
Mumbai

Syllabus
For 6th Semester Courses in
LIFE SCIENCE
(June 2020 onwards)

Contents:
Syllabus (theory and practicals) for Course:

Percent revision:
2015-16: No revision
2016-17: No revision
2017-18: No revision
2018-19: 40 - 50% revision to practicals
2019-20: 30% (0602) and 5% (0603)

LIFE SCIENCE

T.Y.B.Sc. **Course No.: SLSC0601**

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

References

1. *Kuby Immunology* (2007) 6th Edition, Kindt, Goldsby, Osborne, W. H. Freeman.
2. *Immunology* (200) 6th Edition, Roitt, Brostoff, Male, Blackwell Publishing.
3. *Immunobiology* (2005 7th Edition, Janeway and Travers, Garland Sc.
4. *Immunology* (1995) 4th Edition, Ian Tizzard, Saunders College Publishing.
5. *Roitt's Essential Immunology* (2006) Delves, P., Mastin, S. Blackwell Pub.
6. *Immunology* (2010) 2nd Edition, Kalus, E., Wiley Blackwell.
7. *The Immune response to infection* (2011) Kaufmann S., ASM Press.
8. *Cellular and Molecular Immunology* (2003) 5th Edition, Abbas, A.K. Saunders.

LIFE SCIENCE

T.Y.B.Sc. **Course No.: SLSC0602**

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. Cellular diversity of the nervous system **(1)**
2. Neural circuits – Convergent and Divergent circuits, Reflexes **(2)**
3. Anatomical and functional organization of the nervous system: **(5)**
   a) The Central nervous system: Brain (with emphasis on cerebral cortices), Spinal cord.
   b) Peripheral nervous system: cranial and spinal nerves, autonomic nervous system.
   c) The blood-brain-barrier, choroid plexus and cerebrospinal fluid.
4. Ionic basis for nerve potentials **(7)**
   a) Resting membrane potential –ionic basis: Donnan's equilibrium experiments, Nernst' 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 **(2)**
2. Synaptic potentials: chemical synapses –excitatory post synaptic potential (EPSP), inhibitory post synaptic potential (IPSP), neuro-muscular junctions –miniature end plate potentials (MEPPs) **(2)**
3. Neurotransmitters: Synthesis and metabolism, receptor types, second messenger systems, physiological role and pharmacological significance: Acetylcholine, Catecholamines, GABA, Glutamate, Serotonin **(7)**
4. The motor system and control of Movement: Upper and lower motor neurons, modulation of movement by basal ganglia and cerebellum. **(4)**

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. Development of the vertebrate nervous system **(6)**
    a) Neurulation: formation of neuroectoderm, neural tube and neural crest cells and their derivatives, induction as the basis of neurulation
    b) Differentiation into neuronal and glial cell types, neuronal migration and axon guidance, synapse formation, synapse competition, maturation and cell death
    c) Circuit formation: critical periods in development, effect of neuronal activity in development of neural circuits
2. Learning and Memory **(4)**
    Qualitative and temporal categories of memory, molecular mechanisms of short and long term memory, e.g.: behaviour test in Aplysia.
3. Emotions: **(2)**
    The limbic system: amygdala, physiological changes associated with emotions (e.g., fear, pleasure), serotonin as a mood enhancer.
4. Neurobiology of sleep **(3)**
    Neurological diseases and disorders (assignments for continuous internal assessment-II)

References

1. *Neuroscience: Exploring the brain* (2007) 3rd Edition, Baer, M.F., Connors, B.W. and Paradiso, M.A. Lippincott William & Wilkins, Baltimore.
2. *Neurobiology* (1994) 3rd Edition, Shepherd, G.M. Oxford University Press.
3. *Principles of Neural Science* (2000) 4th Edition, Kandel, E.R., Schwartz, J.H. and Jessel, T.M. Prentice Hall International.
4. *Instant Notes – Neuroscience* (2002) Longstaff, A. Viva Books Pvt Ltd., New Delhi.
5. *Text Book of Medical Physiology* (2006) 11th Edition, Guyton, A.C. and Hall, J.E. Saunders College Publishers.

Life Science

T.Y.B.Sc. **Course No.: SLSC0603**

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 and Reporter genes for promoter analysis 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)**

1. *Agrobacterium* mediated transformation (Ti plasmid , Ri plasmid)
2. Transgenic tobacco expressing luciferase gene
3. Bt Cotton
4. Herbicide-resistant plants
5. Plant viruses as vectors (eg CaMV virus)

C. Transgenic Animals **(7)**

1. Selectable markers for animal cells eg HAT, methotrexate
2. Methods for production of transgenic mice (Pronuclear microinjection, retroviruses, Embryonic stem cells)
3. Transgenic mouse / Super mouse – (MT promoter fused to human growth hormone)
4. Transgenic Goats (isolation of cloned proteins from goat milk)
5. Whole animal cloning eg Dolly

Unit IV **(15 lectures)**

A. Advanced Transgenic Technology: **(3)**

1. Knock-out, knock-in technology: Site-specific recombination using Cre-recombinase LOX system
2. Knock-down Technology – RNAi technology
3. Gene Editing Technology: CRISPR, TALEN

B. Gene cloning and DNA analysis in : (one example each) **(3)**

1. Medicine and Agriculture,
2. Forensics and Archaeology
3. Gene therapy eg SCID

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)

References:

1. *Principles of gene manipulation and Genomics* (2006) 7th Edition, Primrose, S.B. and Twyman, R.M. Blackwell Publishing.
2. *Principles of gene manipulation: An Introduction to Genetic Engineering* (2001) 6th Edition, Primrose, S.B., Twyman, R., and Old, R.W. Blackwell Publishing.
3. *Recombinant DNA: Genes and Genomes* (2007) 3rd Edition, Watson, J.D., Caudy, A.A., Myers, R.M. and Witkowski, J.A. W.H. Freeman.
4. Gene cloning and DNA analysis: An Introduction (2010) 2nd Edition, Brown, T.A. Wiley-Blackwell.
5. *Bioinformatics - Methods and Applications* (2006) 2nd Edition, Rastogi, S.C. Mendiratta, N. and Rastogi, P. Himalaya Publishing House.
6. *Integrated Genomics: A Discovery-based Laboratory course* (2006) Caldwell, A., Williams, S.N. and Caldwell, K.A. Wiley Publishers.
7. *Molecular Biotechnology: Principles and Application of Recombinant DNA* (2010) 4th Edition, Glick, B.R., Pasternak, J.J. and Patten, C.L. ASM Press.
8. *Biotechnology- Applying the genetics to revolution* (2009), Clark, D.P. and Pazdernik, N.J. Academic Press.

LIFE SCIENCE

T.Y.B.Sc. **Course No.: SLSC0604**

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 Biodiversity (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

References:

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

Practicals: SLSC06PR:

Immunology:

1. Study of Antigen Antibody Interaction:
    a. Agglutination reactions:
        i. Blood typing: Direct and reverse.
        ii. Determination of Isohemagglutinin titre in blood.
        iii. Quantitative Widal test.
    b. Precipitation reaction:
        i. Determination of shared epitopes between antigens: Ouchterlony test (Double diffusion).
        ii. Quantitative determination of antigen: Mancini test (Single Radial immunodiffusion)
2. Separation of mononuclear cells (lymphocytes) from blood using density gradient and the determination of viable count of the same
3. Electrophoresis of serum proteins
4. ELISA as a diagnostic tool (demonstration)
5. Advanced techniques in immunology (principle, technique and research applications): Fluorescence Activated Cell Sorter (FACS)

Neurobiology:

1. Study of nervous system using permanent slides - Spinal Cord, Retina, Brain
2. Temporary mount of cornea and statocyst of Prawn
3. Dissection and display of vertebrate brain - Bony fish
4. Dissection and display of vertebrate brain - Hen brain
5. Anatomical study of mammalian brain - Goat brain
6. Organization of grey and white matter in vertebrate brain using Mulligan's stain
7. Cognitive tests
    a. Blind spot test
    b. Stroop test
    c. Cognitive test using COGLAB

Recombinant DNA Technology and Bioinformatics:

1. Cloning and expression of an eukaryotic gene in *E.coli*
    a. Genomic DNA extraction
    b. Plasmid DNA extraction
    c. Restriction enzyme digest of plasmid and genomic DNA
    d. Ligation and Competent cells preparation
    e. *E. coli/* Yeast transformation
    f. Antibiotic / lac Z Selection
    g. Expression of a gene (pGlo)
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

Sustainable Development and Carbon Management:

1. Estimation of Dissolved Oxygen content of a given water sample
2. Estimation of BOD of a given water sample
3. Estimation of COD of a given water sample
4. Estimation of phosphorus in a given water sample
5. Estimation of chromium in a given water sample
6. Estimation of lead in a given water sample
7. Effect of pesticides on the heart rate of *Daphnia*
8. Quadrat and Transect Analysis
9. Calculating Carbon footprint of the College or Department or Malhar or any other suitable place/ service using available Carbon tools
10. Calculating a Carbon Footprint or Emissions from a particular source - Life Cycle Analysis (LCA) of Products
11. Creating and Marketing a Green Product or Service

Template of Theory Question paper

Courses: SLSC0601, 602, 603, 604

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: SLSC06PR

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

DEPARTMENT OF LIFE SCIENCES AND BIOCHEMISTRY

T.Y.B.Sc. Life Science Exam Grid Semester 6					
Course	**Exam**	**Knowledge and Information**	**Understanding**	**Application/Analysis**	**Total**
0601	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**
0602	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**
0603	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**
0604	CIA I	12	8		20
	CIA II	12	8		20
	End semester	30	20	10	60