

## Ph.D. Entrance Exam Syllabus – 2022

### Microbial Systematics and Bacteriology

#### Course Contents

##### Bacterial Systematics

Classification and Linnaean System, Natural System of Classification, "Binomial nomenclature, International code of nomenclature of prokaryotes, Taxon, species, strain, Haeckel's three kingdom of classification, Whittaker's five kingdom classification, Molecular phylogeny, Three domain concept of Carl Woese. Criteria used for classification (cultural, morphological, biochemical and physiological), recent trends in microbial taxonomy (Molecular taxonomy, chemotaxonomy, numerical taxonomy, genetic methods in taxonomy, serological methods). Classification and salient features of bacteria according to Bergey's Manual of Systematic Bacteriology. Unculturable and culturable bacteria: Conventional and molecular methods of studying microbial diversity. Culture dependent methods of community analysis – Dilution plating and culturing methods, culture independent methods of community analysis – phospholipids fatty acid analysis, nucleic acid techniques, metagenomics, microbial identification systems, phylogenetic analysis, fluorescent in situ hybridization (FISH).

##### Bacteriology

Bacteria – shapes, sizes and morphological types, ultra structure of bacterial cell – cell wall, cell membrane, structures external to cell wall, cellular organelles, intracytoplasmic inclusions, mesosome, ribosome, nucleoid, extranuclear genetic elements and endospores. Morphological Groups of Bacteria: Myxobacteria, Appendaged bacteria, Phototrophic bacteria, spore forming rods, L-forms of bacteria and endophytic bacteria.

##### Virology

Morphology and ultrastructure of viruses: capsids, envelope, viral genome; Virioids and prions. Bacterial virus: Bacteriophage structure and lifecycle (T4 and Lambda); one step growth curve – latent period, eclipse phase, burst size; lytic (T4) lysogenic (Lambda) cycle.

##### Cultivation of Bacteria

Nutritional requirements – nutrients and nutritional classification of bacteria, Microbiological media – classification, components, preparation and application of different media, Methods of cultivation – aerobic, anaerobic, shake cultures, batch and continuous cultivation, asynchronous and synchronous culture. Growth – cell division and binary fission, growth curve, generation time, growth rate, growth kinetics, measurement of growth, factors affecting growth.

##### Sterilization techniques

Principles, types and techniques, physical, chemical, radiation and mechanical. Isolation and preservation-methods of isolation, enumeration, maintenance and preservation of

microorganisms. Staining – nature of stains, principles, mechanism, method and types of staining.

### Reference books

1. Microbial evolution. (2016). United States: Cold Spring Harbor Laboratory Press.
2. Enigmatic Microorganisms and Life in Extreme environments. (2013). Germany: Springer Netherlands.
3. Prakash, A., Satyanarayana, T., Johri, B. N. (2012). Microorganisms in Environmental Management: Microbes and environment. Netherlands: Springer Netherlands.
4. Allsopp D & Colwell R R (1995), "Microbial Diversity and Ecosystem Function" CAB International, Wallingford, UK.
5. Martinko, J., Clark, D. P., Madigan, M. T., Dunlap, P., Brock, T. (2009). Brock Biology of Microorganisms. United Kingdom: Pearson/Benjamin Cummings.
6. Parte, A. (2012). Bergey's Manual of Systematic Bacteriology: Volume 5: The Actinobacteria. United Kingdom: Springer New York.
7. Magurran, A. E. (2013). Ecological Diversity and Its Measurement. Netherlands: Springer Netherlands.
8. Sullia, S. B., Shantharam, S. (2019). General Microbiology. India: Oxford & IBH Publishing Company Pvt. Limited.
9. Woolverton, C. J., Willey, J. M., Sherwood, L. (2011). Prescott's Microbiology. United Kingdom: McGraw-Hill.

## Mycology and Phycology

### Course Content

#### Introduction to Fungi

History, contribution of Indian mycologists, general features of fungi and examples of divisions with salient features and introduction, Myxomycetes- Acrasiomycetes- Physarum, Plasmodiophoromycetes – Plasmodiophora. Salient features and examples of Zoosporic fungi – Chytridiomycetes - Chytridiomyces, Oomycetes - Saprolegina and Pythium and Phytophthora, Salient features and examples of Zygomycota – Zygomycetes – Mucor and Rhizopus, Study of higher fungi-salient features and examples of divisions – Ascomycota, Basidiomycota and Deuteromycota (Mitosporic fungi).

#### Structure of fungal cells and growth

Hyphae and non-motile unicells, motile cells, spores, dormancy, growth of population and colonies, Mechanics of growth in fungi, Measurement and kinetics of growth, Nutritional and environmental requirements. Effect of environment on growth, pH, temperature, inhibition of fungal growth, Heterothallism, sex hormones in fungi, Physiological specialization, Phylogeny of fungi. Fungi and Ecosystem: Vitamin requirements, Saprophytism, parasitism, mutualism, fungal symbionts-mycorrhiza, Keratinophilous and coprophilous, substrate successions, Fungi as biocontrol agents, fungi as insect symbiont, Mycotoxins and Mycotoxicoses, attack on fungi by other microbes. Economic importance of fungi.

#### Phycology

Distribution of algal cells, Classification of algae; Isolation from soil and water, algal ecology, Media and methods used for culturing algae, *Chlorella*, *Spirulina*, *Nostoc*, measurement of algal growth, Blue green algae: distribution, thallus construction and reproduction in general, Ultrastructure of typical cyanophycean cell, Study of structure and reproduction of *Microcystis*, *Gleocapsa*, *Spirulina*, *Oscillatoria*, *Nostoc* and *Anabaena*.

#### Applications of algae

Therapeutic uses, heavy metal removal, use of immobilized and labeled algae, Economic importance of algae, economic importance of cyanobacteria, cyanotoxins, occurrence, production and regulation in environment, symbiosis in algae, strain selection and large scale cultivation. Algae as SCP, algal pigments and algal lipids for biofuels.

#### Books for Reference

1. Alexopoulos C J and Mims C W (2001), "Introduction to Mycology", Wiley.
2. Becker E W (1994), "Microalgae: Biotechnology and Microbiology, Cambridge University Press.
3. Mehrotra R S and Aneja K R (2002) "An Introduction to Mycology, New Age Publications
4. Singh P K, Dhar D W, Pabbi S, Prasanna and Arora A (2001), "Recent Advances in the Exploitations of Blue Green Algae and Azolla" National Center for Conservation of Blue Green Algae, IARI, New Delhi.

5. Singh P K, Dhar D W, Pabbi S, Prasanna R and Arora A (2000), "Biofertilizers – Blue Green Algae and Azolla" National Center for Conservation of Blue Green Algae, IARI, New Delhi.
6. Kashyap and Kumar H D (1994), "Recent advances in Phycology" Rastogi Company.
7. Chapman V J and Chapman D J (1973), "The Algae" English Language Book Society and Macmillon.
8. Janet R Stein (1975), "Phycological Methods" Cambridge University Press.

## Microbial Physiology and Biochemistry

### Course content

#### Basic concepts of bioenergetics and metabolism

First and second law of thermodynamics, concept of free energy, entropy and enthalpy. High energy compounds- Phospho anhydrides, Phospho carboxylates, Enol Phosphates, Phospho Guanidiene. Role of ATP, ATP cycle, structural basis of free energy change during hydrolysis of ATP. Biological redox reactions, Biological reducing power and its role in biological system.

#### Carbohydrate metabolism

glycolysis and its regulation by allosteric and hormonal processes, Feeder pathway of glycolysis and carbohydrate– homo and hetero lactic fermentation, Glycogenesis, Glycogenolysis and regulation, Gluconeogenesis. Pentose phosphate pathway, E-D pathway, Kreb's cycle and glyoxalate pathway, Glucose-alanine cycle and Cori's cycle Electron transport system in Mitochondria, Chemiosmotic theory, Electron carriers and multi enzyme complex I to IV. ATP synthesis: substrate level and oxidative phosphorylation and uncouplers, inhibitors of oxidative phosphorylation.

#### Lipid Metabolism

Lipid biosynthesis: Biosynthesis of lipids and fatty acids, triglycerol and phospholipids and their regulation; Degradation of Lipids, oxidation of unsaturated, saturated, even and odd chain fatty acids, ketone bodies.

#### Photosynthesis

Oxygenic and an-oxygenic microorganisms, structure of chloroplast, cyclic and non-cyclic photophosphorylation, photolysis of water and photophosphorylation, C<sub>3</sub>, Photorespiration and C<sub>4</sub> pathway of carbon fixation.

#### Amino acid metabolism

Biosynthetic families of amino acids – Outlines, Catabolism of amino acids- General Mechanisms Breakdown of amino acids into six common intermediates and urea cycle and relationship with TCA cycle. – Outlines.

#### Enzymes

Structure and Classification, Mechanism of Enzyme actions: Lock and Key model, induced fit Theory, Factors affecting rates of enzyme mediated reactions (pH, temperature and substrate and enzyme concentration), Enzyme Inhibition and Enzyme regulation.

#### Nucleotide metabolism

Biosynthesis of purines and pyrimidine nucleotides by de novo and salvage pathways. Degradation of Purines and Pyrimidine nucleotides.

### **Membrane transport**

The composition and architecture of membranes, membrane dynamics, solute transport across membranes: passive diffusion, active transport using P and F type ATPases, Ion mediated transport, transport of ions across membrane (ion pumps), model membranes; liposomes.

Biofilm and quorum sensing in gram positive and gram negative bacteria

### **Reference**

1. Zubay, G. L., Aneja, K. R., Rastogi, V. B. (2017). Zubay's Principles of Biochemistry. India: MEDTECH.
2. Advances in Microbial Physiology. (2020). United Kingdom: Elsevier Science.
3. Albert G. Moat, Michael P. Spector John W. Foster (2009) Microbial Physiology;; BWSTM
4. Byung Hong Kim, Geoffrey Michael Gadd (2008) Bacterial Physiology and Metabolism;
5. Cambridge University Press
6. David White, James Drummond, Clay Fuqua (2011) The Physiology and Biochemistry of Prokaryotes, Oxford University Press
7. Robert K. Poole (2014) Advances in Microbial Systems Biology, Volume 64 (Advances in Microbial Physiology); Academic Press

## Immunology

### Course Content

#### Immunity

Factors affecting innate immunity, mechanisms of innate immunity, types of acquired immunity with examples-active and passive immunity Components of the immune system- Haematopoiesis- T lymphocyte, B lymphocyte formation, Monocytes, Macrophages, Eosinophils, Basophils, Neutrophils, mast cells, natural killer cells, dendritic cells (origin, development, maturation, activation, differentiation, surface markers and functions). Isolation and purification of WBCs from bone marrow and liver. Immunohaematology: blood grouping and Rh incompatibilities, analysis of case studies.

#### Antigen and Antibodies

Antigen - factors determining antigenicity, types, haptens, adjuvants.

#### Immunoglobulins

structure, classes, functions, antigenic determinants of immunoglobulins, generation of antibody diversity-class switching. Polyclonal and monoclonal antibody - production, purification and their applications.

#### Complement system

components, properties, classical pathway, properdin pathway and lectin pathway, functions, biological consequences of complement activation. Antigen and antibody reactions: Principles & mechanisms of interactions- types (precipitation, agglutination, complement fixation test, RIA, Immunofluorescence, ELISA), applications, analysis of case studies. Immune responses to bacterial, fungal, protozoan and viral infections with examples. Structure and function of MHC and HLA systems.

**Antigen processing and presentation:** cytosolic and endocytic pathways

#### Transplantation immunology

Immunological basis of allograft rejection, graft versus host reaction, prevention of allograft rejection, immunosuppressive therapy, tissue typing methods. Examples of immune deficiency disorders-SCID, X-linked agammaglobulinemia, DiGeorge's syndrome, ataxia telangiectasia.

#### Tumour immunology

Tumour antigens- immune response to tumours, immunosurveillance, detection of tumour markers- alphafoetal proteins, carcinoembryonic antigen. Auto immunity: theories and mechanisms of autoimmune diseases (hemolytic diseases, Addison's disease, myasthenia gravis, SLE, rheumatoid arthritis, diagnosis and treatment. Analysis of case studies.

### **Hypersensitivity**

pathophysiology of hypersensitivity reactions- type I, II, III, IV, diagnosis and control of allergies, analysis of case studies.

### **Immunization**

Types of vaccines: Conventional vaccines- killed (IPV, Rabies vaccine, and typhoid vaccine) and attenuated (BCG, OPV, MMR), Recombinant vaccines (HBsAg); sub-unit vaccines; peptide vaccines; DNA vaccines; National immunization schedule; Plant - based vaccines (edible vaccines and plantibodies), Current scenario in prevention of contagious diseases and analysis of case studies.

### **Books for Reference**

1. Ivan M. Roit (1998), "Essential immunology" Black well scientific publications, oxford
2. David A Goldsby, Janis Kuby, Thomas J Kindt & Barbara A Osborne (2002), "Immunology" II edition, W H. Freeman and company, New york.
3. Topley & Wilson's (1995), "Text book on principles of Bacteriology, Virology and Immunology" IX Edition (5 volumes), Edward Arnold, London.
4. Abul K Abbas, Andrew K Lightman & Jordan S Pober (1998), "Celluar and molecular immunology" Saunders College Publication.
5. Benjamine Coice R & Sunshine G () Immunology – A short course. Wiley –Liss Publishers.
6. Arthur G. Johnson (2005), "HighYield Immunology" Williams and Wilkins publisher.
7. Klaus D. Elgert (1996), "Immunology-understanding of immune system" Wiley –Liss. NY
8. Tizard IR (1995), "Immunology" 4<sup>th</sup> edn, Saunders college Publication
9. Vaman Rao (2002), "An introduction to immunology" Narosa publications.
10. Hue Davis (1997), "Introductory immunology" Chapman & Hall publisher, London



## **Recombinant DNA Technology and Bioethics**

### **Genetic engineering**

Introduction and prospects in Post genomic era. Transgenic technology in India. How to clone a gene- Fundamental techniques of gene manipulation, Overview of the procedure, Cutting and joining DNA- Restriction endonucleases, Ligation, Alkaline phosphate, double digest, Modification of restriction fragment ends, Other ways of joining DNA molecules. Other enzymes used in RDT. Vectors- Plasmid vectors, Vectors based on the lambda Bacteriophage, Cosmids, Phagemids, M13 vectors, Expression vectors, vectors for cloning and expression in Eukaryotic cells, Super Vectors, YACs, BACs, PAC & MAC; Purification tags- 6XHis, maltose and GST. Promoters- ubiquitous & tissue specific, Signal peptide sequences.

### **Gene library**

cDNA and genomic, cosmid, shot gun library, Hosts for cloning. Molecular cloning, Construction of DNA library, Library screening, Expression libraries.

**Introduction of recombinant DNA into host cells** - Bacteria, Plant and animal cells (direct & indirect methods)

### **Selection methods for recombinants**

selection markers, hybridization techniques- DNA labelling & probes. colony/ Dot/ Plaque hybridization, Blotting techniques (southern, northern, western, southwestern, farwestern), FISH, expression based screening- HART, hybrid selection, yeast two hybrid system; phage display.

### **Molecular techniques**

PCR, principle, types & applications- 3hrs; DNA & protein microarray- printing technologies of oligonucleotides, DNA chips, SNPs, advantages & disadvantages, applications; DNA fingerprinting- RFLP, RAPD, AFLP; Restriction mapping- chromosome walking & jumping; DNA- Protein interaction studies – DNase footprinting, electromobility shift assay, methylinterference assay; chemical synthesis of gene, DNA sequencing - Maxam Gilbert, Sanger's and automated sequencing, Next Generation Sequencing.

### **RDT applications**

Transgenic plants (disease resistant, weedicide resistant, frost resistant, halotolerant, pest resistant); Health- production of growth hormones, monoclonal antibodies, recombinant therapeutics, recombinant vaccines, insulin, Gene therapy- ex vivo, in vivo and targeted, RNA technology- antisense technology, SiRNA technology, Genetic engineering and Public concerns- Ethical and environmental concerns on genetic engineering of plants. Plant genetic engineering future- Genetically Engineered Food products, its safety, Labeling and regulatory challenges. 'Pharm' factories of the future, gene editing-CRISPR.

### **Biotechnology- Biosafety concepts and issues**

Definition of Risk and its classification, relationship between risk, hazard, exposure and safeguards, Biotechnology and biosafety concerns at the level of individuals, institutions, society, region, country and the world. Biosafety levels: Different types and description. Laboratory associated infections and other hazards, Assessment of biological hazards. Biological weapons: - Types and possible role of RDT in production of novel bioweapons. Social, Economic and ethical implications of Bioterrorism. Biosafety regulations and guidelines: Biosafety assessment procedures in India and abroad, International dimensions in biosafety: Cartagena protocol on biosafety. CBW. Biosafety regulations (national and international guidelines): Guidelines on rDNA technology, transgenic science, GM crops, Experimental protocol approvals, levels of containment. Guidelines for research in transgenic plants. Biosafety assessment of pharmaceutical products such as drugs/vaccines (products out of RDT).

### **Reference**

1. Glick, B.R. and Pasternak, J.J., 1998. Principles and applications of recombinant DNA. ASM, Washington DC, 683.
2. Brown TA. (2006). Gene Cloning and DNA Analysis. 5th edition. Blackwell Publishing, Oxford, U.K
3. Primrose SB and Twyman RM. (2006). Principles of Gene Manipulation and Genomics, 7th edition. Blackwell Publishing, Oxford, U.K.
4. DNA Cloning: A practical approach D.M. Glover and D.B. Hames, RL Press, Oxford, 1995
5. Molecular and cellular methods in Biology and Medicine, P.B. Kaufman, W. Wu, D. Kim and L.J. Cseke, CRC Press Florida 1995
6. Methods in Enzymology Guide to Molecular Cloning Techniques, Vol. 152 S.L. Berger and A. R. Kimmel, Academic Press Inc, San Diego, 1996
7. Methods in Enzymology Gene Expression Technology, Vol. 185D. V. Goedel, Academic Press Inc, San Diego, 1990
8. DNA Science: A First Course in Recombinant Technology, D. A. Mickloss and G. A Freyer, Cold Spring Harbor Laboratory Press, New York, 1990
9. Molecular Biotechnology, 2nd Ed. S. B. Primrose, Blackwell Scientific publishers, Oxford, 1994
10. Milestones in Biotechnology, Classic Papers on Genetic Engineering, J. A. Davis and W. S. Reznikoff, Butterworth-Heinemann Boston 1992
11. Route Maps in Gene Technology, M. R. Walker, and R. Rapley, Blakwell Science, Oxford, 1997
12. Genetic Engineering: An Introduction to Gene Analysis and Exploitation in Eukaryotes, S. M. Kingsman, Blackwell Scientific Publications, Oxford, 1998

13. An Introduction to Genetic Engineering, 3rd Edition. Desmond S. T. Nicholl, Cambridge University press, 2008.
14. Gene Cloning and Manipulation, 2nd Ed. Cristopher Howe, Cambridge University Press, 2007

## Medical Microbiology

### Course Content

Significance of normal human flora and human microbiome project.

### Host-pathogen interaction

Portal of entry, role of virulence factors in adhesion and colonization, aggressins, depolymerising enzymes, quorum sensing, bacterial protein toxins- exotoxins and endotoxin.

### Systematic study of major bacterial pathogens

*Staphylococcus*, *Pneumococcus*, *Corynebacterium*, *Mycobacterium*, *Bacillus anthracis*, *Clostridium*, *E. coli*, *Salmonella typhi*, *Shigella*, *Vibrio*, *Treponema pallidum* (with respect to their pathogenicity, epidemiology, laboratory diagnosis, treatment, prevention). Nosocomial infections.

**DNA viruses:** Adenovirus, HSV, HBV.

**RNA viruses:** Polio, Influenza, Rabies, Rota, Measles, Mumps, HIV, Arbo viruses (yellow fever, Japanese encephalitis, chikungunya, dengue) (with respect to pathogenicity, epidemiology, laboratory diagnosis, treatment, prevention).

**Oncogenic virus:** definition, general characters, types, transmission, mechanism of cell transformation.

### Fungal diseases

Superficial (dermatophytosis), Subcutaneous (mycetoma), systemic (histoplasmosis, blastomycosis), opportunistic (aspergillosis, candidiasis).

Antibiotics against bacteria (penicillins, cephalosporins, tetracyclines, chloramphenicol, aminoglycosides), pertaining to mode of action, target organisms, toxicity.

Antifungal drugs (Amphotericin, B, Nystatin, Griseofulvin, Flucytosine, Ketoconazole) pertaining to mode of action, target organisms, toxicity.

### Antiviral drugs and Interferon

Collection, transport, and processing of major clinical samples.

Immunomolecular diagnostic methods (precipitation, agglutination based methods, ELISA, phage based diagnosis, etc.)

### Reference

1. David Greenwood, Richard C D, Slack J F P (1992), "Medical Microbiology" 16<sup>th</sup> edition. ELBS with Churchill Livingstone.
2. Tom Parker, Leslie M & Collie H (1990), "Topley & Wilson's Principles of Bacteriology, Virology and Immunity" (VIII Edition).
3. Joan stokes E, Ridgway G L and Wren M W D (1993), "Clinical Microbiology" 7<sup>th</sup> Edition, Edward Arnold.

4. Brooks George F, Butel Carroll, Karen C, Butel Janet S, Morse Stephen A (2007), "Jawetz, Melnick, & Adelberg's Medical Microbiology" *McGraw-Hill* publication.
5. Collee J G, Duguid J P, Fraser A G & Marimoin B P (1989), "Mackie and Mc Cartney Practical Medical Microbiology" 13<sup>th</sup> Edition. Churchill Livingstone.
6. Nester, Roberts, Pearsall & Anderson (1998), "Microbiology- A human perspective" 2nd edition. Mc Graw Hill.
7. Fields B N, Knipe D M, Howley P M, Chanock R M, Melnick J L, Monath T P, Roizman B & Straus. Fields S E (2000), "Virology" Vol 1 and 2. 3rd Edition. Lippincott Raven, Philadelphia, PA.
8. Flint V R, Racaniello L W, Enquist V R, Rancaniello A M, Skalka (2003), "Principles of Virology: Molecular Biology, Pathogenesis, and Control of Animal Viruses" American Society Microbiology Publisher

## Industrial Microbiology

### Introduction

Definition, concept and scope of industrial microbiology; isolation and screening of cultures for new microbial products, Inoculum development; preservation; strain improvement: mutagenesis and protoplast fusion, Basic concepts in media design-cell growth and product formation: media formulation; fermentation media- carbon; nitrogen; vitamins; buffers; precursors; inhibitors; inducers; foam and antifoam agents; agrowastes; medium rheology

### Microbial growth kinetics

Batch, continuous, fed-batch and cyclic fed batch; methods of fermentation- submerged, surface and solid state, Bioreactor- components and basic functions, body construction, aeration and agitation systems, KLa, baffles. Types- stirred tank, tower, airlift, deep-jet, cyclone column, packed tower, fluidized bed, hollow-fiber, membrane and photo-bioreactor, Scale up and scale down

### Downstream processing (DSP)

Removal of microbial cells and other solids (filtration, centrifugation); Cell disruption methods (chemical, physical and enzymatic); Concentration/ extraction methods (precipitation, ultrafiltration); Analytical methods (Chromatography); membrane processes; solvent recovery; drying; crystallization; distillation and electro dialysis. Immobilization: Definition and concept, methods of immobilization, advantages and applications Industrial production: Organic acid (citric acid); antibiotic (penicillin); solvents (acetone-butanol); alcoholic beverages (beer, wine); biopolymer (PHA); growth hormone and insulin

### Patent Laws

Intellectual property rights- implications for India, WTO, WIPO, GATT, TRIPS, Patenting and the procedures involved in application and granting of patents, Patent Cooperation Treaty; examples of patents; patenting of living organisms; Biodiversity laws; plant breeder's rights, legal implications; classification of biological risk material; handling and disposal of bio-hazardous materials; good manufacturing practices and good lab practices; GMOs.

### Reference

1. Okeke, B. C., Okafor, N. (2017). Modern Industrial Microbiology and Biotechnology. United Kingdom: CRC Press.
2. Crueger, W., Crueger, A. (2017). Crueger's Biotechnology: A Textbook of Industrial Microbiology. India: MedTech
3. Clarke, W. (2016). Biotechnology: Industrial Microbiology a Textbook. India: CBS Publishers & Distributors.
4. Casida, L. E. J. R. (2015). Industrial Microbiology. India: New Age International Pvt. Industrial Microbiology. Edited by Wilson DB, Sahm H, Stahmann KP and Koffas (2019). Germany: Wiley.

5. Intellectual Property Issues in Microbiology. (2019). Germany: Springer, Singapore.
6. Beale, A. J. (2015). Safety in Industrial Microbiology and Biotechnology. Netherlands: Elsevier Science.

## Microbial and Molecular Genetics

### Microbial genomes

Gene: gene concept, unit of function, replication, recombination and mutation Fine structure of gene: bar locus, complex loci, rII locus and complementation analysis Gene function: one gene/one enzyme hypothesis, pathways of gene action. Genome organization: Genome organization in prokaryotes and eukaryotes special features of eukaryotic gene structure and organization. DNA content and C-value paradox, methods to measure DNA content variation; Various types of DNA sequences (simple sequences, repetitive sequences, nonsense sequences, tandem gene clusters, satellites)

DNA Damage and repair: Spontaneous and Induced mutations – Physical and Chemical mutagenesis, Replica block method, auxanography, Molecular mechanisms of mutagenesis – Transition, Transversion, Frame Shift, mis-sense and non-sense mutations, Photo-reactivation, Excision Repair, Mismatch Repair, Post-replication Repair, SOS Repair

### Gene transfer and Replication

Recombination in bacteria and viruses: enzymes and molecular mechanism, Transformation: Competence factors, mechanism of transformation, mapping genes by transformation, Conjugation: Structure of F plasmid, Mechanism of transfer of F plasmid, Hfr, time of entry curve, zygotic induction, Conjugation mapping – different methods. Transduction-generalized and specialized & Gene mapping, Transposons- types - IS and composite, mechanism of transposition- cut-paste and replicative.

Plasmids- types (F, R and Col), yeast 2 micron and properties

DNA Replication: Prokaryotic and eukaryotic DNA replication mechanism, enzymes and accessory proteins involved in DNA replication, modes of replication- theta and rolling circle

### Transcription and Translation

Prokaryotic transcription, eukaryotic transcription, RNA polymerases, General and specific transcription factors, Regulatory elements and mechanisms of transcription regulation, 5' Cap formation, Transcription termination, 3'end processing and polyadenylation, nuclear export of mRNA, mRNA stability. RNA splicing: Nuclear splicing, spliceosome and small nuclear RNAs, group I and group II introns, *Cis*- and *Trans*- splicing reactions, tRNA splicing, alternate splicing. Genetic Code, Prokaryotic and eukaryotic translation - Synthesis of aminoacyl tRNA, aminoacyl synthetases, Mechanism of initiation, elongation and termination, Regulation of translation, co-and post-translational modifications of proteins, mobility shift assay, Dipeptide assay, Tripeptide assay, *In vitro* translation. Interacellular protein transport: synthesis of secretory and membrane proteins, Import into nucleus, mitochondria, chloroplast and peroxisomes, Receptor mediated endocytosis, Protein targeting and protein localization signals, role of golgi

### Regulation of gene expression

Induction and repression, operon theory, lac operon, trp operon, ara operon, attenuation, positive and negative control, catabolite repression, regulation of transcription by cAMP and



CRP, and guanosine tetraphosphate, *Run off* transcription. Britten-Davidson and Mated models of gene regulation, regulation of gene expression in eukaryotes. RNA interference: RNA silencing in cytoplasm and genome level, ds RNA mediated RNA interference (Si RNA and microRNA), RNAi pathways (si RNA and mi RNA pathway), Biochemistry of ribozyme; hammer – head, hairpin and other ribozymes, strategies for designing ribozymes, applications of antisense and ribozyme technologies.

### Reference

1. Henkin, T. M., Peters, J. E., Snyder, L. R., Champness, W. (2013). *Molecular Genetics of Bacteria*. United Kingdom: Wiley
2. Snyder, L. A. (2020). *Bacterial Genetics and Genomics*. United Kingdom: CRC Press.
3. Dorman, C. J. (2020). *Structure and Function of the Bacterial Genome*. United Kingdom: Wiley
4. Bainbridge, B. W. (2013). *Genetics of Microbes*. United States: Springer US.
5. *Genetics of Bacterial Diversity*. (2013). United Kingdom: Elsevier Science.
6. *Concepts of Genetics*. (2015). United States: McGraw-Hill US Higher Ed USE Legacy.
7. Cummings, M. R., Klug, W. S., Spencer, C. A., Nickla, H., Palladino, M. A. (2014). *Student's Handbook and Solutions Manual for Concepts of Genetics*. United Kingdom: Benjamin-Cummings Publishing Company.