

UNIVERSITY OF MUMBAI
No.UG/ 305 of 2008

CIRCULAR :-

A reference is invited to the scheme of papers at the B.Sc. degree course under the revised pattern vide this office Circular No.UG/185 of 1998 dated 2nd June, 1998 and the Principals of the affiliated colleges in Science are hereby informed that the recommendation made by the Ad-hoc Board of Studies in Life Sciences at its meeting held 25th March, 2008 has been accepted by the Academic Council at its meeting held on 15th April, 2008 vide item No.4.24 and that, in accordance therewith, the syllabus of T.Y.B.Sc. examination in Life Sciences is revised as per Appendix and that the same has been brought into force with effect from the academic year 2008-2009.

MUMBAI-400 032
14th July, 2008

PRIN. K. VENKATARAMANI
REGISTRAR

To,

The Principals of the affiliated colleges in Science.

AC/4.24/15.04.2008

No.UG/305-A of 2008, MUMBAI-400 032 14th July, 2008.

Copy forwarded with compliments for information to :-

- 1) The Dean, Faculty of Science
- 2) The Chairman, Ad-hoc Board of Studies in Life Sciences.
- 3) The Controller of Examinations,
- 4) The Co-ordinator, University Computerization Center.

(D.H.KATE)
DEPUTY REGISTRAR
U.G./P.G. Section.

Copy to :-

The Director, Board of College and University Development, , the Deputy Registrar (Eligibility and Migration Section), the Director of Students Welfare, the Executive Secretary to the Vice-Chancellor, the Personal Assistant to the Pro-Vice-Chancellor, the Registrar and the Assistant Registrar, Administrative sub-center, Ratnagiri for information .

The Controller of Examinations (10 copies), the Finance and Accounts Officer (2 copies), Record Section (5 copies), Publications Section (5 copies) the Deputy Registrar

UNIVERSITY OF MUMBAI



Revised Syllabus in the subject of Life Sciences at the T.Y.B.Sc.examinations

(With effect from the academic year 2008-2009)

PAPER I - GENETICS AND IMMUNOLOGY

SECTION I - GENETICS

(Total lectures – 45)

This section seeks to give an overview and conceptual understanding of the nature of genetic material, mechanisms of genetic variation, principles of genome analysis, and regulation of gene expression. Starting with some of the important discoveries of the last century, the syllabus tries to emphasize connections between transmission genetics, molecular genetics and the present day genomics and proteomics.

UNIT - I

1. Nature of Genetic material

a) Early experiments leading to the discovery of the genetic material (2 lec)

Griffith's experiment of 1928; Avery, McLeod and McCarty's experiment of 1944; Hershey-Chase's experiment of 1952; and Fraenkel-Conrat and B. Singer's experiment of 1956.

b) Structural organization of a prokaryotic genome (1 lec)

c) Structural organization of a eukaryotic genome (2 lec)

i) Structural characteristics of chromosomes
Chromosome karyotyping and banding patterns; Higher orders of chromosome packing; 'C value paradox';

ii) Sequence complexity of DNA
Unique and repetitive sequences of DNA; Denaturation kinetics and 'CoT' value; Satellite DNA (1 lec)

d) Extranuclear genetic elements

- i) Plasmids
- ii) Mitochondrial genomes *
- iii) Chloroplast genomes *

2. Variation in Genetic material

a) Recombination

i) Prokaryotic systems :

(10 lec)

1. Genetic recombination in Bacteriophages - Life Cycle of lytic and lysogenic phages; Complementation in phages (Intra- and Inter-genic); Recombination mapping – two and three factor crosses, Deletion Mapping; Numerical examples and problem solving.
2. Genetic recombination in Bacteria - The processes of Conjugation, Transformation and Transduction; Mapping the genome by each method. Numerical examples and problem solving

NT - II

(9 lec)

ii) Eukaryotic systems

1. Genetic recombination in Fungi – Life Cycle; recombination in *Neurospora* and mapping by Tetrad analysis.
2. Genetic recombination in *Drosophila* - Life Cycle; Recombination - Mapping the genome by two and three factor crosses, co-efficient of co-incidence and interference.
3. Genetic recombination in Humans – Somatic cell Genetics: use of cell hybrids and hybridomas for gene mapping; Mapping using DNA markers - SNP's, micro and mini satellites, Restriction Fragment Length Polymorphisms

(3 lec)

b) Mutation

- i) Natural biological mutagenic agents (Transposons and their evolutionary significance)
- ii) Induced mutations - Site-Directed mutagenesis using Oligomers and 'Cassette mutagenicity'; Mutagenicity testing – Ames test.

c) Gene Manipulation (Genetic Engineering)

i) Tools

(2 lec)

1. Restriction Enzymes – General nature of action, Major categories based on type of cut, two typical examples each and recognition sites
2. Vectors in genetic engineering – Plasmids (pBR322, pUC18), Phages (λ , M13)

ii) Techniques and their applications

(8 lec)

1. General strategy for cloning a gene (Somatostatin) in *E. coli*, making a Genomic and c-DNA Library
2. Transformant screening by gene inactivation method
3. Screening for a specific clone by Immunochemical and Hybridization method
4. Restriction mapping
5. DNA Sequencing – Maxam-Gilbert's method and Sanger's Method
6. Polymerase Chain Reaction (using Random and specific primers)

3. Genome Analysis

(2 lec)

a) Genomics –

- i) The Human Genome Project and beyond (origins, aims, major features, information fall-out and applications)
- ii) Structural Genomics Sequencing and annotating a sequence *
- iii) Functional Genomics – transcriptome analysis*
- iv) Comparative Genomics – eg. HOX/Wnt in different organisms*

b) Proteomics *– identification and analysis of cellular proteins eg. using 2D Electrophoresis

4. Applied Genetics

i) Gene Therapy (SCID) *

(2 lec)

ii) DNA Fingerprinting *

iii) Genetically modified organisms / plants / animals / foods *

Note: all topics marked with * are to be given as assignments.

5. Gene regulation in eukaryotes

(3 lec)

a) At the transcriptional level

i) Chromatin condensation,

ii) modification and remodelling by acetylation and methylation

iii) transcriptional regulation (promoters and enhancers and Transcription initiation complex, GAL4-UAS system)

b) At the post-transcriptional level

i) RNA splicing,

ii) RNA editing,

iii) Alternate splicing and reading frames;

iv) Significance of the UnTranscribed Regions in the genome.

SECTION II – IMMUNOLOGY (Total lectures – 45)

This section attempts to familiarize the student with the complex array of immune responses of humans and other vertebrates. Emphasis is made on the underlying mechanisms, and their significance in health and disease.

UNIT - IV

1. Cells and organs of the immune system

(8 lec)

a) Primary and secondary lymphoid organs

b) Cells

i) Myeloid cells- structure and functions

ii) Lymphoid cells

iii) NK cells

c) Innate immunity

i) Anatomical, Physiological, Phagocytic, Inflammatory barriers

ii) Concept of Apoptosis vs Necrosis

iii) Concept of PAMP, PRR and TLR

d) Complement

i) Classical, alternate and lectin pathways and comparison

ii) Biological consequences of complement activation

iii) Complement fixation tests

2. **Adaptive immunity**

(9 lec)

a) Humoral immune responses

i) Antigen-Specificity, avidity, affinity, immunogenicity

ii) Antibody-Structure, Functions and variations

iii) Monoclonal and polyclonal antibodies (Hybridoma Technique)

iv) Antigen-antibody interactions –Cross reactivity, Precipitation, Immuno-electrophoresis, Agglutination, Radio immune assay, ELISA, Immunofluorescence.

v) Antibody diversity-organisation and expression of Ig genes, gene rearrangements for light and heavy chains

vi) B-cell ontogeny. Clonal selection model

vii) Humoral immune response- Role of APCs and T cells in B cell response

UNIT - V

b) Cell-mediated immune response

- i) T-cell ontogeny (4 lec)
- ii) T-cell receptors
- iii) Role of TH1, TH2, TH17 and Tc cells
- iv) Cell-mediated cytotoxicity of T cells
- v) Cytokines- IL-1, IL-2, IL-4, INFs and TNFs

c) Major Histocompatibility Complex

- i) MHC-I And MHC-II molecules. (4 lec)
- ii) MHC allelic polymorphism
- iii) MHC restriction
- iv) Antigen processing and presentation-endogenous and exogenous pathways.

3. **Hypersensitivity**

(4 lec)

Gell and Coombs classification:

- i) Type I: Ag-Ab reactions viz. RIST and RAST
- ii) Type II: Agglutination to be included
- iii) Type III: Immunofluorescence, ELISA
- iv) Type IV: Tuberculin test

4. **Immunodeficiency**

(3 lec)

- i) B-celled- X-linked agammaglobulinemia

- ii) T-celled- Di George
- iii) Combined-SCID
- iv) Phagocytic- CGD
- v) AIDS

UNIT - VI

5. Transplantation

- i) Types of grafts (3 lec)
- ii) Tissue typing (serological and MLR)
- iii) Mechanisms of graft rejection
- iv) Graft vs. host disease w.r.t. bone marrow or cornea

6. Tumor Immunology

- i. Role of the immune system. Cell mediated and humoral responses, (3 lec)
- ii. NK cells and macrophages.
- iii. Tumor specific antigens.
- iv. Immunological surveillance.
- v. Immunological escape and potential for therapy.

7. Tolerance

- i) Mechanism of T cell and B cell tolerance (2 lec)
- ii) Immunology of pregnancy
- iii) Role of T regulatory cells

8. Autoimmunity

- i) Mechanisms for induction (Aetiology) (2 lec)

- ii) Types of Auto immune diseases-organ specific and systemic eg. Myasthenia gravis, Graves disease, SLE and Multiple sclerosis

9. Vaccines

(3 lec)

a) Passive immunization

- i) Preformed antibodies and problems
- ii) use of Chimera / humanized antibodies

b) Active immunization (Different methods used):

- i) Whole organisms (attenuated vs. inactivated ex. Polio)
- ii) Purified macromolecules (Polysaccharide, toxoid and recombinant antigen vaccines)
- iii) Peptide vaccines
- iv) DNA vaccines

TYBSc LIFE SCIENCE

PRACTICALS PAPER I - GENETICS AND IMMUNOLOGY

Note: I – Instrumentation, C - Conceptual understanding, T – Technical skill, R – Relevance to daily life.

Genetics

1) Experiments to be performed by students: Expected learning outcomes

- | | |
|---|----------|
| 1. Viable count for enumeration of bacteria by –Bulk seed method | C,T,R |
| 2. Viable count for enumeration of bacteria by - Surface spread method | C,T,R |
| 3. Estimation of bacteriophage titre by plaque assay | C,T,R |
| 4. Effect of u.v. light on microorganisms - Determination of percent viability of an <i>E. coli</i> culture after u.v. exposure- in the absence of light repair | C,T,R |
| 5. Extraction of chromosomal DNA from chicken liver / goat spleen | I, C,T,R |
| 6. Isolation of antibiotic resistant / auxotrophic mutants using Replica plate | |

technique.

7. Giant Chromosome preparation (*Drosophila / Chironomus*)

C,T,R
C,T

I) Demonstration experiments:

8. a) Extraction of plasmid DNA, restriction enzyme digestion and visualization by agarose gel electrophoresis. I, C,T,R
b) Study of UV-Visible Spectrophotometer, Thermal cycler (PCR instrument), DNA sequencer C,R
9.a) Study of *Drosophila* mutants from specimen / slides / photographs C,R
b) Collection and observation of virgin *Drosophila* females for setting up of genetic crosses. C,R

Immunology

I) Experiments to be performed by students:

1. Study of ABO Blood groups and quantitative Coomb's Test. C, R.
2. Study of Isohemagglutinin titre in blood. C, R.
3. Quantitative Widal Test. C, R.
4. Ouchterlony test for Immunodiffusion – (Qualitative) C, R.

II) Demonstration experiments:

5. a) Dissect and expose the lymphoid organs of rat / photograph C, R.
b) Study of Thymus, Spleen, and Lymph node tissue sections C, R.
c) Observation of Blast cells in bone marrow of any mammal from slides / photographs. C, R.
6. Separation of Mononuclear cells using a gradient and the determination of viable count of the same C, R, T.
7. Agarose slide gel electrophoresis of Serum I, C,T,R.

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Paper I - References

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3. Genetics: A Mendelian approach by Peter Russel 2nd edn. Pearson 2006.
4. Introduction to Genetic Analysis by Griffiths et al 8th edn. Freeman and co. 2005.
5. Genes IX by Benjamin Lewin; Jones and Bartlett publishers, 2008.

6. Principles of Gene Manipulation and Genomics by S. B. Primrose and R. M. Twyman 7th edn., Blackwell publication, asian edn Oxford publishers 2007.
7. Concepts of Genetics W. S. Klug and M. R. Cummings 7th edn. Pearson 2003.
8. Concepts of Genetics W. S. Klug, M. R. Cummings, C. A. Spencer 8th edn. Pearson 2006.
9. Human Molecular Genetics by Tom Strachan and Andrew Read, 3rd edn. Garland Science pub. 2004.
10. Principles of Genetics by R. Tamarin 7th edn 2002
11. Immunology 5th edn. R.A. Goldsby, T. J. Kindt, B. A. Osborne, J. Kuby 2003.
12. Immunology: The immune system in health and disease 6th edn. C. A. Janeway, P. Travers, M. Walport, M. Shlomchik Garland Science Pub. 2005.
13. Cellular and Molecular Immunology, 2nd edn. A. K. Abbas, A. H. Litchman, 5th edn 2000.
14. Basic Immunology: Functions and disorders of the immune system, 2nd edn. A. K. Abbas, A. H. Litchman, 2nd edn 2004.
15. Roitt's Essential Immunology 11th edn. Blackwell publication 2006.
16. Immunology 7th International edn. D. Mole, J. Bronstoff, D. Roth, I. Roitt, Mosbey Elsevier publication, 2006.
17. An Introduction to Immunology C. V. Rao Narossa Publishers 2002.

Section I - Developmental Biology Total 45 lectures

Development Biology helps us to understand how organisms grow and develop, the genetic control of cell growth, differentiation and morphogenesis - a process that gives rise to tissues, organs and the body design. The biological bases of cancer as well as regeneration of lost tissues from stem cells are hot areas of research in Developmental Biology. This discipline also will help in understanding developmental malfunctions. These anatomical abnormalities may be caused by mutant genes or by substances in the environment that interfere with the development of the organism. The study of abnormalities is often used to discover how normal development occurs.

Unit 1 [15lectures]

I. Concepts and tool kit. (8 lectures- more details in some cases will be dealt with in the Lab- see Developmental Biology Practical 1 & 2)

History and basic concepts in development: – (to be discussed using following e.g. as model systems and techniques used to address questions in development.)

Sea Urchin : Mosaic vs. Regulative Development

Dictyostelium : acquisition of multicellularity

Drosophila : mutation series and early development.

Chick and amphibians : fate maps and chimeras.

Zebra fish : in situ hybridization and trace gene expression.

II. Descriptive embryology:

(i) Plant Development-Arabidopsis as the model system (7 lectures)

- a) Life cycle of Arabidopsis – sporophytic and gametophytic generation
- b) Fertilization and embryo development
- c) Formation of meristems (root and shoot)

- d) Formation of different organs – leaf, flower, androecium [including development of anthers, pollen grain, pollen tube etc.] and gynoecium [development of pistil - up to formation of embryo sac], double fertilization, seed formation. [Eventual formation of fruit].
- e) Role of Homeotic genes specifying parts of a flower
- f) Plant genome project (Arabidopsis and rice)

Unit 2 [14 lectures]

(ii) In animals:

- A. An overview of Amphibian development (as done in the S.Y. syllabus). **(3 lectures)**
- B. Chick an overview **(11 lectures – More details in the Lab- see Developmental Biology Practicals 1&2)**
 - Germ cell
 - Fertilization.
 - Cleavage,
 - Morula and blastula.
 - Gastrulation.
 - Neurulation. (i) neural induction, (ii) Neural tube formation
 - Organogenesis – Eye OR limb
 - Role of neural crest

Unit 3 [16 lectures]

III. Cellular aspects of development: (7 lectures)

- Totipotency e.g.. Carrot phloem, animal cell nuclei, stem cells
- Pluripotency e.g. Neural crest cells or Hematopoietic cells
- Determination e.g. Drosophila imaginal disc
- Transdetermination e.g. Drosophila imaginal disc
- Differentiation. E.g. Neural crest cells or hematopoietic cells
- Signaling factors (autocrine and paracrine) Explain with Hematopoiesis as example.
- Induction – e.g. Formation of lens in the eye

IV. Molecular basis of growth and differentiation: (7lectures)

- Differentiation as a change in gene expression. (e.g. β globin gene expression)
- Maternal genes, Segmentation genes, Homeotic genes in early development – Drosophila.
- Cell cycle and its control.
- Apoptosis.

V. Applications of developmental biology (2lectures)

(To be given as guided assignments)

- i) Assisted human reproduction.
- ii) Cancer.
- iii) Regeneration ex Salamander limb (dedifferentiation)
- iv) Wound healing VS regeneration
- v) Aging.
- vi) Congenital abnormalities.
- vii) Fundamentals of Stem cell research

[continued to section II...]

III. Overview of the Cellular organization of the nervous system: (1 lecture)

- (a) Typical nerve cell
- (b) Types of cells: Neuronal, Glial cells, ependymal cells and Schwann cells.
- (c) Role of meninges and CSF.

IV. Chemical Basis of Neural transmission: (4 lectures)

- Ionic basis of resting membrane potential: Donnan's equilibrium experiments, Nernst's potential Goldman's equation. Sodium -Potassium pump.

Unit 5 [15 lectures]

V. Action Potential & propagation (3 lectures)

- (a) Hodgkin and Huxley's model, voltage clamp experiment and the derivation and propagation of Action Potential
- (b) Compound Action potential.

VI. Transmission of nerve impulse continued (4 lectures)

- (a) Graded potential
- (b) Synaptic potential and synaptic integration [Electrical and Chemical Synaptic Potential]
 - (i) Excitatory Post Synaptic Potential (EPSP),
 - (ii) Inhibitory Post Synaptic Potential (IPSP)
- (c) Neuro - muscular junctions

VII. Synapse and synaptic transmission. (8 lectures)

- (a) Synapse: Structure, Types - chemical and electrical
- (b) Neurotransmitter - Biosynthesis, physiological role, pharmacological significance, (examples of one agonist and one antagonist for each neurotransmitter)
 - i) Acetylcholine (Nicotinic and muscarinic receptors).
 - ii) Dopamine (D1 and D2 receptors).
 - iii) GABA.
 - iv) Glutamate

(c) Neuropeptide (Endorphin and Enkephalin).

Unit 6 [16 lectures]

VIII. Sensory organs (10 lectures- details in Lab- see Neurobiology Practicals 4 & 5c)

Human Sense organs: receptors, receptor mechanisms and pathways.

a) Visual system: Vision - structure of the eye, retina, photoreceptors (rods and cones), phototransduction, binocular vision, visual pathway (flow chart only - LGN to visual cortex), light & dark adaptation, colour vision.

b) Auditory System: Structure of the ear, cochlea and organ of corti receptors and Mechanism of transduction.

Auditory pathway: (MGN to audio cortex) Diagrammatic representation only.

c) Vestibular System: Structure of the vestibular labyrinth, maculae and cristae. Mechanism of transduction.

d) Chemosensory system: Olfactory and Gustatory receptors - structure.

e) Skin as sense organ: somatic receptors - Types of mechano- receptors, pain reception & Pain management (example analgesic effect by prostaglandin inhibition - aspirin)

IX. Motor systems: (2 lecture- more details in the lab-see Neurobiology practical 4c, 5 & 7)

a) Molecular basis of Muscle contraction

b) Reflexes: Simple reflex arc, mono and poly-synaptic reflexes, stretch and knee-jerk reflex, crossed - extensor reflex, and Golgi-tendon reflex

X. Neurobiological basis of behaviour: (2 Lectures)

Associative conditioning: Short term memory / Long Term Memory (eg. Aplysia continued from I above).

Addiction - narcotic drugs and their effects on CNS (eg: Opiates)

XI. Neurological diseases- to be given as guided assignments (2 lectures):

i) Prions and Mad cow disease

ii) Duchene's muscular Dystrophy

iii) Alzheimer's disease

iv) Schizophrenia- Positive and negative symptoms

v) Huntington's Disease

PRACTICAL PAPER II

Practicals for Developmental Biology Component:

- 1) Study of developmental stages of chick embryo- C, T
- 2) Cytochrome C- oxidase activity in a developing chick embryo. C, T
- 3) Cell viability in pollen grains using Trypan blue. .C, T, R
- 4) Effect of boron / calcium on pollen tube germination in Vinca rose or any other suitable sample I, C, T, R
- 5) Root and shoot development in sections of a 2 day old plant embryo. I, C, T, R.
- 6) Role of GA in seed germination. C, T

Demonstration experiments (any two of the following):

- 8) Programmed cell death in limb bud using Janus Green B stain (in chick embryo).C, T, R
- 9) Alizarin stain to study limb development in chick embryo/ Regeneration of cartilage / bone C, T, R
- 10) Comparison of embryos of Pisces, Amphibia, Reptilia, Aves and Mammals, to understand the embryological basis of development, using photographs C.
- 11) Plant Tissue Culture: Initiation of plant tissue culture from germinated chick pea/any other suitable source: (project to be performed in groups of 4-5 students) C, T, R
- 12) Bowl culture for study of morphogenetic movement C, T
- 13) Imaginal discs of Drosophila C, T
- 14) Regeneration in earthworm / any other suitable system / hydra (using permanent slide / photographs) T, C
- 15) Seed and fruit development cotton or any suitable system to show variations in the form of fruit structures T, C, R

Practicals for Neurobiology component

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R.M.Twyman, Viva Books Private Limited, New Delhi, Latest Edition (First Edition – 2001)
2. Developmental Biology
T.Subramaniam, Narosa publishing Hopuse, Mumbai, Latest Edition (First Edition – 2002)
3. Principles of Development
L. Wolpert, R. Beddington, J. Brockes, T. Jesell and P. Lawrence
Oxford University Press.
4. Developmental Biology.
W.A. Miller
Springer – Verlag.
5. Molecular Biology 3rd Ed.,
H.Lodish, D.Baltimore, A.Berk, S.L. Zipurski, P.Matsudaira and J. Darnell.
Scientific American Book, W.H. Freeman, N.Y.
6. Molecular Biology of the Cell 3rd Edition.
B. Alberts, D. Bray, J.Lewis, M. Raff, K. Roberts and J.D.Watson.
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Narosa Publishing, Calcutta.
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[Continued on next page]

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MacMillan Publishing Co.

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Oxford University Press

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Oxford University Press.

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A.C.Guyton and J.E.Hall
Saunders College Publishers.

21. Elements Of Molecular Neurobiology
C.U.M. Smith
J Wiley and Sons Publishers, N.Y.

22. An Introduction to Molecular Neurobiology
Z.W. Hall
Sinauer Associates Inc. Publishers.

23. Ion Channels – Molecules in Action
D. J. Aidley and P.R. Stanfield.
Cambridge University Press.

24. Comparative Neurobiology
J. P. Mill
Edward Arnold Publishers.

25. Physiology Of the Nervous Systems
D Ottoson, McMillan Press

TYBSc Paper III

Biotechnology (90 Lectures)

[This paper consists essentially of two parts: one starting with the homegrown technology for the production of food and beverages that depended on fermentation by microorganisms and the other, of altering the very basic features of living organisms through manipulation of genes. A third component is a logical offshoot of the latter, in the era of information technology: the bioinformatics. Since genetic data in the form of huge number of sequences of nucleotides are made available through molecular techniques, it is now possible to derive maximum knowledge from this enormous amount of data with the help of information processing algorithms. The economic, social and ethical implication of such a major technology too is kept in focus.]

Section I

Food & Fermentation Technology

45 Lectures

[Ancient fermented food processes, such as making bread, wine, cheese, curds, *idli* etc., some of which are some 6,000 yr old, and developed long before man had any knowledge of the existence of the micro-organisms involved, also genuinely constitute biotechnology. However, for the sake of convenience, many people exclude these traditional processes from the realm of biotechnology. Aspects of 'modern biotechnology' may have significant effects on 'traditional biotechnology'. Genetic manipulation to improve brewing and baking yeasts or to introduce new characteristics in crops, biological control of plant pests, and new methods of diagnosing and preventing plant, human and animal disease, are all now realisable. This section, therefore, deals with an introduction to **the integrated use of biochemistry, microbiology and chemical engineering** to exploit plant materials and other genetic resources for the production of specific products and services.]

UNIT I

1. History and development of Food & Fermentation Technology (1 lectures)
2. Fermentation technology & Instrumentation (14 lectures)
 - i. Principles of microbial growth, screening (primary & secondary) and strain improvement (mutation & selection using auxotrophy & analogue resistance)
 - ii. Batch vs Continuous fermentation
 - iii. The Bioreactor / Fermenter & accessories (Stirred tank & Airlift)
 - iv. Media design for fermentation (include molasses, corn steep liquor)
 - v. Downstream processing (use ex of Penicillin and an enzyme? for cell disruption)

- vi. Instrumentation: Principles and technique of Centrifugation, Spectrophotometry & Chromatography

UNIT II

3. Food and Beverage Biotechnology (9 lectures)
- Technological aspects of industrial production of Cheese, Beer, Vinegar, Single Cell Protein, Mushroom, Yoghurt and Wine (certain details to be dealt with in corresponding practicals)
 - Food quality assurance: Regulatory & social aspects of food biotechnology
4. Enzyme Technology (5 lectures)
- Enzyme production ex. Amylase (bacterial & fungal)
 - Immobilized Biocatalyst (method of immobilization, applications – biosensors)

Unit III

5. Application of fermentation technology in medicine (7 lectures)
- Production of antibiotics (Penicillin)
 - Vitamins (Vit B12)
 - Vaccines (polio, HbsAg)
 - Monoclonal antibodies
 - Biopharmaceuticals (Insulin / IFN- γ)
6. Application of fermentation technology Agriculture (4 lectures)
- Secondary metabolites from plant tissue culture
 - Biopesticides – bacteria (*B. thuringiensis*), Virus (Polyhedrosis virus) and fungal (*Trichoderma*)
7. Plant and Animal Tissue culture (5 lectures)
- Animal – Laboratory setup, Media, Basic techniques (Disaggregation of tissue and primary culture, maintenance of cell lines- see also Practicals)
 - Plant – Media, Basic techniques (callus and suspension culture, organogenesis, & somatic embryogenesis, Protoplast isolation and fusion)

Section II

GENETIC ENGINEERING (45 lectures)

[The development of genetic manipulation techniques in the latter half of the last century was a breakthrough because not only humankind could create organisms with newer combination of properties, but also it opened up a completely new way of studying biology. At the same time, the field has thrown up newer questions of ethics, morals and environmental safety. Basic understanding of genetic engineering is also important for citizens to make informed choices contributing to public policy.]

Unit IV

1. Introduction to the history of Gene Cloning (1 lecture)
2. Basic methodologies for gene cloning (5 lectures)
 - i. Cutting and Joining DNA molecules: Type I, II, III, Restriction Mapping, DNA Ligase, Homopolymer tailing, Adaptors, Linkers, Use of Alkaline Phosphatase
 - ii. Electrophoresis based techniques: Gel electrophoresis, Southern, Northern and Western blotting.
3. Cloning Vectors (Plasmid, Bacteriophage, Cosmid) (7 lectures)
 - i. Basic properties of Natural and artificial plasmids
 - ii. pBR322 : structure, origin and uses
 - iii. Expression of Insulin and Somatostatin genes in *E. coli* using pBR322.
 - iv. pUC vector
 - v. Special vectors: transcription vectors for probe and ds RNAs
 - vi. Bacteriophage lambda as vector
 - v. M13 vector
 - vi. Cosmid vector
5. CLONING STRATEGIES (3 lectures)
 - i. Shotgun cloning
 - ii. Making genomic and cDNA libraries in *E. coli*
 - iii. Chromosome walking
 - iv. Chromosome jumping

UNIT V

6. Screening and selection of the desired clone (4 lectures)
 - i. Immunochemical method
 - ii. Nucleic acid hybridization method
 - iii. Subtractive cDNA cloning
 - iv. HRT and HART
7. Techniques for analysis of genes and gene products (5 lectures)
 - i. DNA sequencing by Sanger's, Maxam and Gilbert's methods .
Concept of automated sequencing
 - ii. Basic PCR, RT-PCR, and differential display
 - iv. Microarray
 - v. 2D electrophoresis
8. Cloning in eukaryotes: (7 lectures)
 - a) Cloning IN *S. cerevisiae*: basic principle
 - i. Development of vectors: Yep
 - ii. Yeast Artificial Chromosome
 - b) Cloning vectors in plant cells Ti Plasmid, CaMV
 - c) Cloning vectors in animal cells SV 40, Baculovirus

UNIT VI

9. Applications of recombinant DNA technology: (7 lectures)
- Transgenic animals and plants (4)
 - Xenopus oocyte as an expression system
 - Giant mouse (MMT promoter-growth hormone fusion gene)
 - Drosophila (using p element-mediated techniques-enhancer trap)
 - Bt* cotton (pesticide resistance gene, weedicide resistance gene)
 - Knock-out, knock-in and knock-down systems
 - Other important applications: (3)
 - DNA finger printing
 - DNA markers – SNP, VNTR, RFLP, AFLP
10. Issues on recombinant DNA technology: (2 lectures)
- Applications in industry- medical/pharmaceutical, agricultural
 - Applications in basic research –intellectual property rights and the open source biotechnology movement
11. Bioinformatics: (4 lectures- more details will be dealt with in practical)
- Biological Databases
 - Sequence annotation and comparison
 - Multiple sequence alignment
 - Phylogenetic trees

PRACTICALS – III BIOTECHNOLOGY

[This practical syllabus should enable the student to understand basic concepts in enzymology, certain methodologies of bioassays and basic techniques in molecular biology and bioinformatics. Costing too is an important component in technology education. The **Good Lab Practices (GLP)** introduced from the first year of the B.Sc. Lifesciences program is expected to be followed with added urgency in this program.]

As the "Expected Learning Outcome" is a good measure of defining the extent of details of an experiment necessary at a certain level, this is incorporated in each case:

- I= Instrumentation knowledge
- C= Concept understanding
- T= Technical skill
- R= relevance

- Extraction and purification of enzyme: amylase from sweet-potato/salivary amylase/ egg white lysozyme or any other convenient enzyme
 - to determine enzyme activity I.C.T, R
 - specific activity: I.C.T
- Determination of the K_m of amylase/any other convenient enzyme. I.C.T

3. Determination of the effect of pH/temperature on amylase/any other convenient enzyme activity. I,C,T
4. Immobilization of Amylase/any other convenient enzyme using hen egg-white / alginate method and assay its activity. I,C,T
5. Bioassay of antibiotic/plant extract for anti-bacterial activity. I,C,T,R
6. i. Agarose gel electrophoresis of amylase using serum/ egg white as a control: coumassie blue staining I,C,T,R
ii. Activity staining/Zymogram using starch agar plates. I,C,T
7. Thin layer chromatography of lipids/plant alkaloids/any other suitable extract. I,C,T,R
8. Non-denaturing Poly Acrylamide Gel Electrophoresis of E.coli extract/ Serum proteins/ Saliva/Egg white any other suitable sample I,C,T
9. Extraction of plasmid DNA & Agarose Gel Electrophoresis of plasmid DNA/Restriction Digest with costing of the experiment I,C,T
10. Introduction to databases and bioinformatics: use of public domain/open source database and programs for studying genomics of human/ mouse, yeast/ plant/ microbes or any other relevant organisms I,C,T
11. Manual annotation of DNA sequence: i) pUC series or any convenient cloning/expression vector followed by using programmed tools C,T,R
12. Blast search of genome sequence, Sequence alignment – pair wise / multiple, construction of Cladogram / phylogram I,C,T
13. Assay of fermentation product – Estimation of (a) alcohol/Acetic acid/lactic acid (b) Sugar C,T,R
14. Any two of the following open-ended projects:
 - i. Home-Wine production/Home-Vinegar production from any convenient source & assay for fermentation products R,C,T,I
 - ii. Culturing & biomass estimation of mushroom/ *Spirulina* /*chlorella* by cell count/dry weight and estimation of percentage total protein. R,C,T
 - iii. Design & Fabrication of Electrophoresis Chamber R, I,C,T
 - iv. Plant tissue culture: a) Callus production b) Preparation of protoplasts and estimate viability by trypan blue staining T,C
 - v. Growth curve of E coli (DH5 alpha) and preparation of competent cell for transformation experiment. C,R,T,I

- vi. SDS PAGE with suitable Protein sample for Comparison with Experiment no.9 above. C,T,I
- vii. Genomic DNA extraction, purification and estimation by UV spectroscopy. I,C,T
- viii. Costing of DNA extraction protocol & Development of cost effective Method using Liquid Soap, Common Salt and Alcohol or any convenient variation. R,C,T,I
- ix. Costing of Agarose Gel Electrophoresis of DNA with & without Molecular marker ladder R,C,T,I
- x. Finger Printing technique using electrophoresis of protein/DNA digest C,T,I,R
- xi. Animal tissue culture: Tissue dissociation by trypsinization technique and to estimate the viability of cells in physiological saline/MEM at 0 hrs and 2 hrs C,T,R

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TY B.Sc Life Sciences Paper

Paper IV

Environmental Biology

(Total No. of Lectures: 90)

Life creates life; forms of life reproduce themselves and multiply creating a stunning variety of species and natural communities. An ecological complex comprises variability among living organisms from all sources including inter, alias, terrestrial, marine and other aquatic organisms. The conservation of natural environment is important for maintaining the Biodiversity and continuous evolutionary process, which provides support to the living system. Man-environment relationship indicates that pollution and deterioration of environment has a social origin. The modern technological advancements in chemical processes have given rise to new products, new pollutants and in much abundant level which are above the self- cleaning capacities of environment. One of the major issues in recent times is the threat to the human life caused due to the progressive deterioration of the environment. This paper highlights the Ecology, Ecosystem, Biodiversity, Forest & Wild life, Renewable energy, Industrial hygiene & Chemical safety, Toxicology and environmental issues and challenges.

Section I: Life and Environment

Unit I:

(12)

1. Ecology and Ecosystems:

(12)

- i) History and scope of ecology
- ii) Models of successions
- iii) Climax community and types of climax.
- iv) Ecological Principles-Food Chains: Components of a Food Chain, Types of Food Chains, Food web, Ecological pyramids
- v) Biogeochemical cycling -Carbon cycle, Nitrogen cycle, Phosphorus cycle
- vi) Ecosystems, types of Ecosystem and their characteristics and significance

(20)

Unit II:

(10)

1. Biodiversity:

- i) Biodiversity, distribution of fauna and flora
- ii) Evolution of Biodiversity with one example of an evolutionary tree.
- iii) Levels of biodiversity
- iv) Importance and status of biodiversity
- v) Loss of biodiversity
- vi) Conservation of biodiversity
- vii) Genetic diversity- molecular characteristics

2. Bioremediation.

(10)

- i) Bioremediation: Principles, Factors responsible and Microbial population in bioremediation.
- ii) Biomagnification
- iii) Bioaccumulation and biotransformation
- iv) Phytoremediation: Metals, organic pollutants
- v) Composting: Technology, process and factors influencing composting.

Unit III:

1. Toxicology:

(13)

- i) Pesticides: use in agriculture and public health programme
- ii) Basic principles of toxicology including LD50 and LC50, Absorption, Distribution and physiological effects- Lead and Parathion.
- iii) Management of acute intoxication; Parathion and Methyl isocyanate
- iv) Natural detoxification – biochemical mechanism – cytochrome P450 in liver
- v) Genotoxicity: micronuclear and comet assays.
- vi) Ethical aspects :
 - a) Clinical trial,
 - b) Toxicity testing for assessment of environmental agents
 - c) Toxic waste disposal and trading

(12)

Section II: Global issues and resources

Unit IV:

(15)

1. Global Environmental issues.

(7)

- i) Population.
 - a) Overpopulation and depletion of natural resources.
 - b) Role of Women in rural and urban areas.
 - c) Literacy.
 - d) Slums and their causes
 - e) Health- Inadequate diet; malnutrition.
- ii) Global Environmental problem and remedial measures (8)
 - a) Climate change: Global warming and green house effect
 - b) Ozone depletion
 - c) Acid rain
 - d) GMO-Biosafety measures
 - e) Consequences of the use of pesticides and fertilizer.
 - f) Surface water and industrial pollution: e.g. Ganga river water
 - g) Air pollution in metro cities
 - h) Waste management including e-waste.

Unit V:

1. Forests and wild life

(15)

(7)

- i) Deforestation and a forestation
- ii) Forest management
- iii) Factors contributing to declining and extinction of wild species, Wildlife management and Protection Act.
- iv) National parks and sanctuaries
- v) Ecotourism

2. Energy resources: Problems and prospects

(8)

i) Nonrenewable energy

- a. Energy Resources, Energy Efficiency: social and economic cost
- b. Carbon accounting

ii) Renewable energy

- a. Nuclear energy
- b. Solar energy
- c. Wind energy
- d. Tidal energy
- e. Hydral energy
- f. Biomass energy (Biogas plants)

Unit VI:

(15)

1. Industrial hygiene & Chemical safety.

(10)

- (i) Introduction and Concept of Industrial hygiene
- (ii) Recognition, evaluation, monitoring and control
- (iii) Occupational hazards
- (iv) Industry: siting criteria and EIA
- (v) Industrial Safety: Case study- Bhopal gas tragedy

2. Citizen Awareness:

(5)

Ethical and Legal issues:

- a) Ethical issues in Biodiversity- IPR
- b) Awareness of existing environmental laws and role of citizen groups in environmental management.

Practicals- Environmental Biology

I. Biodiversity:

- i) Biodiversity study: Collection, Identification, Classification (up to class) and tracing the habitat of at least three edible varieties of aquatic fauna, fruits and vegetables.
- ii) Introduction of environmental Bioinformatics – use of digital herbarium: Demo
- iii) Introduction to genetic diversity: phylogenetic tree using molecular data

II. Waste management: Vermicomposting in garden pot and collection of cocoons (project)

III. Aquatic Ecosystem

1. Estimation of the dissolved oxygen content of the given water sample.
2. Estimation of the biological oxygen demand of the given water sample.
3. Estimation of the chemical oxygen demand of the given water sample.
4. Estimation of the hardness of the given water sample.
5. Estimation of the salinity of the given water sample.
6. Estimation of the acidity of the given water sample.
7. Estimation of the alkalinity of the given water sample.
8. Estimation of the Sulphate of the given water sample.
9. Estimation of the phosphate of the given water sample.
10. Estimation of the copper, lead in the given water sample.
- (Any five of the above experiment)
11. Quality assessment of the given water sample (Total Coliform count and MPN). (Compulsory)

4. Soil: Microbial interaction.

- i) Study of nitrogen fixing bacteria. e.g. Rhizobium/ Azotobacter /Nematode
- ii) Biodegradation of Phenol

5. Toxicity studies:

- i) Evaluation of Lc50 of insecticide on Daphnia/Effect of insecticide on heart beat of daphnia

6. Instrumentation: pH meter

7. Hands on Research project: Not excluding the above techniques

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