

# **SYLLABUS FOR CHOICE BASED CREDIT SYSTEM**

## **BSc Honours in Botany/Zoology/Microbiology**

(Effective from Academic Session: 2019-20)



**Offered by**

**Department of Biological Sciences**

**ALIAH UNIVERSITY**

II-A/27, Action Area II, New Town  
Kolkata 700160



## **BSc Honours in Botany (CBCS)**

### **Preamble**

Ministry of Human Resource Development (HRD), Govt. of India, has already initiated the process for developing New Education Policy (NEP) in our country to bring out reforms in Indian education system. University Grants Commission (UGC) participates more actively in developing National Education Policy, its execution and promotion of higher education in our country. The UGC has already initiated several steps to bring equity, efficiency and academic excellence in National Higher Education System. The important ones include innovation and improvement in course- curricula, introduction of paradigm shift in learning and teaching pedagogy, examination and education system. The education plays enormously significant role in building of a nation. There are quite a large number of educational institutions, engaged in imparting education in our country. Majority of them have entered recently into semester system to match with international educational pattern. However, our present education system produces young minds lacking knowledge, confidence, values and skills. It could be because of complete lack of relationship between education, employment and skill development in conventional education system. The present alarming situation necessitates transformation and/or redesigning of education system, not only by introducing innovations but developing “learner-centric approach in the entire education delivery mechanism and globally followed evaluation system as well. Majority of Indian higher education institutions have been following marks or percentage-based evaluation system, which obstructs the flexibility for the students to study the subjects/ courses of their choice and their mobility to different institutions. There is need to allow the flexibility in education system, so that students depending upon their interests and aims can choose interdisciplinary, intra-disciplinary and skill-based courses. This can only be possible when choice based credit system (CBCS), an internationally acknowledged system, is adopted. The choice based credit system not only offers opportunities and avenues to learn core subjects but also exploring additional avenues of learning beyond the core subjects for holistic development of an individual. The CBCS will undoubtedly facilitate us bench mark our courses with best international academic practices. The CBCS has more advantages than disadvantages.

#### **Advantages of the choice based credit system:**

- Shift in focus from the teacher-centric to student-centric education.
- Student may undertake as many credits as they can cope with (without repeating all courses in a given semester if they fail in one/ more courses).
- CBCS allows students to choose inter-disciplinary, intra-disciplinary courses, skill oriented papers (even from other disciplines according to their learning needs, interests and aptitude) and more flexibility for students).
- CBCS makes education broad-based and at par with global standards. One can take credits by combining unique combinations. For example, Physics with Economics, Microbiology with Chemistry or Environment Science etc.
- CBCS offers flexibility for students to study at different times and at different institutions to complete one course (ease mobility of students). Credits earned at one institution can be transferred.

#### **Disadvantages:**

- Difficult to estimate the exact marks
- Workload of teachers may fluctuate
- Demand good infrastructure for dissemination of education

**CHOICE BASED CREDIT SYSTEM (CBCS):** The CBCS provides an opportunity for the students to choose courses from the prescribed courses comprising core, elective/minor or skill based courses. The courses can be evaluated following the grading system, which is considered to be better than the conventional marks system. Therefore, it is necessary to introduce uniform grading system in the entire higher education in India. This will benefit the students to move across institutions within India to begin with and across countries. The uniform grading system will also enable potential employers in assessing the performance of the candidates. In order to bring uniformity in evaluation system and computation of the Cumulative Grade Point Average (CGPA) based on student's performance in examinations, the UGC has formulated the guidelines to be followed. Present syllabus is strictly in accordance with guidelines prescribed by UGC.

**Department of Biological Sciences, Aliah University**

**Outline for BSc (H) Botany [Choice Based Credit System]**

Type of Paper	Sub Category	Theory Papers	Practical Papers	Credits	Total Credits
<b>Core Course (CC)</b>	Core Course(CC)	14		4 each	56
	Core Course (CC)		14	2 each	28
<b>Elective Course (EC)</b>	Generic Elective (GE)	04		4 each	16
	Generic Elective (GE)		04	2 each	08
	Discipline Specific Elective (DS)	04		4 each	16
	Discipline Specific Elective (DS)		04	2 each	08
<b>Skill Enhancement Course (SE)</b>	Skill Enhancement Course (SE)	02		4 each	08
<b>Ability Enhancement (AE)</b>	Ability Enhancement Compulsory (AE)	02		4 each	08
<b>Aliah University Non credit compulsory course</b>	Arabic and Islamic Studies (AU)	01		Non credit	0
<b>Total Credits</b>					<b>148</b>

**Detailed Course Outline**

Sem	Paper Code	Paper Name	Credits (T+P)
<b>I</b>	BSBUGCC01	Algae and Microbiology	4+2
	BSBUGCC02	Mycology and Phytopathology	4+2
	BSBUGAE01	EVS	4
	CHMUGGE01	Chemistry	4+2
<b>Semester Total</b>			<b>22</b>
<b>II</b>	BSBUGCC03	Morphology and Anatomy	4+2
	BSBUGCC04	Archegoniate	4+2
	BSBUGAE02	Communicative English	4
	CHMUGGE02	Chemistry	4+2
	ARBUGAU02	Arabic and Islamic Studies	0
<b>Semester Total</b>			<b>22</b>
<b>III</b>	BSBUGCC05	Biomolecules and Plant Metabolism	4+2
	BSBUGCC06	Cell Biology	4+2
	BSBUGCC07	Plant Systematics	4+2
	BSBUGSE01	Mushroom Culture Technology	4
	BSZUGGE01	Animal Diversity	4+2
<b>Semester Total</b>			<b>28</b>
<b>IV</b>	BSBUGCC08	Molecular Biology	4+2
	BSBUGCC09	Plant Ecology and Phytogeography	4+2
	BSBUGCC10	Reproductive Biology of Angiosperms	4+2
	BSBUGSE02	Nursery and Gardening	4
	BSZUGGE02	Human Physiology	4+2
<b>Semester Total</b>			<b>28</b>
<b>V</b>	BSBUGCC11	Plant Physiology	4+2
	BSBUGCC12	Genetics	4+2
	BSBUGDS01	Bioinformatics	4+2
	BSBUGDS02	Industrial and Environmental Microbiology	4+2
<b>Semester Total</b>			<b>24</b>
<b>VI</b>	BSBUGCC13	Economic Botany	4+2
	BSBUGCC14	Plant Biotechnology	4+2
	BSBUGDS03	Biostatistics & Biotechniques	4+2
	BSBUGDS04	Biosafety and Intellectual Property Rights	4+2
<b>Semester Total</b>			<b>24</b>
<b>Grand Total</b>			<b>148</b>

**List of Papers with Respective Codes****Core Papers**

S No	Paper Code	Paper Name
1	BSBUGCC01	Algae and Microbiology
2	BSBUGCC02	Mycology and Phytopathology
3	BSBUGCC03	Morphology and Anatomy
4	BSBUGCC04	Archegoniate
5	BSBUGCC05	Biomolecules and Plant Metabolism
6	BSBUGCC06	Cell Biology
7	BSBUGCC07	Plant Systematics
8	BSBUGCC08	Molecular Biology
9	BSBUGCC09	Plant Ecology and Phytogeography
10	BSBUGCC10	Reproductive Biology of Angiosperms
11	BSBUGCC11	Plant Physiology
12	BSBUGCC12	Genetics
13	BSBUGCC13	Economic Botany
14	BSBUGCC14	Plant Biotechnology

**Discipline Specific Electives**

S No	Code	Botany
1	BSBUGDS01	Bioinformatics
2	BSBUGDS02	Industrial and Environmental Microbiology
3	BSBUGDS03	Biostatistics & Biotechniques
4	BSBUGDS04	Biosafety and Intellectual Property Rights
5	BSBUGDS05	Stress Biology
6	BSBUGDS06	Plant Breeding

**Skill Enhancement Courses**

S No	Paper Code	Paper Name
1	BSBUGSE01	Mushroom Culture Technology
2	BSBUGSE02	Nursery and Gardening
3	BSBUGSE03	Biofertilizers

**Generic Electives to be Offered**

S No	Paper Code	Paper Name
1	BSBUGGE01	Biodiversity (Microbes, Algae, Fungi and Archegoniate)
2	BSBUGGE02	Plant Physiology and Metabolism
3	BSBUGGE03	Economic Botany and Biotechnology

## Detailed Syllabus of Papers

### A) Core Papers

<b>BSBUGCC01</b>	<b>Algae and Microbiology</b>
Theory (Credits: 4)	

#### **Unit 1: Algae**

General characteristics; range of thallus organization; Cell structure and components; cell wall, pigment system, reserve food (of only groups represented in the syllabus), flagella; methods of reproduction; Classification; criteria, general concept of endosymbiosis, system of Fritsch' 1935 (only upto class), and evolutionary classification of Lee' 2008 (only upto groups); Significant contributions of important phycologists (F.E. Fritsch & M.O.P. Iyengar); Role of algae in the environment, agriculture, biotechnology and industry.

#### **Unit 2: Cyanophyta and Xanthophyta**

Ecology and occurrence; Cell structure; Reproduction, Genetic recombination (in Cyanophyta); Morphology and life-cycle of *Vaucheria*.

#### **Unit 3: Chlorophyta and Charophyta**

General characteristics; Occurrence; Cell structure. Life-cycles of *Volvox*, *Zygnema*, *Oedogonium*, *Coleochaete* and *Chara*.

#### **Unit 4: Phaeophyta and Rhodophyta**

Characteristics; Occurrence; Cell structure; Reproduction, life-cycles of *Fucus* and *Polysiphonia*.

#### **Unit 5: Introduction to microbial world**

Microbial nutrition, growth and metabolism. Economic importance of viruses with reference to vaccine production, role in medicine and as causal organisms of plant diseases. Economic importance of bacteria with reference to their role in agriculture and industry (fermentation and antibiotics)

#### **Unit 6: Viruses**

Discovery, physiochemical and biological characteristics; classification (Baltimore), general structure with special reference to TMV, T2-Phage, viroids and prions; lytic and lysogenic cycle.

#### **Unit 7: Bacteria**

Discovery, general characteristics; Principles in Bacterial Taxonomy, Bergey's Man. of Syst. Bact.; 2<sup>nd</sup>Ed. - 2001-05; Types-Archaea, Eubacteria, wall-less forms (mycoplasma and spheroplasts); Cell structure; Bacterial Chromosome & extra-chromosomal genetic elements; Nutritional types; Vegetative Reproduction and genetic recombination (conjugation, transformation and transduction), Endospore.

### Practical (Credits: 2)

#### **Phycology**

1. Study and Camera Lucida drawings of vegetative and reproductive structures of *Nostoc*, *Scytonema*, *Zygnema*, *Oedogonium*, *Cham* and *Vaucheria* temporary preparations and identification from permanent slides.
2. Identification of all the genera included in the theoretical syllabus from Permanent slides (vegetative and reproductive structures).

#### **Microbiology**

1. Aseptic method
  - a) Sterilization technique by Autoclaving, Hot air oven and surface sterilization.
  - b) Preparation of standard bacteriological medium (Nutrient agar, Nutrient broth and glucose - peptone medium).
  - c) Preparation of slant and plates.
  - d) Subculturing of pure bacteriological culture.
  - e) Pure culture technique: dilution streak method.
2. Simple staining; Differential staining; Gram staining.
3. Microscopic examination of bacteria from natural habitats: curd and root nodules of leguminous plants.

#### **Suggested Readings**

1. Lee, R.E. (2008). Phycology, Cambridge University Press, Cambridge. 4th edition.

2. Wiley JM, Sherwood LM and Woolverton C.J. (2013). Prescott's Microbiology. 9th Edition. McGrawHill International.
3. Kumar, H.D. (1999). Introductory Phycology. Affiliated East-West Press, Delhi.
4. Sahoo, D. (2000). Farming the ocean: seaweeds cultivation and utilization. Aravali International, New Delhi.
5. Campbell, N.A., Reece J.B., Urry L.A., Cain M.L., Wasserman S.A. Minorsky P.V., Jackson R.B.(2008). Biology, Pearson Benjamin Cummings, USA. 8th edition.
6. Pelczar, M.J. (2001). Microbiology, 5th edition, Tata McGraw-Hill Co, New Delhi.

<b>BSBUGCC02</b>	<b>Mycology and Phytopathology</b>
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Theory (Credits: 4)

**Unit 1: Introduction to true fungi**

General characteristics; Affinities with plants and animals; Thallus organization; Cell wall composition; Nutrition; Classification (Alexopoulos and Mims, 1979)

**Unit 2: Chytridiomycota and Zygomycota**

Characteristic features; Thallus organisation; Life cycle with reference to *Synchytrium* and *Rhizopus*.

**Unit 3: Ascomycota**

General characteristics, sexual reproduction and development of ascus and ascospores, types of ascocarp; Phenomenon of Heterokaryosis and parasexuality in asexual members; Life cycle of *Saccharomyces*, *Talaromyces*, *Neurospora* and *Ascobolus*.

**Unit 4: Basidiomycota**

General characteristics; Phenomenon of dikaryotization, development of basidia and basidiospores and basidiocarp, Life cycle of *Puccinia* (Physiological Specialization) and *Agaricus*, Bioluminescence, FairyRings.

**Unit 5: Allied Fungi**

General characteristics; Status of Slime moulds, Occurrence; Types of plasmodia.

**Unit 6: Oomycota**

General characteristics; Life cycle of *Phytophthora* and *Albugo*.

**Unit 7: Symbiotic associations**

Lichen - Occurrence; General characteristics; Range of thallus organization; Nature of associations of algal and fungal partners; Reproduction; Mycorrhiza-Ectomycorrhiza, Endomycorrhiza with special reference to VAM and their significance.

**Unit 8: Applied Mycology**

Role of fungi in biotechnology; Application of fungi in food industry (Flavour and texture, Fermentation, Baking, Organic acids, Enzymes, Mycoproteins); Secondary metabolites (Pharmaceutical preparations); Agriculture (Biofertilizers); Mycotoxins; Biological control (Mycofungicides, Mycoherbicides, Mycoinsecticides, Myconematicides)

**Unit 9: Phytopathology**

Terms and concepts; General symptoms; Geographical distribution of diseases; Symptomology; Koch's Postulate; Host-Pathogen relationships; Disease cycle and environmental relation; types of diseases, host defense mechanism; prevention and control of plant diseases (biological & chemical), and role of quarantine. Bacterial diseases-Citrus canker and bacterial blight of rice. Viral diseases-Tobacco Mosaic virus. Fungal diseases and Control - Late blight of potato. Ergot of rye; Black stem rust of wheat, loose and covered smut of wheat, White rust of crucifer

**Practical (Credits: 2)****Mycology**

1. Study of the following genera and their identification: *Rhizopus*, *Talaromyces*, *Alternaria*, *Ascobolus*, *Agaricus* and *Polyporus*.
2. Identification of all the macroscopic and microscopic genera included in the theoretical syllabus.

**Plant Pathology**

1. Identification of diseases prescribed in the theoretical syllabus.

2. Study of the following diseases: White rust, Rust of wheat/*Justicia*, loose smut of wheat.
3. Herbarium specimens of bacterial diseases; Citrus Canker; Angular leaf spot of cotton, Viral diseases: TMV, Vein clearing, Fungal diseases: Early & Late blight of potato, Black stem rust of wheat and White rust of crucifers.
4. Mycorrhizae-Ecto and Endo mycorrhizae (photographs only)

**Suggested Readings**

1. Agrios, G.N. (1997). Plant Pathology, 4th edition, Academic Press, U.K.
2. Alexopoulos, C.J., Mims, C.W., Blackwell, M. (1996). Introductory Mycology, John Wiley & Sons (Asia) Singapore. 4th edition.
3. Webster, J. and Weber, R. (2007). Introduction to Fungi, Cambridge University Press, Cambridge. 3rd edition.
4. Sethi, I.K. and Walia, S.K. (2011). Text book of Fungi and Their Allies, Macmillan Publishers India Ltd.
5. Sharma, P.D. (2011). Plant Pathology, Rastogi Publication, Meerut, India.

BSBUGCC03

**Morphology and Anatomy**Theory (Credits: 4)**Unit 1: Introduction and scope of Plant Anatomy**

Applications in systematics, forensics and pharmacognosy

**Unit 2: Structure and Development of Plant Body**

Internal organization of plant body: The three tissue systems, types of cells and tissues; Development of plant body: a brief account.

**Unit 3: Tissues**

Classification of tissues; Simple and complex tissues (no phylogeny); cyto-differentiation of tracheary elements and sieve elements; Cell wall and its secondary growth; Pits and plasmodesmata; Ergastic substances. Hydathodes, cavities, lithocysts and laticifers.

**Unit 4: Apical meristems**

Evolution of concept of organization of shoot apex (Apical cell theory, Histogen theory, Tunica Coipus theory, continuing meristematic residue, cytohistological zonation); Types of vascular bundles; Structural differences of dicot and monocot stem, root &amp; leaf, Kranz anatomy. Organization of root apex (Apical cell theory, Histogen theory, Korper-Kappe theory); Quiescent centre; Endodermis, exodermis and origin of lateral root.

**Unit 5: Vascular Cambium and Wood**Structure, function and seasonal activity of cambium; Secondary growth in root and stem with special reference to *Bignonia*, *Dracaena* (*Cordyline*), *Boerhaavia* and *Strychnos*. Types of rays and axial parenchyma; Sapwood and heartwood; Ring and diffuse porous wood; Early and late wood, tyloses; Dendrochronology. Development and composition of periderm; General account of Rhytidome and lenticels.**Unit 6: Adaptive and Protective Systems**

Epidermal tissue system, cuticle, epicuticular waxes, trichomes (uni- and multicellular, glandular and nonglandular, two examples of each), stomata (classification). Adcrustation and incrustation; Anatomical adaptations of xerophytes and hydrophytes.

**Unit 7: Leaves and Inflorescence**

Leaves-types, phyllotaxy and modifications; Inflorescence-Types and evolution

**Unit 8: Flower, Fruit and Seed**

Types of flower; Aestivation, placentation - types and evolution. Floral formula &amp; floral diagram; Adhesion-Cohesion of floral parts, micro and mega gameto- and sporogenesis; embryosac, Fruits -types, dispersal. Seed dispersal.

**Practical (Credits: 2)**

1. Study of anatomical details through permanent slides/temporary stain mounts/ macerations/museum specimens with the help of suitable examples.
2. Study of the secondary structures of stem of the following genera: *Bignonia*, *Dracaena* (*Cordyline*), *Boerhaavia* and *Strychnos*.
3. Xylem: Tracheary elements-tracheids, vessel elements; thickenings; perforation plates;xylem fibres. (from permanent slides)



4. Phloem: Sieve tubes-sieve plates; companion cells; phloem fibres, (from permanent slides)
5. Epidermal system: cell types, stomata types; trichomes: non-glandular and glandular, lenticels.
6. Root: monocot, dicot, secondary growth (from permanent slides).
7. Stem: monocot, dicot - primary and secondary growth; periderm (from permanent slides);
8. Leaf: Different variations; C4 leaves (Kranz anatomy).
9. Cystolith, lithocysts and Raphides.
10. Types of inflorescence, placentation and fruits.

#### **Suggested Readings**

1. Dickison, W.C. (2000). Integrative Plant Anatomy. Harcourt Academic Press, USA.
2. Fahn, A. (1974). Plant Anatomy. Pergmon Press, USA.
3. Mauseth, J.D. (1988). Plant Anatomy. The Benjamin/Cummings Publisher, USA.
4. Evert, R.F. (2006). Esau's Plant Anatomy: Meristems, Cells, and Tissues of the Plant Body: Their Structure, Function and Development. John Wiley and Sons, Inc.

<b>SBUGCC04</b>	<b>Archegoniate</b>
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Theory (Credits: 4)

#### **Unit 1: Introduction**

Unifying features of archegoniates; Transition and adaptation to land habit; Alternation of generations.

#### **Unit 2: Bryophytes**

General characteristics & Classification [upto order] of Schuster (1968); Adaptations to land habit; Range of thallus organization

#### **Unit 3: Type Studies**

Bryophytes Morphology, anatomy, reproduction and evolutionary trends in *Riccia*, *Marchantia*, *Pellia*, *Anthoceros*, *Sphagnum* and *Funaria* (developmental stages not included). Ecological and economic importance of bryophytes (a brief account)

#### **Unit 4: Pteridophytes**

General characteristics; Classification (PichiSermolli, 1977 upto order); early land plants (Cooksonia and Rhynia)

#### **Unit 5: Type Studies**

Pteridophytes Morphology, anatomy and reproduction of *Lycopodium*, *Selaginella*, *Equisetum*, *Pteris* and *Marsilea* (Developmental details not to be included). Apogamy, and apospory, heterospory and seed habit, telome theory, stelar evolution; Ecological and economic importance

#### **Unit 6: Gymnosperms**

General characteristics, classification (Stewart and Rothwell 1993, up to order), morphology, anatomy and reproduction of *Cycas*, *Pinus* and *Gnetum* (Developmental details not to be included); Ecological and economic importance.

#### **Practical (Credits: 2)**

1. **Marchantia**- Morphology of thallus, whole mount of rhizoids & Scales, vertical section of thallus through Gemma cup, whole mount of Gemmae (all temporary slides), vertical section of Antheridiophore, Archegoniophore, longitudinal section of Sporophyte (from permanent slides).
2. **Anthoceros**- Morphology of thallus, dissection of sporophyte (to show stomata, spores, pseudoelaters, columella) (temporary slide), vertical section of thallus (from permanent slide).
3. **Pellia** - Study from Permanent slides.
4. **Funaria**- Morphology, whole mount of leaf, rhizoids, operculum, peristome, annulus, spores (temporary slides); permanent slides showing antheridial and archegonial heads, longitudinal section of capsule.
5. **Lycopodium**- Morphology, whole mount of leaf, transverse section of stem (temporary slide), longitudinal section of strobilus (from permanent slide).
6. **Selaginella**- Morphology, whole mount of leaf with ligule, transverse section of stem, whole mount of strobilus, whole mount of microsporophyll and megasporophyll (temporary slides), longitudinal section of strobilus (from permanent slide).
7. **Equisetum**- Morphology, transverse section of intemode, longitudinal section of strobilus, transverse section of strobilus, whole mount of sporangiophore, whole mount of spores (temporary slide), transverse section of rhizome (from permanent slide).

8. **Pteris**- Morphology, transverse section of rachis, vertical section of sporophyll, whole mount of sporangium, whole mount of spores (temporary slides), transverse section of rhizome, whole mount of prothallus with sex organs and young sporophyte (from permanent slide).
9. **Cycas**- Morphology (coralloid roots, bulbil, leaf), whole mount of microsporophyll, transverse section of coralloid root, transverse section of rachis, vertical section of leaflet, vertical section of microsporophyll, whole mount of spores (temporary slides), longitudinal section of ovule, transverse section of root (permanent slide).
10. **Pinus**- Morphology (long and dwarf shoots, whole mount of dwarf shoot, male and female cones), transverse section of Needle, transverse section of stem, longitudinal section of / transverse section of male cone, whole mount of microsporophyll, whole mount of Microspores (temporary slides), longitudinal section of female cone (Permanent slide), tangential longitudinal section & radial longitudinal sections stem (permanent slide).
11. **Gnetum**- Morphology (stem, male & female cones), transverse section of stem, vertical section of ovule (permanent slide)

#### Suggested Readings

1. Vashistha, P.C., Sinha, A.K., Kumar, A. (2010). Pteridophyta. S. Chand. Delhi, India.
2. Bhatnagar, S.P. & Moitra, A. (1996). Gymnosperms. New Age International (P) Ltd Publishers, New Delhi, India.
3. Parihar, N.S. (1991). An introduction to Embryophyta: Vol. I. Bryophyta. Central Book Depot. Allahabad.
4. Raven, P.H., Johnson, G.B., Losos, J.B., Singer, S.R. (2005). Biology. Tata McGraw Hill, Delhi.
5. Vanderpoorten, A. & Goffinet, B. (2009) Introduction to Bryophytes. Cambridge University

<b>BSBUGCC05</b>	<b>Biomolecules and Plant Metabolism</b>
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Theory (Credits: 4)

#### Unit 1: Biomolecules

Types and significance of chemical bonds; Structure and properties of water; pH and buffers.

**Carbohydrates:** Nomenclature and classification; Monosaccharides; Disaccharides; Oligosaccharides and polysaccharides. **Lipids:** Definition and major classes of storage and structural lipids; Fatty acids structure and functions; Essential fatty acids; Triacyl glycerols structure, functions and properties; Phosphoglycerides. **Proteins:** Structure of amino acids; Levels of protein structure-primary, secondary, tertiary and quaternary; Protein denaturation and biological roles of proteins. **Nucleic acids:** Structure of nitrogenous bases; Structure and function of nucleotides; Types of nucleic acids; Structure of A, B, Z types of DNA; Types of RNA; Structure of tRNA.

#### Unit 2: Bioenergetics

Laws of thermodynamics, concept of free energy, endergonic and exergonic reactions, coupled reactions, redox reactions. ATP: structure, its role as a energy currency molecule.

#### Unit 3: Enzymes

Structure of enzyme: holoenzyme, apoenzyme, cofactors, coenzymes and prosthetic group; Classification of enzymes; Features of active site, substrate specificity, mechanism of action (activation energy, lock and key hypothesis, induced - fit theory), Michaelis - Menten equation, enzyme inhibition and factors affecting enzyme activity.

#### Unit 4: Concept of metabolism

Introduction, anabolic and catabolic pathways, regulation of metabolism, role of regulatory enzymes (allosteric, covalent modulation and Isozymes)

#### Unit 5: Carbon assimilation

Historical background, photosynthetic pigments, role of photosynthetic pigments (chlorophyll and accessory pigments), antenna molecules and reaction centres, photochemical reactions, photosynthetic electron transport, PSI, PSII, Q cycle, CO<sub>2</sub> reduction, photorespiration, C<sub>4</sub> pathways; Crassulacean acid metabolism; Factors affecting CO<sub>2</sub> reduction.

#### Unit 6: Carbohydrate metabolism

Synthesis and catabolism of sucrose and starch

#### Unit 7: Carbon Oxidation

Glycolysis, fate of pyruvate, regulation of glycolysis, oxidative pentose phosphate pathway, oxidative decarboxylation of pyruvate, regulation of PDH, NADH shuttle; TCA cycle, amphibolic role, anaplerotic reactions, regulation of the cycle, mitochondrial electron transport, oxidative phosphorylation, cyanide-resistant respiration, factors affecting respiration.

**Unit 8: ATP-Synthesis**

Mechanism of ATP synthesis, substrate level phosphorylation, chemiosmotic mechanism (oxidative and photophosphorylation), ATP synthase, Boyers conformational model, Racker's experiment, Jagendorf's experiment; role of uncouplers

**Unit 9: Lipid metabolism**

Synthesis and breakdown of triglycerides,  $\beta$ -oxidation, glyoxylate cycle, gluconeogenesis and its role in mobilisation of lipids during seed germination,  $\alpha$  oxidation

**Unit 10: Nitrogen metabolism**

Nitrate assimilation, biological nitrogen fixation (examples of legumes and non-legumes); Physiology and biochemistry of nitrogen fixation; Ammonia assimilation and transamination.

**Unit 11: Mechanisms of signal transduction**

Receptor-ligand interactions; Second messenger concept, Calcium calmodulin, MAP kinase cascade

**Practical (Credits: 2)**

1. Qualitative tests for carbohydrates, reducing sugars, non-reducing sugars, lipids and proteins.
2. Chemical separation of photosynthetic pigments.
3. Experimental demonstration of Hill's reaction.
4. To study the effect of light intensity on the rate of photosynthesis.
5. Effect of carbon dioxide on the rate of photosynthesis.
6. To compare the rate of respiration in different parts of a plant.
7. To demonstrate activity of Nitrate reductase in germinating leaves of different plant sources.
8. To study the activity of lipases in germinating oilseeds and demonstrate mobilization of lipids during germination.
9. Demonstration of fluorescence by isolated chlorophyll pigments.
10. Demonstration of absorption spectrum of photosynthetic pigments.

**Suggested Readings**

1. Hopkins, W.G. and Huner, A. (2008). Introduction to Plant Physiology. John Wiley and Sons.U.S.A. 4th edition.
2. Taiz, L., Zeiger, E., Møller, I.M. and Murphy, A (2015). Plant Physiology and Development.Sinauer Associates Inc. USA. 6th edition.
3. Harborne, J.B. (1973). Phytochemical Methods. John Wiley & Sons. New York.

BSBUGCC06

Cell Biology

Theory (Credits: 4)**Unit 1: Structure and organization of Cell**

Cell Organization – Eukaryotic (Plant and animal cells) and prokaryotic  
Plasma membrane: Structure and transport across membranes: Active and Passive transport, Facilitated transport; Cell junctions: Tight junctions, Desmosomes, Gap junctions; Cell Wall: Eukaryotic cell wall, Extra cellular matrix and cell matrix interactions, Cell-Cell Interactions - adhesion junctions, tight junctions, gap junctions, and plasmodesmata (only structural aspects); Mitochondria, chloroplasts and peroxisomes; Cytoskeleton: Structure and organization of actin filaments, association of actin filaments with plasma membrane, cell surface protrusions, intermediate filaments, microtubules

**Unit 2: Nucleus**

Nuclear envelope, nuclear pore complex and nuclear lamina; Chromatin – Molecular organization, Nucleolus

**Unit 3: Protein Sorting and Transport**

Ribosomes, Endoplasmic Reticulum – Structure, targeting and insertion of proteins in the ER; Golgi Apparatus– Organization, protein glycosylation, protein sorting and export from Golgi Apparatus Lysosomes

**Unit 4: Cell Signalling**

Signalling molecules and their receptors; Function of cell surface receptors; Pathways of intra-cellular receptors – Cyclic AMP pathway

**Unit 5: Cell Cycle, Cell Death and Cell Renewal**

Eukaryotic cell cycle and its regulation, Mitosis and Meiosis

Cancer, causes and types, Programmed cell death, Stem cells, Embryonic stem cell, induced pluripotent stem cells

**Practical (Credits: 2)**

1. Study a representative plant and animal cell by microscopy.
2. Study of the structure of cell organelles through electron micrographs
3. Cytochemical staining of DNA – Feulgen
4. Demonstration of the presence of mitochondria in striated muscle cells/ cheek epithelial cell using vital stain Janus Green B
5. Study of polyploidy in Onion root tip by colchicine treatment.
6. Identification and study of cancer cells by photomicrographs.
7. Study of different stages of Mitosis.
8. Study of different stages of Meiosis.

**Suggested Reading**

1. Hardin J, Bertoni G and Kleinsmith LJ. (2010). Becker's World of the Cell. 8th edition. Pearson.
2. Karp G. (2010) Cell and Molecular Biology: Concepts and Experiments. 6th edition. John Wiley & Sons. Inc.
3. De Robertis, EDP and De Robertis EMF. (2006). Cell and Molecular Biology. 8th edition. Lipincott Williams and Wilkins, Philadelphia.
4. Cooper, G.M. and Hausman, R.E. (2009). The Cell: A Molecular Approach. 5<sup>th</sup> Edition. ASM Press & Sunderland, Washington, D.C.; Sinauer Associates, MA.

<b>BSBUGCC07</b>	<b>Plant Systematics</b>
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Theory (Credits: 4)

**Unit 1: Significance of Plant systematics**

Introduction to systematics; Plant identification, Classification, Nomenclature. Evidences from palynology, cytology, phytochemistry and molecular data. Field inventory; Functions of Herbarium; Important herbaria and botanical gardens of the world and India; Virtual herbarium; E-flora; Documentation: Flora, Monographs, Journals; Keys: Single access and Multi-access.

**Unit 2: Taxonomic hierarchy**

Concept of taxa (family, genus, species); Categories and taxonomic hierarchy; Species concept (taxonomic, biological, evolutionary)

**Unit 3: Botanical nomenclature**

Principles and rules (ICN); Ranks and names; Typification, author citation, valid publication, rejection of names, principle of priority and its limitations; Names of hybrids.

**Unit 4: Systems of classification**

Major contributions of Theophrastus, Bauhin, Tournefort, Linnaeus, Adanson, de Candolle, Bessey, Hutchinson, Takhtajan and Cronquist; Classification systems of Bentham and Hooker (upto series) and Engler and Prantl (upto series); Brief reference of Angiosperm Phylogeny Group (APG III) classification.

**Unit 5: Biometrics, numerical taxonomy and cladistics**

Characters; Variations; OTUs, character weighting and coding; Cluster analysis; Phenograms, cladograms (definitions and differences)

**Unit 6: Phylogeny of Angiosperms**

Terms and concepts (primitive and advanced, homology and analogy, parallelism and convergence, monophyly, Paraphyly, polyphyly and clades). Origin and evolution of angiosperms; Co-evolution of angiosperms and animals; Methods of illustrating evolutionary relationship (phylogenetic tree, cladogram)

**Practical (Credits: 2)**

1. Study of vegetative and floral characters of the following families (Description, V.S. flower, section of ovary, floral diagram/s, floral formula/e and systematic position according to Bentham & Hooker's system of classification):  
Ranunculaceae - *Ranunculus*, *Delphinium*  
Brassicaceae - *Brassica*, *Alyssum* / *Iberis*

Myrtaceae - *Eucalyptus*, *Callistemon*  
 Umbelliferae - *Coriandrum* / *Anethum* / *Foeniculum*  
 Asteraceae - *Sonchus/Launaea*, *Vernonia/Ageratum*, *Eclipta/Tridax*  
 Solanaceae - *Solanum nigrum/Withania*  
 Lamiaceae - *Salvia/Ocimum*  
 Euphorbiaceae - *Euphorbia hirta/E.milii*, *Jatropha*  
 Liliaceae - *Asphodelus/Lilium/Allium*  
 Poaceae - *Triticum/Hordeum/Avena*

2. Field visit (local) – Subject to grant of funds from the university.
3. Mounting of a properly dried and pressed specimen of any wild plant with herbarium label (to besubmitted in the record book).

#### Suggested Readings

1. Singh, (2012). *Plant Systematics: Theory and Practice* Oxford & IBH Pvt. Ltd., New Delhi. 3rd edition.
2. Jeffrey, C. (1982). *An Introduction to Plant Taxonomy*. Cambridge University Press, Cambridge.
3. Judd, W.S., Campbell, C.S., Kellogg, E.A., Stevens, P.F. (2002). *Plant Systematics-A*  
 1. Phylogenetic Approach. Sinauer Associates Inc., U.S.A. 2nd edition.
4. Maheshwari, J.K. (1963). *Flora of Delhi*. CSIR, New Delhi.
5. Radford, A.E. (1986). *Fundamentals of Plant Systematics*. Harper and Row, New York.

<b>BSBUGCC08</b>	<b>Molecular Biology</b>
<u>Theory (Credits: 4)</u>	

#### Unit 1: Nucleic acids : Carriers of genetic information

Historical perspective; DNA as the carrier of genetic information (Griffith's, Hershey & Chase, Avery, McLeod & McCarty)

#### Unit 2: The Structures of DNA and RNA

DNA Structure: Miescher to Watson and Crick- historic perspective, DNA structure, Salient features of double helix, Types of DNA, Types of genetic material, denaturation and renaturation, cot curves; Organization of DNA- Prokaryotes, Viruses, Eukaryotes. RNA Structure; Organelle DNA -- mitochondria and chloroplast DNA. The Nucleosome; Chromatin structure- Euchromatin, Heterochromatin- Constitutive and Facultative heterochromatin.

#### Unit 3: The replication of DNA

Chemistry of DNA synthesis (Kornberg's discovery); General principles – bidirectional, semiconservative and semi discontinuous replication, RNA priming; Various models of DNA replication, including rolling circle,  $\theta$  (theta) mode of replication, replication of linear ds-DNA, replication of the 5' end of linear chromosome; Enzymes involved in DNA replication.

#### Unit 4: Central dogma and genetic code

Key experiments establishing-The Central Dogma (Adaptor hypothesis and discovery of mRNA template), Genetic code (deciphering & salient features)

#### Unit 5: Transcription

Transcription: Definition, difference from replication, promoter - concept and strength of promoter RNA Polymerase and the transcription unit; Transcription in Eukaryotes: RNA polymerases, general Transcription factors

#### Unit 6: Processing and modification of RNA

Split genes-concept of introns and exons, removal of introns, spliceosome machinery, splicing pathways, group I and group II intron splicing, alternative splicing eukaryotic mRNA processing (5' cap, 3' polyA tail); Ribozymes; RNA editing and mRNA transport.

#### Unit 7: Translation

Ribosome structure and assembly, mRNA; Charging of tRNA, aminoacyl tRNA synthetases; Various steps in protein synthesis, proteins involved in initiation, elongation and termination of polypeptides; Fidelity of translation; Inhibitors of protein synthesis; Post-translational modifications of proteins.

**Practical (Credits: 2)**

1. Preparation of LB medium and raising *E. Coli*.
2. Isolation of genomic DNA from *E. Coli*.
3. DNA isolation from cauliflower head.
4. DNA estimation by diphenylamine reagent/UV Spectrophotometry.
5. Study of DNA replication mechanisms through photographs (Rolling circle, Theta replication and semi-discontinuous replication).
6. Study of structures of prokaryotic RNA polymerase and eukaryotic RNA polymerase II through photographs.
7. Photographs establishing nucleic acid as genetic material (Messelson and Stahl's, Avery et al, Griffith's, Hershey & Chase's and Fraenkel & Conrat's experiments)
8. Study of the following through photographs: Assembly of Spliceosome machinery; Splicing mechanism in group I & group II introns; Ribozyme and Alternative splicing.

**Suggested Readings**

1. Watson J.D., Baker, T.A., Bell, S.P., Gann, A., Levine, M., Losick, R. (2007). Molecular Biology of the Gene, Pearson Benjamin Cummings, CSHL Press, New York, U.S.A. 6th edition.
2. Snustad, D.P. and Simmons, M.J. (2010). Principles of Genetics. John Wiley and Sons Inc., U.S.A. 5th edition.
3. Klug, W.S., Cummings, M.R., Spencer, C.A. (2009). Concepts of Genetics. Benjamin Cummings. U.S.A. 9th edition.
4. Russell, P. J. (2010). i-Genetics- A Molecular Approach. Benjamin Cummings, U.S.A. 3<sup>rd</sup> edition.
5. Griffiths, A.J.F., Wessler, S.R., Carroll, S.B., Doebley, J. (2010). Introduction to Genetic Analysis. W. H. Freeman and Co., U.S.A. 10th edition.

**BSBUGCC09****Plant Ecology and Phytogeography**Theory (Credits: 4)**Unit 1: Introduction**

Basic concepts; Levels of organization. Inter-relationships between the living world and the environment, the components and dynamism, homeostasis

**Unit 2: Soil**

Importance; Origin; Formation; Composition; Physical; Chemical and Biological components; Soil profile; Role of climate in soil development.

**Unit 3: Water**

Importance: States of water in the environment; Atmospheric moisture; Precipitation types (rain, fog, snow, hail, dew); Hydrological Cycle; Water in soil; Water table.

**Unit 4: Light, temperature, wind and fire**

Variations; adaptations of plants to their variation

**Unit 5: Biotic interactions**

Trophic organization, basic source of energy, autotrophy, heterotrophy; symbiosis, commensalism, parasitism; food chains and webs; ecological pyramids; biomass, standing crop

**Unit 6: Population ecology**

Characteristics and Dynamics .Ecological Speciation

**Unit 7: Plant communities**

Concept of ecological amplitude; Habitat and niche; Characters: analytical and synthetic; Ecotone and edge effect; Dynamics: succession – processes, types; climax concepts.

**Unit 8: Ecosystems**

Structure; Processes; Trophic organisation; Food chains and Food webs; Ecological pyramids

**Unit 9: Functional aspects of ecosystem**

Principles and models of energy flow; Production and productivity; Ecological efficiencies; Biogeochemical cycles; Cycling of Carbon, Nitrogen and Phosphorus

**Unit 10: Phytogeography**

Principles; Continental drift; Theory of tolerance; Endemism; Brief description of major terrestrial biomes (one each from tropical, temperate & tundra); Phytogeographical division of India; Local Vegetation.

**Practical (Credits: 2)**

1. Study of instruments used to measure microclimatic variables: Soil thermometer, maximum and minimum thermometer, anemometer, psychrometer/hygrometer, rain gauge and lux meter.
2. Determination of pH of various soil and water samples (pH meter, universal indicator/Lovibond comparator and pH paper)
3. Analysis for carbonates, chlorides, nitrates, sulphates, organic matter and base deficiency from two soil samples by rapid field tests.
4. Determination of organic matter of different soil samples by Walkley & Black rapid titration method.
5. Comparison of bulk density, porosity and rate of infiltration of water in soils of three habitats.
6. Determination of dissolved oxygen of water samples from polluted and unpolluted sources.
7. (a). Study of morphological adaptations of hydrophytes and xerophytes (four each)  
(b). Study of biotic interactions of the following: Stem parasite (*Cuscuta*), Root parasite (*Orobanche*) Epiphytes, Predation (Insectivorous plants).
8. Determination of minimal quadrat size for the study of herbaceous vegetation in the college campus, by species area curve method (species to be listed).
9. Quantitative analysis of herbaceous vegetation in the college campus for frequency and comparison with Raunkiaer's frequency distribution law.
10. Quantitative analysis of herbaceous vegetation for density and abundance in the college campus.
11. Field visit to familiarise students with ecology of different sites.

**Suggested Readings**

1. Odum, E.P. (2005). Fundamentals of ecology. Cengage Learning India Pvt. Ltd., New Delhi. 5<sup>th</sup> edition.
2. Singh, J.S., Singh, S.P., Gupta, S. (2006). Ecology Environment and Resource Conservation. Anamaya Publications, New Delhi, India.
3. Sharma, P.D. (2010). Ecology and Environment. Rastogi Publications, Meerut, India. 8th edition.
4. Wilkinson, D.M. (2007). Fundamental Processes in Ecology: An Earth Systems Approach. Oxford University Press. U.S.A.
5. Kormondy, E.J. (1996). Concepts of ecology. PHI Learning Pvt. Ltd., Delhi, India. 4th edition.

**BSBUGCC10****Reproductive Biology of Angiosperms**

Theory (Credits: 4)

**Unit 1: Introduction**

History (contributions of G.B. Amici, W. Hofmeister, E. Strasburger, S.G. Nawaschin, P. Maheshwari, B.M. Johri, W.A. Jensen, J. Heslop-Harrison) and scope.

**Unit 2: Reproductive development**

Induction of flowering; flower as a modified determinate shoot. Flower development: genetic and molecular aspects.

**Unit 3: Anther and pollen biology**

Anther wall: Structure and functions, microsporogenesis, callose deposition and its significance. Microgametogenesis; Pollen wall structure, MGU (male germ unit) structure, NPC system; Palynology and scope (a brief account); Pollen wall proteins; Pollen viability, storage and germination; Abnormal features: Pseudomonads, polyads, massulae, pollinia.

**Unit 4: Ovule**

Structure; Types; Special structures—endothelium, obturator, aril, caruncle and hypostase; Female gametophyte—megasporogenesis (monosporic, bisporic and tetrasporic) and megagametogenesis (details of *Polygonum* type); Organization and ultrastructure of mature embryo sac.

**Unit 4: Pollination and fertilization**

Pollination types and significance; adaptations; structure of stigma and style; path of pollen tube in pistil; double fertilization

**Unit 5: Self incompatibility**

Basic concepts (interspecific, intraspecific, homomorphic, heteromorphic, GSI and SSI); Methods to overcome self-incompatibility: mixed pollination, bud pollination, stub pollination; Intra-ovarian and *in vitro* pollination; Modification of stigma surface, parasexual hybridization; Cybrids, *in vitro* fertilization.



**Unit 6: Embryo, Endosperm and Seed**

Structure and types; General pattern of development of dicot and monocot embryo and endosperm; Suspensor: structure and functions; Embryo-endosperm relationship; Nutrition of embryo; Unusual features; Embryo development in *Paeonia*. Seed structure, importance and dispersal mechanisms

**Units 7: Polyembryony and apomixis**

Introduction; Classification; Causes and applications

**Practical (Credits: 2)**

1. **Anther:** Wall and its ontogeny; Tapetum (amoeboid and glandular); MMC, spore tetrads, uninucleate, bicelled and dehisced anther stages through slides/micrographs, male germ unit (MGU) through photographs and schematic representation.
2. **Pollen grains:** Fresh and acetolyzed showing ornamentation and aperture, pseudomonads, polyads, pollinia (slides/photographs, fresh material), ultrastructure of pollen wall (micrograph); Pollen viability: Tetrazolium test, germination: Calculation of percentage germination in different media using hanging drop method.
3. **Ovule:** Types-anatropous, orthotropous, amphitropous/campylotropous, circinotropous, unitegmic, bitegmic; Tenuinucellate and crassinucellate; Special structures: Endothelium, obturator, hypostase, caruncle and aril (permanent slides/specimens/photographs).
4. **Female gametophyte** through permanent slides/ photographs: Types, ultrastructure of mature egg apparatus.
5. **Intra-ovarian pollination;** Test tube pollination through photographs.
6. **Endosperm:** Dissections of developing seeds for endosperm with free-nuclear haustoria.
7. **Embryogenesis:** Study of development of dicot embryo through permanent slides; dissection of developing seeds for embryos at various developmental stages; Study of suspensor through electron micrographs.

**Suggested Readings**

1. Bhojwani, S.S. and Bhatnagar, S.P. (2011). The Embryology of Angiosperms, Vikas Publishing House. Delhi. 5th edition.
2. Shivanna, K.R. (2003). Pollen Biology and Biotechnology. Oxford and IBH Publishing Co. Pvt.Ltd. Delhi.
3. Raghavan, V. (2000). Developmental Biology of Flowering plants, Springer, Netherlands.
4. Johri, B.M. I (1984). Embryology of Angiosperms, Springer-Verlag, Netherlands.

<b>BSBUGCC11</b>	<b>Plant Physiology</b>
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**Theory (Credits: 4)****Unit 1: Plant-water relations**

Water Potential and its components, water absorption by roots, aquaporins, pathway of water movement, symplast, apoplast, transmembrane pathways, root pressure, guttation. Ascent of sap-cohesion-tension theory. Transpiration and factors affecting transpiration, antitranspirants, mechanism of stomatal movement.

**Unit 2: Mineral nutrition**

Essential and beneficial elements, macro and micronutrients, methods of study and use of nutrient solutions, criteria for essentiality, mineral deficiency symptoms, roles of essential elements, chelating agents

**Unit 3: Nutrient Uptake**

Soil as a nutrient reservoir, transport of ions across cell membrane, passive absorption, electrochemical gradient, facilitated diffusion, active absorption, role of ATP, carrier systems, proton ATPase pump and ion flux, uniport, co-transport, symport, antiport.

**Unit 4: Translocation in the phloem**

Experimental evidence in support of phloem as the site of sugar translocation. Pressure-Flow Model; Phloem loading and unloading; Source-sink relationship

**Unit 5: Plant growth regulators**

Discovery, chemical nature (basic structure), bioassay and physiological roles of Auxin, Gibberellins, Cytokinin, Abscisic acid, Ethylene, Brassinosteroids and Jasmonic acid

**Unit 6: Physiology of flowering**

Photoperiodism, flowering stimulus, florigen concept, vernalization, seed dormancy



**Unit 7: Phytochrome, cryptochromes and phototropins**

Discovery, chemical nature, role in photomorphogenesis, low energy responses (LER) and high irradiance responses (HIR), mode of action

**Practical (Credits: 2)**

1. Determination of osmotic potential of plant cell sap by plasmolytic method.
2. Determination of water potential of given tissue (potato tuber) by weight method.
3. Study of the effect of wind velocity and light on the rate of transpiration in excised twig/leaf.
4. Calculation of stomatal index and stomatal frequency from the two surfaces of leaves of a mesophyte and xerophyte.
5. To calculate the area of an open stoma and percentage of leaf area open through stomata in a mesophyte and xerophyte (both surfaces).
6. To study the phenomenon of seed germination (effect of light).
7. To study the effect of different concentrations of IAA on *Avenacoleoptile* elongation (IAA Bioassay).
8. To study the induction of amylase activity in germinating barley grains.

**Demonstration experiments**

1. To demonstrate suction due to transpiration.
2. Fruit ripening/Rooting from cuttings (Demonstration).
3. Bolting experiment/*Avenacoleptile* bioassay (demonstration).

**Suggested Readings**

1. Hopkins, W.G. and Huner, A. (2008). Introduction to Plant Physiology. John Wiley and Sons. U.S.A. 4th edition.
2. Taiz, L., Zeiger, E., Møller, I.M. and Murphy, A (2015). Plant Physiology and Development. Sinauer Associates Inc. USA. 6th edition.
3. Bajracharya D. (1999). Experiments in Plant Physiology-A Laboratory Manual. Narosa Publishing House, New Delhi.

<b>BSBUGCC12</b>	<b>Genetics</b>
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Theory (Credits: 4)

**Unit 1: Mendelian genetics and its extension**

Mendelism: History; Principles of inheritance; Chromosome theory of inheritance; Autosomes and sex chromosomes; Probability and pedigree analysis; Incomplete dominance and codominance; Multiple alleles, Lethal alleles, Epistasis, Pleiotropy, Recessive and Dominant traits, Penetrance and Expressivity, Numericals; Polygenic inheritance.

**Unit 2: Extrachromosomal Inheritance**

Chloroplast mutation: Variegation in Four o'clock plant; Mitochondrial mutations in yeast; Maternal effects-shell coiling in snail; Infective heredity- Kappa particles in *Paramecium*.

**Unit 3: Linkage, crossing over and chromosome mapping**

Linkage and crossing over-Cytological basis of crossing over; Recombination frequency, two factor and three factor crosses; Interference and coincidence; Numericals based on gene mapping; Sex Linkage.

**Unit 4: Variation in chromosome number and structure**

Deletion, Duplication, Inversion, Translocation, Position effect, Euploidy and Aneuploidy

**Unit 5: Gene mutations**

Types of mutations; Molecular basis of Mutations; Mutagens – physical and chemical (Base analogs, deaminating, alkylating and intercalating agents); Detection of mutations: ClB method. Role of Transposons in mutation. DNA repair mechanisms.

**Unit 6: Fine structure of gene**

Classical vs molecular concepts of gene; Cis-Trans complementation test for functional allelism; Structure of Phage T4, rII Locus

**Unit 7: Population and Evolutionary Genetics**

Allele frequencies, Genotype frequencies, Hardy-Weinberg Law, role of natural selection, mutation, genetic drift. Genetic variation and Speciation

**Practical (Credits: 2)**

1. Meiosis through temporary squash preparation.
2. Mendel's laws through seed ratios. Laboratory exercises in probability and chi-square.
3. Chromosome mapping using point test cross data.
4. Pedigree analysis for dominant and recessive autosomal and sex linked traits.
5. Incomplete dominance and gene interaction through seed ratios (9:7, 9:6:1, 13:3, 15:1, 12:3:1, 9:3:4).
6. Blood Typing: ABO groups & Rh factor.
7. Study of aneuploidy: Down's, Klinefelter's and Turner's syndromes.
8. Photographs/Permanent Slides showing Translocation Ring, Laggards and Inversion Bridge.
9. Study of human genetic traits: Sickle cell anemia, Xeroderma Pigmentosum, Albinism, red-green Colour blindness, Widow's peak, Rolling of tongue, Hitchhiker's thumb and Attached ear lobe.

**Suggested Readings**

1. Gardner, E.J., Simmons, M.J., Snustad, D.P. (1991). Principles of Genetics, John Wiley & sons, India. 8th edition.
2. Snustad, D.P. and Simmons, M.J. (2010). Principles of Genetics, John Wiley & Sons Inc., India. 5th edition.
3. Klug, W.S., Cummings, M.R., Spencer, C.A. (2009). Concepts of Genetics. Benjamin Cummings, U.S.A. 9th edition.
4. Griffiths, A.J.F., Wessler, S.R., Carroll, S.B., Doebley, J. (2010). Introduction to Genetic Analysis. W. H. Freeman and Co., U.S.A. 10th edition.

<b>BSBUGCC13</b>	<b>Economic Botany</b>
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**Theory (Credits: 4)****Unit 1: Origin of Cultivated Plants**

Concept of Centres of Origin, their importance with reference to Vavilov's work. Examples of major plant introductions; Crop domestication and loss of genetic diversity; evolution of new crops/varieties, importance of germplasm diversity

**Unit 2: Cereals**

Wheat and Rice (origin, morphology, processing & uses); Brief account of millets

**Unit 3: Legumes**

Origin, morphology and uses of Chick pea, Pigeon pea and fodder legumes. Importance to man and ecosystem

**Unit 4: Sources of sugars and starches**

Morphology and processing of sugarcane, products and by-products of sugarcane industry. Potato – morphology, propagation & uses.

**Unit 5: Spices**

Listing of important spices, their family and part used. Economic importance with special reference to fennel, saffron, clove and black pepper

**Unit 6: Beverages**

Tea, Coffee (morphology, processing & uses)

**Unit 7: Sources of oils and fats**

General description, classification, extraction, their uses and health implications groundnut, coconut, linseed, soybean, mustard and coconut (Botanical name, family & uses). Essential Oils: General account, extraction methods, comparison with fatty oils & their uses.

**Unit 8: Natural Rubber**

Para-rubber: tapping, processing and uses.

**Unit 9: Drug-yielding plants**

Therapeutic and habit-forming drugs with special reference to *Cinchona*, *Digitalis*, *Papaver* and *Cannabis*; Tobacco (Morphology, processing, uses and health hazards)

**Unit 10: Timber plants**

General account with special reference to teak and pine

**Unit 11: Fibers**

Classification based on the origin of fibers; Cotton, Coir and Jute (morphology, extraction and uses).

**Practical (Credits: 2)**

1. **Cereals:** Wheat (habit sketch, L. S/T.S. grain, starch grains, micro-chemical tests) Rice (habit sketch, study of paddy and grain, starch grains, micro-chemical tests).
2. **Legumes:** Soybean, Groundnut, (habit, fruit, seed structure, micro-chemical tests).
3. **Sources of sugars and starches:** Sugarcane (habit sketch; cane juice- micro-chemical tests) Potato (habit sketch, tuber morphology, T.S. tuber to show localization of starch grains, w.m.starch grains, micro-chemical tests).
4. **Spices:** Black pepper, Fennel and Clove (habit and sections).
5. **Beverages:** Tea (plant specimen, tea leaves), Coffee (plant specimen, beans).
6. **Sources of oils and fats:** Coconut- T.S. nut, Mustard–plant specimen, seeds; tests for fats in crushed seeds.
7. **Essential oil-yielding plants:** Habit sketch of *Rosa*, *Vetiveria*, *Santalum* and *Eucalyptus* (specimens/photographs).
8. **Rubber:** specimen, photograph/model of tapping, samples of rubber products.
9. **Drug-yielding plants:** Specimens of *Digitalis*, *Papaver* and *Cannabis*.
10. **Tobacco:** specimen and products of Tobacco.
11. **Woods:** *Tectona*, *Pinus*: Specimen, Section of young stem.
12. **Fiber-yielding plants:** Cotton (specimen, whole mount of seed to show lint and fuzz; whole mount of fiber and test for cellulose), Jute (specimen, transverse section of stem, test for lignin on transverse section of stem and fiber).

**Suggested Readings**

1. Kochhar, S.L. (2012). Economic Botany in Tropics, MacMillan & Co. New Delhi, India.
2. Wickens, G.E. (2001). Economic Botany: Principles & Practices. Kluwer Academic Publishers, The Netherlands.
3. Chrispeels, M.J. and Sadava, D.E. 1994 Plants, Genes and Agriculture. Jones & Bartlett Publishers.

<b>BSBUGCC14</b>	<b>Plant Biotechnology</b>
	<u>Theory (Credits: 4)</u>

**Unit 1: Plant Tissue Culture**

Historical perspective; Composition of media; Nutrient and hormone requirements (role of vitamins and hormones); Totipotency; Organogenesis; Embryogenesis (somatic and zygotic); Protoplast isolation, culture and fusion; Tissue culture applications (micropropagation, androgenesis, virus elimination, secondary metabolite production, haploids, triploids and hybrids; Cryopreservation; Germplasm Conservation).

**Unit 2: Recombinant DNA technology**

Restriction Endonucleases (History, Types I-IV, biological role and application); Restriction Mapping (Linear and Circular); Cloning Vectors: Prokaryotic (pUC 18 and pUC19, pBR322, Tiplasmid, BAC); Lambda phage, M13 phagemid, Cosmid, Shuttle vector; Eukaryotic Vectors (YAC).

**Unit 3: Gene Cloning**

Recombinant DNA, Bacterial Transformation and selection of recombinant clones, PCR mediated gene cloning; Gene Construct; construction of genomic and cDNA libraries, screening DNA libraries to obtain gene of interest by genetic selection; complementation, colony hybridization; PCR

**Unit 4: Methods of gene transfer**

*Agrobacterium*-mediated, Direct gene transfer by Electroporation, Microinjection, Microprojectile bombardment; Selection of transgenics– selectable marker and reporter genes (Luciferase, GUS, GFP).

**Unit 5: Applications of Biotechnology**

Pest resistant (Bt-cotton); herbicide resistant plants (RoundUp Ready soybean); Transgenic crops with improved quality traits (FlavrSavr tomato, Golden rice); Improved horticultural varieties (Moon dust carnations); Role of transgenics in bioremediation (Superbug); edible vaccines; Industrial enzymes (Aspergillase, Protease, Lipase); Genetically Engineered Products–Human Growth Hormone; Humulin; Biosafety concerns.

**Practical (Credits: 2)**

1. (a) Preparation of MS medium.  
(b) Demonstration of *in vitro* sterilization and inoculation methods using leaf and nodal explants of tobacco, *Datura*, *Brassica* etc.
2. Study of anther, embryo and endosperm culture, micropropagation, somatic embryogenesis and artificial seeds through photographs.
3. Isolation of protoplasts.
4. Construction of restriction map of circular and linear DNA from the data provided.
5. Study of methods of gene transfer through photographs: *Agrobacterium*-mediated, direct gene transfer by electroporation, microinjection, microprojectile bombardment.
6. Study of steps of genetic engineering for production of Bt cotton, Golden rice, FlavrSavr tomato through photographs.
7. Isolation of plasmid DNA.
8. Restriction digestion and gel electrophoresis of plasmid DNA.

**Suggested Readings**

1. Bhojwani, S.S. and Razdan, M.K., (1996). Plant Tissue Culture: Theory and Practice. Elsevier Science Amsterdam. The Netherlands.
2. Glick, B.R., Pasternak, J.J. (2003). Molecular Biotechnology- Principles and Applications of recombinant DNA. ASM Press, Washington.
3. Bhojwani, S.S. and Bhatnagar, S.P. (2011). The Embryology of Angiosperms. Vikas Publication House Pvt. Ltd., New Delhi. 5th edition.
4. Snustad, D.P. and Simmons, M.J. (2010). Principles of Genetics. John Wiley and Sons, U.K. 5th edition.
5. Stewart, C.N. Jr. (2008). Plant Biotechnology & Genetics: Principles, Techniques and Applications. John Wiley & Sons Inc. U.S.A.

**B) Discipline Specific Electives**

<b>BSBUGDS01</b>	<b>Bioinformatics</b>
<u>Theory (Credits: 4)</u>	

**Unit 1: Introduction to Bioinformatics**

Introduction, Branches of Bioinformatics, Aim, Scope and Research areas of Bioinformatics.

**Unit 2: Databases**

Introduction, Biological Databases, Classification format of Biological Databases, Biological Database Retrieval System

**Unit 3: Biological Sequence Databases**

National Center for Biotechnology Information (NCBI): Tools and Databases of NCBI, Database; Retrieval Tool, Sequence Submission to NCBI, Basic local alignment search tool (BLAST), Nucleotide Database, Protein Database, Gene Expression Database. EMBL Nucleotide Sequence Database (EMBL-Bank): Introduction, Sequence Retrieval, Sequence Submission to EMBL, Sequence analysis tools. DNA Data Bank of Japan (DDBJ): Introduction, Resources at DDBJ, Data Submission at DDBJ. Protein Information Resource (PIR): About PIR, Resources of PIR, Databases of PIR, Data Retrieval in PIR. Swiss-Prot: Introduction and Salient Features.

**Unit 4: Sequence Alignments**

Introduction, Concept of Alignment, Multiple Sequence Alignment (MSA), MSA by CLUSTALW, Scoring Matrices, Percent Accepted Mutation (PAM), Blocks of Amino Acid Substitution Matrix (BLOSUM)

**Unit 5: Molecular Phylogeny**

Methods of Phylogeny, Software for Phylogenetic Analyses, Consistency of Molecular Phylogenetic Prediction

**Unit 6: Applications of Bioinformatics**

Structural Bioinformatics in Drug Discovery, Quantitative structure-activity relationship (QSAR) techniques in Drug Design

**Practical (Credits: 2)**

1. Introduction to different operating systems - UNIX, LINUX and Windows
2. Introduction to bioinformatics databases (any three): NCBI/PDB/DDBJ/PDB
3. Sequence retrieval using BLAST
4. Sequence alignment & phylogenetic analysis using clustal W & phylip
5. Picking out a given gene from genomes using Genscan or other softwares (promoter region identification, repeat in genome, ORF prediction). Gene finding tools (Glimmer, GENSCAN), Primer designing, Genscan/Genetool
6. Protein structure prediction: primary structure analysis, secondary structure prediction using psipred, homology modeling using Swiss model. Molecular visualization using jmol, Protein structure model evaluation (PROCHECK)
7. Prediction of different features of a functional gene.

**Suggested Readings**

1. Bioinformatics: Sequence and Genome analysis, 2nd edition (2004), David W. Mount, Cold Spring Harbour Laboratory Press. ISBN-13: 978-0879697129.
2. Bioinformatics: A practical guide to the analysis of genes and proteins, 3rd edition (2004), Andreas D. Baxeavanis and B.F. Francis Ouellette, John Wiley and Sons.
3. Introduction to Medicinal Chemistry, 4th edition (2009), Graham I. Patrick, Oxford University Press
4. The Process of New Drug Discovery and Development, 2nd edition (2006), C.G. Smith and J.T.O'Donnell, Informa Healthcare, ISBN-13: 978-0849327797.
5. Cheminformatics (2003), J. Gasteiger, Thomas Engel; Wiley-VCH. ISBN: 9783527618279.
6. Molecular modeling - Principles and Applications, 2nd edition (2003), A. R. Leach, Pearson Education Limited, UK. ISBN 13: 9780582382107.
7. Cheminformatics in Drug Discovery (2006), edited by. T.I. Opera; Wiley Publishers, ISBN: 9783527604203.
8. Goel D & Prashar S (2013). IPR, Biosafety and Bioethics. Pearson
9. Senthil Kumar Sadhasivam and Mohammed Jaabir, M. S. 2008. IPR, Biosafety and biotechnology Management. Jasen Publications, Tiruchirappalli, India.

<b>BSBUGDS02</b>	<b>Industrial and Environmental Microbiology</b>
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Theory (Credits: 4)

**Unit 1: Scope of microbes in industry and environment**

**Unit 2: Bioreactors/Fermenters and fermentation processes**

Solid-state and liquid-state (stationary and submerged) fermentations; Batch and continuous fermentations. Components of a typical bioreactor, Types of bioreactors laboratory, pilotscale and production fermenters; Constantly stirred tank fermenter, tower fermenter, fixed bed and fluidized bed bioreactors and air-lift fermenter.

**Unit 3: Microbial production of industrial products**

Microorganisms involved, media, fermentation conditions, downstream processing and uses; Filtration, centrifugation, cell disruption, solvent extraction, precipitation and ultrafiltration, lyophilization, spray drying; Hands on microbial fermentations for the production and estimation(qualitative and quantitative) of Enzyme: amylase or lipase activity, Organic acid (citric acid or glutamic acid), alcohol (Ethanol) and antibiotic (Penicillin)

**Unit 4: Microbial enzymes of industrial interest and enzyme immobilization**

Microorganisms for industrial applications and hands on screening microorganisms for casein hydrolysis; starch hydrolysis; cellulose hydrolysis. Methods of immobilization, advantages and applications of immobilization, large scale applications of immobilized enzymes (glucose isomerase and penicillin acylase)

**Unit 5: Microbes and quality of environment**

Distribution of microbes in air; Isolation of microorganisms from soil, air and water

**Unit 6: Microbial flora of water**

Water pollution, role of microbes in sewage and domestic waste water treatment systems. Determination of BOD, COD, TDS and TOC of water samples; Microorganisms as indicators of water quality, check coliform and fecal coliform in water samples

**Unit 7: Microbes in agriculture and remediation of contaminated soils**

Biological fixation; Mycorrhizae; Bioremediation of contaminated soils. Isolation of root nodulating bacteria, arbuscular mycorrhizal colonization in plant roots

**Practical (Credits: 2)**

1. Principles and functioning of instruments in microbiology laboratory
2. Hands on sterilization techniques and preparation of culture media.
3. A visit to any educational institute/ industry to see an industrial fermenter, and other downstream processing operations.

***Suggested Readings***

1. Pelzar, M.J. Jr., Chen E.C. S., Krieg, N.R. (2010). Microbiology: An application based approach. Tata McGraw Hill Education Pvt. Ltd., Delhi.
2. Tortora, G.J., Funke, B.R., Case. C.L. (2007). Microbiology. Pearson Benjamin

<b>BSBUGDS03</b>	<b>Biostatistics &amp; Biotechniques</b>
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Theory (Credits: 4)

**Unit 1: Bioenergetics**

First and Second Laws of Thermodynamics; Definition of Gibb's Free Energy, Enthalpy, and Entropy; Mathematical Relationships Among Them; Standard Free Energy Change and Equilibrium Constant; Coupled Reactions And Additive Nature of Standard Free Energy Change; Energy Rich Compounds: Phosphoenolpyruvate, 1,3-Bisphosphoglycerate, Thioesters, ATP.

**Unit 2: Microscopy: Principles and applications**

Principles and applications of - Light microscopy: brightfield and darkfield, Phase contrast microscopy, Fluorescence Microscopy, Confocal Microscopy, Electron Microscopy (Scanning and Transmission Electron Microscopy); Micrometry.

**Unit 3. Electromagnetic radiation and Spectrophotometry**

*Basic principles of electromagnetic radiation:* Energy, wavelength, wave numbers and frequency, review of electronic structure of molecules.

*UV-visible spectrophotometry:* Beer Lambert law, light absorption and its transmittance, factors affecting absorption properties of a chromophore, Principle and use of study of absorption spectra of biomolecules; structural analyses of DNA/ protein using absorption of UV light. Colorimetry and turbidometry

*Fluorescence spectroscopy:* Theory of fluorescence, static and dynamic quenching, resonance energy transfer, fluorescent probes in the study of protein and nucleic acids.

*Mass spectrometry (MALDI-TOF):* Physical basis and uses of MS in the analysis of proteins/ nucleic acids.

#### **Unit 4: Radiation Biology**

Concept of radioisotopes, types of radioactive decay (gamma and beta emitter), half-life, detection and measurement of radioactivity: methods based upon ionization (GM counter), methods based upon excitation (scintillation counter). Autoradiography, radioisotopes in diagnosis and radiotherapy. Effect of radiations (ionizing and non-ionizing) on living systems, precautions and safety measures in handling radioisotopes

#### **Unit 5: Chromatography**

Principles and applications of paper chromatography (including Descending and 2-D), Thin layer chromatography, Column chromatography: packing and fraction collection. Gel filtration chromatography, ion exchange chromatography and affinity chromatography; GLC, HPLC.

#### **Unit 6: Electrophoresis**

Principle and applications of native polyacrylamide gel electrophoresis, SDS- polyacrylamide gel electrophoresis, Isoelectric focusing, 2D gel electrophoresis; Zymogram preparation; Principle and applications of Agarose gel electrophoresis.

#### **Unit 7: Hydrodynamic methods**

*Viscosity:* Methods of measurement of viscosity, specific and intrinsic viscosity, relationship between viscosity and molecular weight, measurement of viscoelasticity of DNA.

*Sedimentation:* Principle of centrifugation; Svedberg equation, RCF and sedimentation coefficient; relationship between RPM and RCF; differential and density gradient centrifugation, preparative and analytical ultracentrifugation techniques, fractionation of cellular components using centrifugation with examples.

*Flow Cytometry:* Basic principle of flow cytometry and cell sorting, detection strategies in flow cytometry.

#### **Unit 8: Biostatistics**

Introduction to biostatistics & its use. Basic idea on variables, frequency distribution and sampling. Measures of central tendency: mean, median, mode. Measures of distributions: variance, range, quartile deviation. Standard deviation and standard error - problems and application. Student's t-test and Chi square test- problems and application. Correlation and Regression

#### **Practical (Credits: 2)**

1. Study of fluorescent micrographs to visualize bacterial cells.
2. Ray diagrams of phase contrast microscopy and Electron microscopy.
3. Study of structural changes of proteins at different pH/Temperature using UV spectrophotometry.
4. Determination of melting temperature of DNA.
5. Separation of mixtures by paper / thin layer chromatography.
6. Demonstration of column packing in any form of column chromatography.
7. Separation of protein mixtures by any form of chromatography.
8. Separation of protein mixtures by Polyacrylamide Gel Electrophoresis (PAGE).
9. Preparation of agarose gel and loading of sample.
10. Determination of  $\lambda_{max}$  for an unknown sample and calculation of extinction coefficient.
11. Study the effect of temperature on the viscosity of a macromolecule (Protein/DNA).
12. Separation of components of a given mixture using a laboratory scale centrifuge.

#### **Suggested Readings:**

1. Wilson K and Walker J. (2010). Principles and Techniques of Biochemistry and Molecular Biology. 7<sup>th</sup>Ed., Cambridge University Press.
2. David Freifelder (1982) Physical Biochemistry: Applications to Biochemistry and Molecular Biology, 2<sup>nd</sup> Ed., W.H. Freeman and Company.
3. Nelson DL and Cox MM. (2008). Lehninger Principles of Biochemistry, 5<sup>th</sup>Ed., W.H. Freeman and Company.
4. Willey MJ, Sherwood LM & Woolverton C J. (2013). Prescott, Harley and Klein's Microbiology. 9<sup>th</sup>Ed., McGrawHill.
5. Karp G. (2010) Cell and Molecular Biology: Concepts and Experiments. 6th edition. John Wiley & Sons. Inc.
6. De Robertis EDP and De Robertis EMF. (2006). Cell and Molecular Biology. 8th edition. Lipincott Williams and Wilkins, Philadelphia.

7. Cooper G.M. and Hausman R.E. (2009). The Cell: A Molecular Approach. 5<sup>th</sup> Edition. ASM Press & Sunderland, Washington D.C., Sinauer Associates, MA.
8. Nigam A and Ayyagari A. 2007. Lab Manual in Biochemistry, Immunology and Biotechnology. Tata McGraw Hill.
9. A. Edmondson and D. Druce : Advanced Biology Statistics, Oxford University Press; 1996.
10. W. Danial : Biostatistics : A foundation for Analysis in Health Sciences, John Wiley and Sons Inc; 2004.

<b>BSBUGDS04</b>	<b>Biosafety and Intellectual Property Rights</b>
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Theory (Credits: 4)

**Unit 1: Biosafety**

Introduction; biosafety issues in biotechnology; Biological Safety Cabinets & their types; Primary Containment for Biohazards; Biosafety Levels of Specific Microorganisms.

**Unit 2: Biosafety Guidelines**

Biosafety guidelines and regulations (National and International); GMOs/LMOs- Concerns and Challenges; Role of Institutional Biosafety Committees (IBSC), RCGM, GEAC etc. for GMO applications in food and agriculture; Environmental release of GMOs; Risk Analysis; Risk Assessment; Risk management and communication; Overview of International Agreements - Cartagena Protocol.

**Unit 3**

AERB/RSD/RES guidelines for using radioisotopes in laboratories and precautions

**Unit 4: Introduction to Intellectual Property**

Patents, Types, Trademarks, Copyright & Related Rights, Industrial Design and Rights, Traditional Knowledge, Geographical Indications- importance of IPR – patentable and non patentables – patenting life – legal protection of biotechnological inventions – World Intellectual Property Rights Organization (WIPO).

**Unit 5: Grant of Patent and Patenting Authorities**

Types of patent applications: Ordinary, PCT, Conventional, Divisional and Patent of Addition; An introduction to Patent Filing Procedures; Patent licensing and agreement; Patent infringement- meaning, scope, litigation, case studies, Rights and Duties of patent owner.

**Unit 6: Agreements and Treaties**

GATT, TRIPS Agreements; Role of Madrid Agreement; Hague Agreement; WIPO Treaties; Budapest Treaty on international recognition of the deposit of microorganisms; UPOV & Brene conventions; Patent Co-operation Treaty (PCT); Indian Patent Act 1970 & recent amendments.

**Practical (Credits: 2)**

1. Filing primary applications for patents.
2. Study of steps of a patenting process.
3. A case study.

**Suggested Readings:**

1. Goel D & Prashar S (2013). IPR, Biosafety and Bioethics. Pearson
2. Senthil Kumar Sadhasivam and Mohammed Jaabir, M. S. 2008. IPR, Biosafety and biotechnology Management. Jasen Publications, Tiruchirappalli, India.

<b>BSBUGDS05</b>	<b>Stress Biology</b>
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Theory (Credits: 4)

**Unit 1: Defining plant stress**

Acclimation and adaptation

**Unit 2: Environmental factors**

Water stress; Salinity stress, High light stress; Temperature stress; Hypersensitive reaction; Pathogenesis- related (PR) proteins; Systemic acquired resistance; Mediation of insect and disease resistance by jasmonates.

**Unit 3: Stress sensing mechanisms in plants**

Calcium modulation, Phospholipid signaling



**Unit 4: Developmental and physiological mechanisms that protect plants against environmental stress**

Adaptation in plants; Changes in root: shoot ratio; Aerenchyna development; Osmotic adjustment; Compatible solute production.

**Unit 5: Reactive oxygen species–Production and scavenging mechanisms.****Practical (Credits: 2)**

1. Quantitative estimation of peroxidase activity in the seedlings in the absence and presence of salt stress.
2. Superoxide activity in seedlings in the absence and presence of salt stress.
3. Zymographic analysis of peroxidase.
4. Zymographic analysis of superoxide dismutase activity.
5. Quantitative estimation and zymographic analysis of catalase.
6. Quantitative estimation and zymographic analysis of glutathione reductase.
7. Estimation of superoxide anions.

***Suggested Readings:***

1. Hopkins, W.G. and Huner, A. (2008). Introduction to Plant Physiology. John Wiley and Sons. U.S.A. 4th edition.
2. Taiz, L., Zeiger, E., Møller, I.M. and Murphy, A (2015). Plant Physiology and Development. Sinauer Associates Inc. USA. 6th edition.

<b>BSBUGDS06</b>	<b>Plant Breeding</b>
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Theory (Credits: 4)

**Unit 1: Plant Breeding**

Introduction and objectives. Breeding systems: modes of reproduction in crop plants. Important achievements and undesirable consequences of plant breeding

**Unit 2: Methods of crop improvement**

Introduction: Centres of origin and domestication of crop plants, plant genetic resources; Acclimatization; Selection methods: For self pollinated, cross pollinated and vegetatively propagated plants; Hybridization: For self, cross and vegetatively propagated plants – Procedure, advantages and limitations.

**Unit 3: Quantitative inheritance**

Concept, mechanism, examples of inheritance of Kernel colour in wheat, Skin colour in human beings. Monogenic vs polygenic Inheritance

**Unit 4: Inbreeding depression and heterosis**

History, genetic basis of inbreeding depression and heterosis; Applications

**Unit 5: Crop improvement and breeding**

Role of mutations; Polyploidy; Distant hybridization and role of biotechnology in crop improvement

***Suggested Readings***

1. Singh, B.D. (2005). Plant Breeding: Principles and Methods. Kalyani Publishers. 7<sup>th</sup> edition.
1. Chaudhari, H.K. (1984). Elementary Principles of Plant Breeding. Oxford – IBH. 2<sup>nd</sup> edition.

**C) Skill Enhancement Courses****BSBUGSE01****Mushroom Culture Technology**Credits: 4**Unit 1: Introduction**

History. Nutritional and medicinal value of edible mushrooms; Poisonous mushrooms. Types of edible mushrooms available in India – *Volvariella volvacea*, *Pleurotus sajor-caju*, *Calocybe indica*, *Agaricus bisporus*

**Unit 2: Cultivation Technology**

Infrastructure: substrates (locally available) Polythene bag, vessels, Inoculation hook, inoculation loop, low cost stove, sieves, culture rack, mushroom unit (Thatched house) water sprayer, tray, small polythene bag. Pure culture: Medium, sterilization, preparation of spawn, multiplication. Mushroom bed preparation - paddy straw, sugarcane trash, maize straw, banana leaves. Factors affecting the mushroom bed preparation - Low cost technology, Composting technology in mushroom production.

**Unit 3: Storage and nutrition**

Short-term storage (Refrigeration - upto 24 hours) Long term Storage (canning, pickels, papads), drying, storage in salt solutions. Nutrition - Proteins -amino acids, mineral elements nutrition - Carbohydrates, Crude fibre content - Vitamins.

**Unit 4: Food Preparation**

Types of foods prepared from mushroom. Research Centres - National level and Regional level. Cost benefit ratio - Marketing in India and abroad, Export Value.

**Suggested Readings**

1. Marimuthu, T. Krishnamoorthy, A.S. Sivaprakasam, K. and Jayarajan. R (1991) Oyster Mushrooms, Department of Plant Pathology, Tamil Nadu Agricultural University, Coimbatore.
2. Swaminathan, M. (1990) Food and Nutrition. Bappco, The Bangalore Printing and Publishing Co. Ltd., No. 88, Mysore Road, Bangalore - 560018.
3. Tewari, Pankaj Kapoor, S.C., (1988). Mushroom cultivation, Mittal Publications, Delhi.
4. Nita Bahl (1984-1988) Hand book of Mushrooms, II Edition, Vol. I & Vol. II.

**BSBUGSE02****Nursery and Gardening**Credits: 4**Unit 1: Nursery**

Definition, objectives and scope and building up of infrastructure for nursery, planning and seasonal activities - Planting - direct seeding and transplants

**Unit 2: Seed**

Structure and types - Seed dormancy; causes and methods of breaking dormancy - Seed storage: Seed banks, factors affecting seed viability, genetic erosion – Seed production technology - seed testing and certification.

**Unit 3: Vegetative propagation**

Air-layering, cutting, selection of cutting, collecting season, treatment of cutting, rooting medium and planting of cuttings - Hardening of plants – green house - mist chamber, shed root, shade house and glass house.

**Unit 4: Gardening**

Definition, objectives and scope - different types of gardening – landscape and home gardening - parks and its components - plant materials and design – computer applications in landscaping - Gardening operations: soil laying, manuring, watering, management of pests and diseases and harvesting.

**Unit 5: Sowing/raising of seeds and seedlings**

Transplanting of seedlings - Study of cultivation of different vegetables: cabbage, brinjal, lady's finger, onion, garlic, tomatoes, and carrots - Storage and marketing procedures

**Suggested Readings**

1. Bose T.K. & Mukherjee, D., 1972, Gardening in India, Oxford & IBH Publishing Co., New Delhi.
1. Sandhu, M.K., 1989, Plant Propagation, Wile Eastern Ltd., Bangalore, Madras.
2. Kumar, N., 1997, Introduction to Horticulture, Rajalakshmi Publications, Nagercoil.

3. Edmond Musser & Andres, Fundamentals of Horticulture, McGraw Hill Book Co., New Delhi.
4. Agrawal, P.K. 1993, Hand Book of Seed Technology, Dept. of Agriculture and Cooperation, National Seed Corporation Ltd., New Delhi.
5. Janick Jules. 1979. Horticultural Science. (3rd Ed.), W.H. Freeman and Co., San Francisco, USA.

BSBUGSE03

Biofertilizers

Credits: 4

**Unit 1: Introduction**

General account about the microbes used as biofertilizer – Rhizobium – isolation, identification, mass multiplication, carrier based inoculants, Actinorrhizal symbiosis.

**Unit 2: Microbial inocula**

*Azospirillum*: isolation and mass multiplication – carrier based inoculant, associative effect of different microorganisms. *Azotobacter*: classification, characteristics – crop response to *Azotobacter* inoculum, maintenance and mass multiplication.

**Unit 3: Cyanobacteria**

Cyanobacteria (blue green algae), *Azolla* and *Anabaena azollae* association, nitrogen fixation, factors affecting growth, blue green algae and *Azolla* in rice cultivation.

**Unit 4: Mycorrhiza**

Mycorrhizal association, types of mycorrhizal association, taxonomy, occurrence and distribution, phosphorus nutrition, growth and yield – colonization of VAM – isolation and inoculum production of VAM, and its influence on growth and yield of crop plants.

**Unit 5: Organic farming**

Green manuring and organic fertilizers, Recycling of biodegradable municipal, agricultural and Industrial wastes – biocompost making methods, types and method of vermicomposting – field Application.

**Suggested Readings**

1. Dubey, R.C., 2005 A Text book of Biotechnology S.Chand & Co, New Delhi.
2. Kumaresan, V. 2005, Biotechnology, Saras Publications, New Delhi.
3. John Jothi Prakash, E. 2004. Outlines of Plant Biotechnology. Emkay Publication, New Delhi.
4. Sathe, T.V. 2004 Vermiculture and Organic Farming. Daya publishers.
5. Subha Rao, N.S. 2000, Soil Microbiology, Oxford & IBH Publishers, New Delhi.
6. Vayas, S.C, Vayas, S. and Modi, H.A. 1998 Bio-fertilizers and organic Farming Akta Prakashan, Nadiad

**D) Generic Electives to be Offered**

<b>BSBUGGE01</b>	<b>Biodiversity (Microbes, Algae, Fungi and Archegoniate)</b>
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Theory (Credits: 4)

**Unit 1: Microbes**

Viruses – Discovery, general structure, replication (general account), DNA virus (T-phage); Lytic and lysogenic cycle, RNA virus (TMV); Economic importance; Bacteria – Discovery, General characteristics and cell structure; Reproduction – vegetative, asexual and recombination conjugation, transformation and transduction); Economic importance.

**Unit 2: Algae**

General characteristics; Ecology and distribution; Range of thallus organization and reproduction; Classification of algae; Morphology and life-cycles of the following: *Nostoc*, *Chlamydomonas*, *Oedogonium*, *Vaucheria*, *Fucus*, *Polysiphonia*. Economic importance of algae

**Unit 3: Fungi**

Introduction- General characteristics, ecology and significance, range of thallus organization, cell wall composition, nutrition, reproduction and classification; True Fungi- General characteristics, ecology and significance, life cycle of *Rhizopus* (Zygomycota) *Penicillium*, *Alternaria* (Ascomycota), *Puccinia*, *Agaricus* (Basidiomycota); Symbiotic Associations-Lichens: General account, reproduction and significance; Mycorrhiza: ectomycorrhiza and endomycorrhiza and their significance

**Unit 4: Introduction to Archegoniate**

Unifying features of archegoniates, Transition to land habit, Alternation of generations.

**Unit 5: Bryophytes**

General characteristics, adaptations to land habit, Classification, Range of thallus organization. Classification (up to family), morphology, anatomy and reproduction of *Marchantia* and *Funaria*. (Developmental details not to be included). Ecology and economic importance of bryophytes with special mention of *Sphagnum*.

**Unit 6: Pteridophytes**

General characteristics, classification, Early land plants (*Cooksonia* and *Rhynia*). Classification (up to family), morphology, anatomy and reproduction of *Selaginella*, *Equisetum* and *Pteris*. (Developmental details not to be included). Heterospory and seed habit, stellar evolution. Ecological and economical importance of Pteridophytes

**Unit 4: Gymnosperms (6 lectures)**

General characteristics; Classification (up to family), morphology, anatomy and reproduction of *Cycas* and *Pinus* (Developmental details not to be included). Ecological and economical importance

**Practical (Credits: 2)**

- EMs/Models of viruses – T-Phage and TMV, Line drawing/Photograph of Lytic and Lysogenic Cycle.
- Types of Bacteria from temporary/permanent slides/photographs; EM bacterium; Binary Fission; Conjugation; Structure of root nodule.
- Gram staining
- Study of vegetative and reproductive structures of *Nostoc*, *Chlamydomonas* (electron micrographs), *Oedogonium*, *Vaucheria*, *Fucus*\* and *Polysiphonia* through temporary preparations and permanent slides. (\* *Fucus* - Specimen and permanent slides)
- Rhizopus* and *Penicillium*: Asexual stage from temporary mounts and sexual structures through permanent slides.
- Alternaria*: Specimens/photographs and tease mounts.
- Puccinia*: Herbarium specimens of Black Stem Rust of Wheat and infected Barberry leaves; section/tease mounts of spores on Wheat and permanent slides of both the hosts.
- Agaricus*: Specimens of button stage and full grown mushroom; Sectioning of gills
- Lichens: Study of growth forms of lichens (crustose, foliose and fruticose)
- Mycorrhiza: ecto mycorrhiza and endo mycorrhiza (Photographs)
- Marchantia*- morphology of thallus, w.m. rhizoids and scales, v.s. thallus through gemma cup, w.m. gemmae (all temporary slides), v.s. antheridiophore, archegoniophore, l.s. sporophyte (all permanent slides).
- Funaria*- morphology, w.m. leaf, rhizoids, operculum, peristome, annulus, spores (temporary slides); permanent slides showing antheridial and archegonial heads, l.s. capsule and protonema.

13. *Selaginella*- morphology, w.m. leaf with ligule, t.s. stem, w.m. strobilus, w.m. microsporophyll and megasporophyll (temporary slides), l.s. strobilus (permanent slide).
14. *Equisetum*- morphology, t.s. internode, l.s. strobilus, t.s. strobilus, w.m. sporangiophore, w.m. spores (wet and dry)(temporary slides); t.s rhizome (permanent slide).
15. *Pteris*- morphology, t.s. rachis, v.s. sporophyll, w.m. sporangium, w.m. spores (temporary slides), t.s. rhizome, w.m. prothallus with sex organs and young sporophyte (permanent slide).
16. *Cycas*- morphology (coralloid roots, bulbil, leaf), t.s. coralloid root, t.s. rachis, v.s. leaflet, v.s. microsporophyll, w.m. spores (temporary slides), l.s. ovule, t.s. root (permanent slide).
17. *Pinus*- morphology (long and dwarf shoots, w.m. dwarf shoot, male and female), w.m. dwarf shoot, t.s. needle, t.s. stem, , l.s./t.s. male cone, w.m. microsporophyll, w.m. microspores (temporary slides), l.s. female cone, t.l.s. & r.l.s. stem (permanent slide).

#### **Suggested Readings**

1. Kumar, H.D. (1999). Introductory Phycology. Affiliated East-West. Press Pvt. Ltd. Delhi. 2nd edition.
2. Tortora, G.J., Funke, B.R., Case, C.L. (2010). Microbiology: An Introduction, Pearson Benjamin Cummings, U.S.A. 10th edition.
3. Sethi, I.K. and Walia, S.K. (2011). Text book of Fungi & Their Allies, MacMillan Publishers Pvt. Ltd., Delhi.
4. Alexopoulos, C.J., Mims, C.W., Blackwell, M. (1996). Introductory Mycology, John Wiley and Sons (Asia), Singapore. 4th edition.
5. Raven, P.H., Johnson, G.B., Losos, J.B., Singer, S.R., (2005). Biology. Tata McGraw Hill, Delhi, India.
6. Vashishta, P.C., Sinha, A.K., Kumar, A., (2010). Pteridophyta, S. Chand. Delhi, India.
7. Bhatnagar, S.P. and Moitra, A. (1996). Gymnosperms. New Age International (P) Ltd Publishers, New Delhi, India.
8. Parihar, N.S. (1991). An introduction to Embryophyta. Vol. I. Bryophyta. Central Book Depot, Allahabad.

<b>BSBUGGE02</b>	<b>Plant Physiology and Metabolism</b>
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Theory (Credits: 4)

#### **Unit 1: Plant-water relations**

Importance of water, water potential and its components; Transpiration and its significance; Factors affecting transpiration; Root pressure and guttation

#### **Unit 2: Mineral nutrition**

Essential elements, macro and micronutrients; Criteria of essentiality of elements; Role of essential elements; Transport of ions across cell membrane, active and passive transport, carriers, channels and pumps.

#### **Unit 3: Translocation in phloem.**

Composition of phloem sap, girdling experiment; Pressure flow model; Phloem loading and unloading

#### **Unit 4: Photosynthesis**

Photosynthetic Pigments (Chl a, b, xanthophylls, carotene); Photosystem I and II, reaction center, antenna molecules; Electron transport and mechanism of ATP synthesis; C<sub>3</sub>, C<sub>4</sub> and CAM pathways of carbon fixation; Photorespiration

#### **Unit 5: Respiration**

Glycolysis, anaerobic respiration, TCA cycle; Oxidative phosphorylation, Glyoxylate, Oxidative Pentose Phosphate Pathway

#### **Unit 6: Enzymes**

Structure and properties; Mechanism of enzyme catalysis and enzyme inhibition

#### **Unit 7: Nitrogen metabolism**

Biological nitrogen fixation; Nitrate and ammonia assimilation

#### **Unit 8: Plant growth regulators**

Discovery and physiological roles of auxins, gibberellins, cytokinins, ABA, ethylene

#### **Unit 9: Plant response to light and temperature**

Photoperiodism (SDP, LDP, Day neutral plants); Phytochrome (discovery and structure), red and far red light responses on photomorphogenesis; Vernalization

**Practical (Credits: 2)**

1. Determination of osmotic potential of plant cell sap by plasmolytic method.
2. To study the effect of two environmental factors (light and wind) on transpiration by excised twig.
3. Calculation of stomatal index and stomatal frequency of a mesophyte and a xerophyte.
4. Demonstration of Hill reaction.
5. Demonstrate the activity of catalase and study the effect of pH and enzyme concentration.
6. To study the effect of light intensity and bicarbonate concentration on O<sub>2</sub> evolution in photosynthesis.
7. Comparison of the rate of respiration in any two parts of a plant.
8. Separation of amino acids by paper chromatography.

**Demonstration experiments (any four)**

1. Bolting.
2. Effect of auxins on rooting.
3. Suction due to transpiration.
4. R.Q.
5. Respiration in roots.

**Suggested Readings**

1. Taiz, L., Zeiger, E., Møller, I.M. and Murphy, A (2015). Plant Physiology and Development. Sinauer Associates Inc. USA. 6th edition.
2. Hopkins, W.G., Huner, N.P., (2009). Introduction to Plant Physiology. John Wiley & Sons, U.S.A. 4th Edition.
3. Bajracharya, D., (1999). Experiments in Plant Physiology- A Laboratory Manual. Narosa Publishing House, New Delhi.

**BSBUGGE03****Economic Botany and Biotechnology**Theory (Credits: 4)**Unit 1: Origin of Cultivated Plants**

Concept of centres of origin, their importance with reference to Vavilov's work

**Unit 2: Cereals**

Wheat -Origin, morphology, uses

**Unit 3: Legumes**

General account with special reference to Gram and soybean

**Unit 4: Spices**

General account with special reference to clove and black pepper (Botanical name, family, part used, morphology and uses)

**Unit 5: Beverages**

Tea (morphology, processing, uses)

**Unit 6: Oils and Fats**

General description with special reference to groundnut

**Unit 7: Fibre Yielding Plants**

General description with special reference to Cotton (Botanical name, family, part used, morphology and uses)

**Unit 8: Introduction to biotechnology****Unit 9: Plant tissue culture**

Micropropagation; haploid production through androgenesis and gynogenesis; brief account of embryo and endosperm culture with their applications

**Unit 10: Recombinant DNA Techniques**

Blotting techniques: Northern, Southern and Western Blotting, DNA Fingerprinting; Molecular DNA markers i.e. RAPD, RFLP, SNPs; DNA sequencing, PCR and Reverse Transcriptase-PCR. Hybridoma and monoclonal antibodies, ELISA and Immunodetection. Molecular diagnosis of human disease, Human gene Therapy

**Practical (Credits: 2)**

1. Study of economically important plants : Wheat, Gram, Soybean, Black pepper, Clove Tea, Cotton, Groundnut through specimens, sections and microchemical tests
2. Familiarization with basic equipments in tissue culture.
3. Study through photographs: Anther culture, somatic embryogenesis, endosperm and embryo culture; micropropagation.
4. Study of molecular techniques: PCR, Blotting techniques, AGE and PAGE.

**Suggested Readings**

1. Kochhar, S.L. (2011). Economic Botany in the Tropics, MacMillan Publishers India Ltd., New Delhi. 4th edition.
2. Bhojwani, S.S. and Razdan, M.K., (1996). Plant Tissue Culture: Theory and Practice. Elsevier Science Amsterdam. The Netherlands.
3. Glick, B.R., Pasternak, J.J. (2003). Molecular Biotechnology- Principles and Applications of recombinant DNA. ASM Press, Washington.



## **BSc Honours in Zoology (CBCS)**



### **Preamble**

Ministry of Human Resource Development (HRD), Govt. of India, has already initiated the process for developing New Education Policy (NEP) in our country to bring out reforms in Indian education system. University Grants Commission (UGC) participates more actively in developing National Education Policy, its execution and promotion of higher education in our country. The UGC has already initiated several steps to bring equity, efficiency and academic excellence in National Higher Education System. The important ones include innovation and improvement in course- curricula, introduction of paradigm shift in learning and teaching pedagogy, examination and education system. The education plays enormously significant role in building of a nation. There are quite a large number of educational institutions, engaged in imparting education in our country. Majority of them have entered recently into semester system to match with international educational pattern. However, our present education system produces young minds lacking knowledge, confidence, values and skills. It could be because of complete lack of relationship between education, employment and skill development in conventional education system. The present alarming situation necessitates transformation and/or redesigning of education system, not only by introducing innovations but developing “learner-centric approach in the entire education delivery mechanism and globally followed evaluation system as well. Majority of Indian higher education institutions have been following marks or percentage-based evaluation system, which obstructs the flexibility for the students to study the subjects/ courses of their choice and their mobility to different institutions. There is need to allow the flexibility in education system, so that students depending upon their interests and aims can choose interdisciplinary, intra-disciplinary and skill-based courses. This can only be possible when choice based credit system (CBCS), an internationally acknowledged system, is adopted. The choice based credit system not only offers opportunities and avenues to learn core subjects but also exploring additional avenues of learning beyond the core subjects for holistic development of an individual. The CBCS will undoubtedly facilitate us bench mark our courses with best international academic practices. The CBCS has more advantages than disadvantages.

#### **Advantages of the choice based credit system:**

- Shift in focus from the teacher-centric to student-centric education.
- Student may undertake as many credits as they can cope with (without repeating all courses in a given semester if they fail in one/ more courses).
- CBCS allows students to choose inter-disciplinary, intra-disciplinary courses, skill oriented papers (even from other disciplines according to their learning needs, interests and aptitude) and more flexibility for students).
- CBCS makes education broad-based and at par with global standards. One can take credits by combining unique combinations. For example, Physics with Economics, Microbiology with Chemistry or Environment Science etc.
- CBCS offers flexibility for students to study at different times and at different institutions to complete one course (ease mobility of students). Credits earned at one institution can be transferred.

#### **Disadvantages:**

- Difficult to estimate the exact marks
- Workload of teachers may fluctuate
- Demand good infrastructure for dissemination of education

**CHOICE BASED CREDIT SYSTEM (CBCS):** The CBCS provides an opportunity for the students to choose courses from the prescribed courses comprising core, elective/minor or skill based courses. The courses can be evaluated following the grading system, which is considered to be better than the conventional marks system. Therefore, it is necessary to introduce uniform grading system in the entire higher education in India. This will benefit the students to move across institutions within India to begin with and across countries. The uniform grading system will also enable potential employers in assessing the performance of the candidates. In order to bring uniformity in evaluation system and computation of the Cumulative Grade Point Average (CGPA) based on student's performance in examinations, the UGC has formulated the guidelines to be followed. Present syllabus is strictly in accordance with guidelines prescribed by UGC.

**Department of Biological Sciences, Aliah University**

**Outline for B Sc (H) Zoology [Choice Based Credit System]**

Type of Paper	Sub Category	Theory Papers	Practical Papers	Credits	Total Credits
<b>Core Course (CC)</b>	Core Course(CC)	14		4 each	56
	Core Course (CC)		14	2 each	28
<b>Elective Course (EC)</b>	Generic Elective (GE)	04		4 each	16
	Generic Elective (GE)		04	2 each	08
	Discipline Specific Elective (DS)	04		4 each	16
	Discipline Specific Elective (DS)		04	2 each	08
<b>Skill Enhancement Course (SE)</b>	Skill Enhancement Course (SE)	02		4 each	08
<b>Ability Enhancement (AE)</b>	Ability Enhancement Compulsory (AE)	02		4 each	08
<b>Aliah University Non credit compulsory course</b>	Arabic and Islamic Studies (AU)	01		Non credit	0
<b>Total Credits</b>					<b>148</b>

**Detailed Course Outline**

Sem	Paper Code	Paper Name	Credits(T+P)
<b>I</b>	BSZUGCC01	Non-chordates I: Protista to Pseudocoelomates	4+2
	BSZUGCC02	Fundamentals of Biochemistry	4+2
	BSBUGAE01	EVS	4
	CHMUGGE01	Chemistry	4+2
<b>Semester Total</b>			<b>22</b>
<b>II</b>	BSZUGCC03	Perspectives in Ecology	4+2
	BSZUGCC04	Non-chordates II: Coelomates	4+2
	BSZUGAE02	Communicative English	4
	CHMUGGE02	Chemistry	4+2
	ARBUGAU02	Arabic and Islamic Studies	0
<b>Semester Total</b>			<b>22</b>
<b>III</b>	BSZUGCC05	Diversity of Chordates	4+2
	BSZUGCC06	Cell Biology	4+2
	BSZUGCC07	Physiology: Controlling and Coordinating Systems	4+2
	BSZUGSE01	Apiculture	4
	BSMUGGE01	Biodiversity (Microbes, Algae, Fungi and Archegoniate)	4+2
<b>Semester Total</b>			<b>28</b>
<b>IV</b>	BSZUGCC08	Molecular Biology	4+2
	BSZUGCC09	Comparative Anatomy of Vertebrates	4+2
	BSZUGCC10	Physiology & Metabolism	4+2
	BSZUGSE02	Medical Diagnostics	4
	BSMUGGE02	Introduction and Scope of Microbiology	4+2
<b>Semester Total</b>			<b>28</b>
<b>V</b>	BSZUGCC11	Immunology	4+2
	BSZUGCC12	Principles of Genetics	4+2
	BSZUGDS01	Bioinformatics	4+2
	BSZUGDS02	Reproductive Biology	4+2
<b>Semester Total</b>			<b>24</b>
<b>VI</b>	BSZUGCC13	Developmental Biology	4+2
	BSZUGCC14	Evolutionary Biology	4+2
	BSZUGDS03	Biostatistics & Biotechniques	4+2
	BSZUGDS04	Fisheries and Entomology	4+2
<b>Semester Total</b>			<b>24</b>
<b>Grand Total</b>			<b>148</b>

**List of Papers with Respective Codes****Core Papers**

S No	Paper Code	Paper Name
1	BSZUGCC01	Non-chordates I: Protista to Pseudocoelomates
2	BSZUGCC02	Fundamentals of Biochemistry
3	BSZUGCC03	Principles of Ecology
4	BSZUGCC04	Non-chordates II: Coelomates
5	BSZUGCC05	Diversity of Chordates
6	BSZUGCC06	Cell Biology
7	BSZUGCC07	Physiology: Controlling and Coordinating Systems
8	BSZUGCC08	Molecular Biology
9	BSZUGCC09	Comparative Anatomy of Vertebrates
10	BSZUGCC10	Physiology & Metabolism
11	BSZUGCC11	Immunology
12	BSZUGCC12	Principles of Genetics
13	BSZUGCC13	Developmental Biology
14	BSZUGCC14	Evolutionary Biology

**List of Discipline Specific Electives**

S No	Code	Paper Name
1	BSZUGDS01	Bioinformatics
2	BSZUGDS02	Reproductive Biology
3	BSZUGDS03	Biostatistics & Biotechniques
4	BSZUGDS04	Fisheries and Entomology
5	BSZUGDS05	Animal Biotechnology
6	BSZUGDS06	Basics of Neuroscience

**List of Skill Enhancement Courses**

S No	Paper Code	Paper Name
1	BSZUGSE01	Apiculture
2	BSZUGSE02	Medical Diagnostics
3	BSZUGSE03	Sericulture

**Generic Electives to be Offered**

S No	Paper Code	Paper Name
1	BSZUGGE01	Animal Diversity
2	BSZUGGE02	Human Physiology
3	BSZUGGE03	Insect Vectors and Diseases

**Detailed Syllabus of Papers****A) Core Papers**

<b>BSZUGCC01</b>	<b>Non-chordates I: Protista to Pseudocoelomates</b>
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Theory (Credits: 4)

**Unit 1: Protista, Parazoa and Metazoa**

General characteristics and Classification up to classes. Study of Euglena, Amoeba and Paramecium. Life cycle and pathogenicity of Plasmodium vivax and Entamoebahistoltytica. Locomotion and Reproduction in Protista. Evolution of symmetry and segmentation of Metazoa

**Unit 2: Porifera**

General characteristics and Classification up to classes. Canal system and spicules in sponges

**Unit 3: Cnidaria**

General characteristics and Classification up to classes. Metagenesis in Obelia. Polymorphism in Cnidaria. Corals and coral reefs

**Unit 4: Ctenophora**

General characteristics and Evolutionary significance

**Unit 5: Platyhelminthes**

General characteristics and Classification up to classes. Life cycle and pathogenicity of Fasciola hepatica and Taeniasolium

**Unit 6: Nematelminthes**

General characteristics and Classification up to classes. Life cycle, and pathogenicity of Ascarislumbricoides and Wuchereriabancrofti. Parasitic adaptations in helminthes

*(Note: Classification to be followed from "Barnes, R.D. (1982). Invertebrate Zoology, V Edition" CBCS Undergraduate Program in Zoology 2015)*

**Practicals (Credits: 2)**

1. Study of whole mount of Euglena, Amoeba and Paramecium, Binary fission and
1. Conjugation in Paramecium
2. Examination of pond water collected from different places for diversity in protista
3. Study of Sycon (T.S. and L.S.), Hyalonema, Euplectella, Spongilla
4. Study of Obelia, Physalia, Millepora, Aurelia, Tubipora, Corallium, Alcyonium,
5. Gorgonia, Metridium, Pennatula, Fungia, Meandrina, Madrepora
6. One specimen/slide of any ctenophore
7. Study of adult Fasciola hepatica, Taeniasolium and their life cycles (Slides/microphotographs)
8. Study of adult Ascarislumbricoides and its life stages (Slides/micro-photographs)
9. To submit a Project Report on any related topic on life cycles/coral/ coral reefs.

*Note: Classification to be followed from "Ruppert and Barnes (2006) Invertebrate Zoology, 8th edition, Holt Saunders International Edition"*

**Suggested Readings**

1. Ruppert and Barnes, R.D. (2006). *Invertebrate Zoology*, VIII Edition. Holt Saunders International Edition.
2. Barnes, R.S.K., Calow, P., Olive, P.J.W., Golding, D.W. and Spicer, J.I. (2002). *The Invertebrates: A New Synthesis*, III Edition, Blackwell Science.
3. Barrington, E.J.W. (1979). *Invertebrate Structure and Functions*. II Edition, E.L.B.S. and Nelson

<b>BSZUGCC02</b>	<b>Fundamentals of Biochemistry</b>
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Theory (Credits: 4)

**Unit 1: Water and Buffer**

Physical properties of water, structure of water molecules, Ionization of water, Bronsted – Lowry concept of acid and bases, Concept of pH of weak acids and weak bases, Henderson-Hasselbalch equation, concept of buffer, strength of buffer, buffer value, important biological buffers (with the help of numerical problems).

Forces involved in biomolecular interactions with examples: Van der Waals interactions, electrostatic interactions, hydrogen bond and hydrophobic interaction. Configuration versus conformation

**Unit 2. Stereochemistry**

General concepts on: Plane of symmetry, centre and axis of symmetry; Concepts of chirality; optical isomerism; geometrical isomerism; DL, RS nomenclature; Projection formula (Fischer & Howarth); Isomers: anomers, epimers; Stereochemistry of cyclohexane: idea of axial & equatorial bonds (related to chair form conformation).

**Unit 3: Carbohydrates**

Structure and Biological importance: Monosaccharides, Disaccharides, Polysaccharides and Glycoconjugates.

**Unit 4: Lipids**

Structure and Significance: Physiologically important saturated and unsaturated fatty acids, Tri-acylglycerols, Phospholipids, Glycolipids, Steroids

**Unit 5: Proteins**

Amino acids: Structure, Classification and General properties of  $\alpha$ -aminoacids; Physiological importance of essential and non-essential  $\alpha$ -amino acids Proteins: Bonds stabilizing protein structure; Levels of organization in proteins; Denaturation; Introduction to simple and conjugate proteins.

**Unit 6: Nucleic Acids**

Structure: Purines and pyrimidines, Nucleosides, Nucleotides, Nucleic acids; Cot Curves: Base pairing, Denaturation and Renaturation of DNA. Types of DNA and RNA, Complementarity of DNA, Hypo-Hyperchromaticity of DNA

**Unit 7: Enzymes**

Nomenclature and classification; Cofactors; Specificity of enzyme action; Isozymes; Mechanism of enzyme action; Enzyme kinetics; Factors affecting rate of enzyme-catalyzed reactions; Derivation of Michaelis-Menten equation, Concept of  $K_m$  and  $V_{max}$ , Lineweaver-Burk plot; Multi-substrate reactions; Enzyme inhibition; Allosteric enzymes and their kinetics; Regulation of enzyme action.

**Unit 8. Vitamins**

Classification and characteristics with suitable examples, sources and importance

**Practicals (Credits: 2)**

1. Concept of molarity, normality, percentage, dilutions, pH and buffers, Preparation of buffers and Numerical problems to explain the concepts.
2. Qualitative tests of functional groups in carbohydrates, proteins and lipids.
3. Paper chromatography of amino acids.
4. Action of salivary amylase under optimum conditions.
5. Effect of pH, temperature and inhibitors on the action of salivary amylase.
6. Demonstration of proteins separation by SDS-PAGE.

**Suggested Readings**

1. Cox, M.M and Nelson, D.L. (2008). Lehninger's Principles of Biochemistry, V Edition, W.H. Freeman and Co., New York.
2. Berg, J.M., Tymoczko, J.L. and Stryer, L. (2007). Biochemistry, VI Edition, W.H. Freeman and Co., New York.
3. Murray, R.K., Bender, D.A., Botham, K.M., Kennelly, P.J., Rodwell, V.W. and Well, P.A. (2009). Harper's Illustrated Biochemistry, XXVIII Edition, International Edition, The McGraw-Hill Companies Inc.
4. Hames, B.D. and Hooper, N.M. (2000). Instant Notes in Biochemistry, II Edition, BIOS Scientific Publishers Ltd., U.K.
5. Watson, J.D., Baker, T.A., Bell, S.P., Gann, A., Levine, M. and Losick, R. (2008). Molecular Biology of the Gene, VI Edition, Cold Spring Harbor Lab. Press, Pearson Pub.
6. Voet, D. and Voet J.G (2004) Biochemistry 3rd edition, John Wiley and Sons

BSZUGCC03

Principles of Ecology

Theory (Credits: 4)

**Unit 1: Introduction to Ecology**

History of ecology, Autecology and synecology, Levels of organization, Laws of limiting factors, Study of physical factors.

**Unit 2: Population**

Unitary and Modular populations. Unique and group attributes of population: Density, natality, mortality, life tables, fecundity tables, survivorship curves, age ratio, sex ratio, dispersal and dispersion. Exponential and logistic growth, equation and patterns, r and K strategies. Population regulation - density-dependent and independent

factors. Population interactions, Gause's Principle with laboratory and field examples. Lotka-Volterra equation for competition and Predation, functional and numerical responses

### Unit 3: Community

Community characteristics: species richness, dominance, diversity, abundance, vertical stratification, Ecotone and edge effect; Ecological succession with one example. Theories pertaining to climax community

### Unit 4: Ecosystem

Types of ecosystems with one example in detail, Food chain: Detritus and grazing food chains, Linear and Y-shaped food chains, Food web, Energy flow through the ecosystem, Ecological pyramids and Ecological efficiencies. Nutrient and biogeochemical cycle with one example of Nitrogen cycle. Human modified ecosystem.

### Unit 5: Applied Ecology

Ecology in Wildlife Conservation and Management

### **Practicals (Credits: 2)**

1. Study of life tables and plotting of survivorship curves of different types from the hypothetical/real data provided
2. Determination of population density in a natural/hypothetical community by quadrat method and calculation of Shannon-Weiner diversity index for the same community
3. Study of an aquatic ecosystem: Phytoplankton and zooplankton, Measurement of area, temperature, turbidity/penetration of light, determination of pH, and Dissolved Oxygen content (Winkler's method), Chemical Oxygen Demand and free CO<sub>2</sub>
4. Report on a visit to National Park/Biodiversity Park/Wild life sanctuary

### **Suggested Readings**

1. Colinvaux, P. A. (1993). Ecology. II Edition. Wiley, John and Sons, Inc.
2. Krebs, C. J. (2001). Ecology. VI Edition. Benjamin Cummings.
3. Odum, E.P., (2008). Fundamentals of Ecology. Indian Edition. Brooks/Cole
4. Robert Leo Smith Ecology and field biology Harper and Row publisher
5. Ricklefs, R.E., (2000). Ecology. V Edition. Chiron Pres

<b>BSZUGCC04</b>	<b>Non-chordates II: Coelomates</b>
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Theory (Credits: 4)

### **Unit 1: Introduction to Coelomates**

Evolution of coelom and metamerism

### **Unit 2: Annelida**

General characteristics and Classification up to classes. Excretion in Annelida

### **Unit 3: Arthropoda**

General characteristics and Classification up to classes. Vision and Respiration in Arthropoda. Metamorphosis in Insects. Social life in bees and termites

### **Unit 4: Onychophora**

General characteristics and Evolutionary significance

### **Unit 5: Mollusca**

General characteristics and Classification up to classes. Respiration in Mollusca. Torsion and detorsion in Gastropoda. Pearl formation in bivalves. Evolutionary significance of trochophore larva

### **Unit 6: Echinodermata**

General characteristics and Classification up to classes. Water-vascular system in Asterozoa. Larval forms in Echinodermata. Affinities with Chordates

**(Note: Classification to be followed from "Ruppert and Barnes (2006) Invertebrate Zoology, 8th edition, Holt Saunders International Edition")**

### **Practical (Credits: 2)**

1. Study of following specimens:
  - a. Annelids - *Aphrodite*, *Nereis*, *Heteronereis*, *Sabella*, *Serpula*, *Chaetopterus*, *Pheretima*, *Hirudinaria*

- b. Arthropods - *Limulus*, *Palaemon*, *Daphnia*, *Balanus*, *Sacculina*, *Cancer*, *Eupagurus*, *Scolopendra*, *Julus*, *Bombyx*, *Periplaneta*, termites and honey bees.
  - c. Onychophora-*Peripatus*.
  - d. Molluscs - *Chiton*, *Dentalium*, *Pila*, *Doris*, *Helix*, *Unio*, *Ostrea*, *Pinctada*, *Sepia*, *Octopus*, *Nautilus*.
  - e. Echinodermates - *Pentaceros*/*Asterias*, *Ophiura*, *Clypeaster*, *Echinus*, *Cucumaria* and *Antedon*.
2. Study of digestive system, septal nephridia and pharyngeal nephridia of earthworm.
  3. T.S. through pharynx, gizzard, and typhlosolar intestine of earthworm.
  4. Mount of mouth parts and dissection of digestive system and nervous system of *Periplaneta*\*
  5. To submit a Project Report on any related topic to larval forms (crustacean, mollusk and echinoderm).

**Note:** Classification to be followed from "Ruppert and Barnes (2006) *Invertebrate Zoology*, 8th edition, Holt Saunders International Edition"

#### **Suggested Readings**

1. Ruppert and Barnes, R.D. (2006). *Invertebrate Zoology*, VIII Edition. Holt Saunders International Edition.
2. Barnes, R.S.K., Calow, P., Olive, P. J. W., Golding, D.W. and Spicer, J.I. (2002). *The Invertebrates: A New Synthesis*, III Edition, Blackwell Science
3. Barrington, E.J.W. (1979). *Invertebrate Structure and Functions*. II Edition, E.L.B.S. and Nelson

<b>BSZUGCC05</b>	<b>Diversity of Chordates</b>
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Theory (Credits 4)

#### **Unit 1: Introduction to Chordates**

General characteristics and outline classification.

#### **Unit 2: Protochordata**

General characteristics of Hemichordata, Urochordata and Cephalochordata; Study of larval forms in protochordates; Retrogressive metamorphosis in Urochordata.

#### **Unit 3: Origin of Chordata**

Dipleurula concept and the Echinoderm theory of origin of chordates; Advanced features of vertebrates over Protochordata.

#### **Unit 4: Agnatha**

General characteristics and classification of cyclostomes up to class

#### **Unit 5: Pisces**

General characteristics of Chondrichthyes and Osteichthyes, classification up to order Migration, Osmoregulation and Parental care in fishes

#### **Unit 6: Amphibia**

Origin of *Tetrapoda* (Evolution of terrestrial ectotherms); General characteristics and classification up to order; Parental care in Amphibians

#### **Unit 7: Reptilia**

General characteristics and classification up to order; Affinities of *Sphenodon*; Poison apparatus and Biting mechanism in snakes

#### **Unit 8: Aves**

General characteristics and classification up to order *Archaeopteryx*- a connecting link; Principles and aerodynamics of flight, Flight adaptations and Migration in birds

#### **Unit 9: Mammals**

General characters and classification up to order; Affinities of Prototheria; Adaptive radiation with reference to locomotory appendages

#### **Unit 10: Zoogeography**

Zoogeographical realms, Theories pertaining to distribution of animals, Plate tectonic and Continental drift theory, distribution of vertebrates in different realms.



**Practical (Credits: 2)**

1. **Protochordata**  
*Balanoglossus, Herdmania, Branchiostoma*, Colonial Urochordata Sections of *Balanoglossus* through proboscis and branchiogenital regions, Sections of *Amphioxus* through pharyngeal, intestinal and caudal regions. Permanent slide of *Herdmaniaspicules*
2. **Agnatha**  
*Petromyzon, Myxine*
3. **Fishes**  
*Scoliodon, Sphyrna, Pristis, Torpedo, Chimaera, Mystus, Heteropneustes, Labeo, Exocoetus, Echeuis, Anguilla, Hippocampus, Tetodon/ Diodon, Anabas*, Flat fish
4. **Amphibia**  
*Ichthyophis/Ureotyphlus, Necturus, Bufo, Hyla, Alytes, Salamandra*
6. **Reptilia**  
*Chelone, Trionyx, Hemidactylus, Varanus, Uromastix, Chamaeleon, Ophiosaurus, Draco, Bungarus, Vipera, Naja, Hydrophis, Zamenis, Crocodylus*.  
Key for Identification of poisonous and non-poisonous snakes
7. **Aves**  
Study of six common birds from different orders. Types of beaks and claws
8. **Mammalia**  
*Sorex*, Bat (Insectivorous and Frugivorous), *Funambulus, Loris, Herpestes, Erinaceus*.  
Mount of weberian ossicles of *Mystus*, pecten from Fowl head  
Dissection of Fowl head (Dissections and mounts subject to permission).  
Power point presentation on study of any two animals from two different classes by students (may be included if dissections not given permission).

**Note:** Classification from Young, J. Z. (2004) to be followed.

**Suggested Readings**

1. Young, J. Z. (2004). *The Life of Vertebrates*. III Edition. Oxford university press.
2. Pough H. *Vertebrate life*, VIII Edition, Pearson International.
3. Darlington P.J. *The Geographical Distribution of Animals*, R.E. Krieger Pub Co.
4. Hall B.K. and Hallgrimsson B. (2008). *Strickberger's Evolution*. IV Edition. Jones and Bartlett Publishers Inc.

<b>BSZUGCC06</b>	<b>Cell Biology</b>
Theory (Credits: 4)	

**Unit 1: Structure and organization of Cell**

Cell Organization – Eukaryotic (Plant and animal cells) and prokaryotic  
Plasma membrane: Structure and transport across membranes: Active and Passive transport, Facilitated transport; Cell junctions: Tight junctions, Desmosomes, Gap junctions; Cell Wall: Eukaryotic cell wall, Extra cellular matrix and cell matrix interactions, Cell-Cell Interactions - adhesion junctions, tight junctions, gap junctions, and plasmodesmata (only structural aspects); Mitochondria, chloroplasts and peroxisomes; Cytoskeleton: Structure and organization of actin filaments, association of actin filaments with plasma membrane, cell surface protrusions, intermediate filaments, microtubules

**Unit 2: Nucleus**

Nuclear envelope, nuclear pore complex and nuclear lamina; Chromatin – Molecular organization, Nucleolus

**Unit 3: Protein Sorting and Transport**

Ribosomes, Endoplasmic Reticulum – Structure, targeting and insertion of proteins in the ER; Golgi Apparatus – Organization, protein glycosylation, protein sorting and export from Golgi Apparatus Lysosomes

**Unit 4 Cell Signalling**

Signalling molecules and their receptors; Function of cell surface receptors  
Pathways of intra-cellular receptors – Cyclic AMP pathway

**Unit 5 Cell Cycle, Cell Death and Cell Renewal**

Eukaryotic cell cycle and its regulation, Mitosis and Meiosis  
Cancer, causes and types, Programmed cell death, Stem cells, Embryonic stem cell, induced pluripotent stem cells



**Practical (Credits: 2)**

1. Study a representative plant and animal cell by microscopy.
2. Study of the structure of cell organelles through electron micrographs
3. Cytochemical staining of DNA – Feulgen
4. Demonstration of the presence of mitochondria in striated muscle cells/ cheek epithelial cell using vital stain Janus Green B
5. Study of polyploidy in Onion root tip by colchicine treatment.
6. Identification and study of cancer cells by photomicrographs.
7. Study of different stages of Mitosis.
8. Study of different stages of Meiosis.

**Suggested Reading**

1. Hardin J, Bertoni G and Kleinsmith LJ. (2010). Becker's World of the Cell. 8<sup>th</sup> edition. Pearson.
2. Karp G. (2010) Cell and Molecular Biology: Concepts and Experiments. 6<sup>th</sup> edition. John Wiley & Sons. Inc.
3. De Robertis, EDP and De Robertis EMF. (2006). Cell and Molecular Biology. 8<sup>th</sup> edition. Lipincott Williams and Wilkins, Philadelphia.
4. Cooper, G.M. and Hausman, R.E. (2009). The Cell: A Molecular Approach. 5<sup>th</sup> Edition. ASM Press & Sunderland, Washington, D.C.; Sinauer Associates, MA.

BSZUGCC07

**Physiology: Controlling and Coordinating Systems**Theory (Credit 4)**Unit 1: Tissues**

Structure, location, classification and functions of epithelial tissue, connective tissue, muscular tissue and nervous tissue.

**Unit 2: Blood**

Components of blood and their functions; Structure and functions of haemoglobin. Haemostasis: Blood clotting system, Kallikrein-Kininogen system, Complement system & Fibrinolytic system, Haemopoiesis. Blood groups: Rh factor, ABO and MN.

**Unit 3: Bone and Cartilage**

Structure and types of bones and cartilages, Ossification, bone growth and resorption.

**Unit 4: Muscle**

Histology of different types of muscle; Ultra structure of skeletal muscle; Molecular and chemical basis of muscle contraction; Characteristics of muscle twitch; Motor unit, summation and tetanus

**Unit 5: Nervous System**

Structure of neuron, resting membrane potential, Origin of action potential and its propagation across the myelinated and unmyelinated nerve fibers; Types of synapse, Synaptic transmission and, Neuromuscular junction; Reflex action and its types - reflex arc; Physiology of hearing and vision

**Unit 6: Reproductive System**

Histology of testis and ovary; Physiology of male and female reproduction; Puberty, Methods of contraception in male and female

**Unit 7: Endocrine System**

Histology of endocrine glands - pineal, pituitary, thyroid, parathyroid, pancreas, adrenal; hormones secreted by them and their mechanism of action; Classification of hormones; Regulation of their secretion; Mode of hormone action, Signal transduction pathways for steroidal and non-steroidal hormones; Hypothalamus (neuroendocrine gland) - principal nuclei involved in neuroendocrine control of anterior pituitary and endocrine system; Placental hormones.

**Practicals (Credits: 2)**

1. \*Recording of simple muscle twitch with electrical stimulation (or Virtual)
2. Demonstration of the unconditioned reflex action (Deep tendon reflex such as knee jerk reflex)
3. Preparation of temporary mounts: Squamous epithelium, Striated muscle fibres and nerve cells.
4. Study of permanent slides of Mammalian skin, Cartilage, Bone, Spinal cord, Nerve cell, Pituitary, Pancreas, Testis, Ovary, Adrenal, Thyroid and Parathyroid.

5. Microtomy: Preparation of permanent slide of any five mammalian (Goat/whiterat) tissues.  
(\*Subject to UGC guidelines)

#### **Suggested Books**

1. Guyton, A.C. & Hall, J.E. (2006). Textbook of Medical Physiology. XI Edition. Hercourt Asia PTE Ltd. /W.B. Saunders Company.
2. Tortora, G.J. & Grabowski, S. (2006). Principles of Anatomy & Physiology. XI Edition John Wiley & sons.
3. Victor P. Eroschenko. (2008). diFiore's Atlas of Histology with Functional correlations. XII Edition. Lippincott W. & Wilkins.

<b>BSZUGCC08</b>	<b>Molecular Biology</b>
<u>Theory (Credits: 4)</u>	

#### **Unit 1: Nucleic acids: Carriers of genetic information**

Historical perspective; DNA as the carrier of genetic information (Griffith's, Hershey & Chase, Avery, McLeod & McCarty)

#### **Unit 2: The Structures of DNA and RNA**

DNA Structure: Miescher to Watson and Crick- historic perspective, DNA structure, Salient features of double helix, Types of DNA, Types of genetic material, denaturation and renaturation, cot curves; Organization of DNA- Prokaryotes, Viruses, Eukaryotes. RNA Structure; Organelle DNA -- mitochondria and chloroplast DNA. The Nucleosome; Chromatin structure- Euchromatin, Heterochromatin- Constitutive and Facultative heterochromatin.

#### **Unit 3: The replication of DNA**

Chemistry of DNA synthesis (Kornberg's discovery); General principles – bidirectional, semiconservative and semi discontinuous replication, RNA priming; Various models of DNA replication, including rolling circle,  $\theta$  (theta) mode of replication, replication of linear ds-DNA, replication of the 5' end of linear chromosome; Enzymes involved in DNA replication.

#### **Unit 4: Central dogma and genetic code**

Key experiments establishing-The Central Dogma (Adaptor hypothesis and discovery of mRNA template), Genetic code (deciphering & salient features)

#### **Unit 5: Transcription**

Transcription: Definition, difference from replication, promoter- concept and strength of promoter RNA Polymerase and the transcription unit; Transcription in Eukaryotes: RNA polymerases, general Transcription factors

#### **Unit 6: Processing and modification of RNA**

Split genes-concept of introns and exons, removal of introns, spliceosome machinery, splicing pathways, group I and group II intron splicing, alternative splicing eukaryotic mRNA processing (5' cap, 3' polyA tail); Ribozymes; RNA editing and mRNA transport.

#### **Unit 7: Translation**

Ribosome structure and assembly, mRNA; Charging of tRNA, aminoacyl tRNA synthetases; Various steps in protein synthesis, proteins involved in initiation, elongation and termination of polypeptides; Fidelity of translation; Inhibitors of protein synthesis; Post-translational modifications of proteins.

#### **Practical (Credits: 2)**

1. Preparation of LB medium and raising *E.Coli*.
2. Isolation of genomic DNA from *E.Coli*.
3. DNA isolation from cauliflower head.
4. DNA estimation by diphenylamine reagent/UV Spectrophotometry.
5. Study of DNA replication mechanisms through photographs (Rolling circle, Theta replication and semi-discontinuous replication).
6. Study of structures of prokaryotic RNA polymerase and eukaryotic RNA polymerase II through photographs.
7. Photographs establishing nucleic acid as genetic material (Messelson and Stahl's, Avery et al, Griffith's, Hershey & Chase's and Fraenkel & Conrat's experiments)
8. Study of the following through photographs: Assembly of Spliceosome machinery; Splicing mechanism in group I & group II introns; Ribozyme and Alternative splicing.

#### **Suggested Readings**

1. Watson J.D., Baker, T.A., Bell, S.P., Gann, A., Levine, M., Losick, R. (2007). Molecular Biology of the Gene, Pearson Benjamin Cummings, CSHL Press, New York, U.S.A. 6th edition.

2. Snustad, D.P. and Simmons, M.J. (2010). Principles of Genetics. John Wiley and Sons Inc., U.S.A. 5th edition.
3. Klug, W.S., Cummings, M.R., Spencer, C.A. (2009). Concepts of Genetics. Benjamin Cummings. U.S.A. 9th edition.
4. Russell, P. J. (2010). i-Genetics- A Molecular Approach. Benjamin Cummings, U.S.A. 3<sup>rd</sup> edition.
5. Griffiths, A.J.F., Wessler, S.R., Carroll, S.B., Doebley, J. (2010). Introduction to Genetic Analysis. W. H. Freeman and Co., U.S.A. 10th edition.

<b>BSZUGCC09</b>	<b>Comparative Anatomy of Vertebrates</b> <u>Theory (Credit 4)</u>
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**Unit 1: Integumentary System**

Structure, functions and derivatives of integument

**Unit 2: Skeletal System**

Overview of axial and appendicular skeleton, Jaw suspensorium, Visceralarches

**Unit 3: Digestive System**

Alimentary canal and associated glands, dentition

**Unit 4: Respiratory System**

Skin, gills, lungs and air sacs; Accessory respiratory organs

**Unit 5: Circulatory System**

General plan of circulation, evolution of heart and aortic arches

**Unit 6: Urinogenital System**

Succession of kidney, Evolution of urinogenital ducts, Types of mammalian uteri

**Unit 7: Nervous System**

Comparative account of brain. Autonomic nervous system, Spinal cord, Cranial nerves in mammals

**Unit 8: Sense Organs**

Classification of receptors Brief account of visual and auditory receptors in man

**Practicals (Credits: 2)**

1. Study of placoid, cycloid and ctenoid scales through permanent slides/photographs.
2. Disarticulated skeleton of Frog, *Varanus*, Fowl, Rabbit.
3. Carapace and plastron of turtle /tortoise.
4. Mammalian skulls: One herbivorous and one carnivorous animal.
5. Dissection of rat to study arterial and urino-genital system (subject to permission).
6. Study of structure of any two organs (heart, lung, kidney, eye and ear) from video recording (may be included if dissection not permitted).
7. Project on skeletal modifications in vertebrates (may be included if dissection not permitted).

***Suggested Readings***

1. Kardong, K.V. (2005) *Vertebrates' Comparative Anatomy, Function and Evolution*. IV Edition. McGraw-Hill Higher Education
2. Kent, G.C. and Carr R.K. (2000). *Comparative Anatomy of the Vertebrates*. IX Edition. The McGraw-Hill Companies.
3. Hilderbrand, M and Gaslow G.E. *Analysis of Vertebrate Structure*, John Wiley and Sons.
4. Walter, H.E. and Sayles, L.P; *Biology of Vertebrates*, Khosla Publishing House.

<b>BSZUGCC10</b>	<b>Physiology &amp; Metabolism</b>
	<u>Theory (credit 4)</u>

**Unit 1: Physiology of Digestion**

Structural organization and functions of gastrointestinal tract and associated glands; Mechanical and chemical digestion of food; Absorptions of carbohydrates, lipids, proteins, water, minerals and vitamins; Hormonal control of secretion of enzymes in Gastrointestinal tract

**Unit 2: Physiology of Respiration**

Histology of trachea and lung; Mechanism of respiration, Pulmonary ventilation; Respiratory volumes and capacities; Transport of oxygen and carbon dioxide in blood; Respiratory pigments, Dissociation curves and the factors influencing it; Carbon monoxide poisoning; Control of respiration.

**Unit 3: Renal Physiology**

Structure of kidney and its functional unit; Mechanism of urine formation; Regulation of water balance; Regulation of acid-base balance

**Unit 5: Physiology of Heart**

Structure of mammalian heart; Coronary circulation; Structure and working of conducting myocardial fibers; Origin and conduction of cardiac impulses; Cardiac cycle; Cardiac output and its regulation, Frank-Starling Law of the heart, nervous and chemical regulation of heart rate; Electrocardiogram; Blood pressure and its regulation

**Unit 6: Overview of Metabolism**

Catabolism *vs* Anabolism, Stages of catabolism, Compartmentalization of metabolic pathways, Shuttle systems and membrane transporters; ATP as "Energy Currency of cell"; coupled reactions; Use of reducing equivalents and cofactors; Intermediary metabolism and regulatory mechanisms.

**Unit 7: Carbohydrate Metabolism**

Sequence of reactions and regulation of glycolysis, Citric acid cycle, Phosphate pentose pathway, Gluconeogenesis, Glycogenolysis and Glycogenesis

**Unit 8: Lipid Metabolism**

$\beta$ -oxidation and omega -oxidation of saturated fatty acids with even and odd number of carbon atoms; Biosynthesis of palmitic acid; Ketogenesis

**Unit 9: Protein Metabolism**

Catabolism of amino acids: Transamination, Deamination, Urea cycle; Fate of C-skeleton of Glucogenic and Ketogenic amino acids.

**Unit 10: Oxidative Phosphorylation**

Redox systems; Review of mitochondrial respiratory chain, Inhibitors and uncouplers of Electron Transport System

**Practicals (Credits: 2)**

1. Determination of ABO Blood group.
2. Enumeration of red blood cells and white blood cells using haemocytometer.
3. Estimation of haemoglobin using Sahli's haemoglobinometer.
4. Preparation of haemin and haemochromogen crystals.
5. Recording of frog's heart beat under *in situ* and perfused conditions.\*
6. Recording of blood pressure using a sphygmomanometer.
7. Examination of sections of mammalian oesophagus, stomach, duodenum, ileum, rectum liver, trachea, lung, kidney.
8. Estimation of total protein in given solutions by Lowry's method.
9. Detection of SGOT and SGPT or GST and GSH in serum/ tissue.
10. To study the enzymatic activity of Trypsin and Lipase.
11. Study of biological oxidation (SDH) [goat liver].
12. To perform the Acid and Alkaline phosphatase assay from serum/ tissue.
13. Dry Lab: To trace the labelled C atoms of Acetyl-CoA till they evolve as CO<sub>2</sub> in the TCA cycle.

(\*Subject to UGC guidelines)

(Any 10 of the above practical equivalent to 30 hours will be performed)

**Suggested Readings**

1. Guyton, A.C. & Hall, J.E. (2006). Textbook of Medical Physiology. XI Edition. Hecourt Asia PTE Ltd. W.B. Saunders Company.
2. Tortora, G.J. & Grabowski, S. (2006). Principles of Anatomy & Physiology. XI Edition John Wiley & sons,

3. Victor P. Eroschenko. (2008). diFiore's Atlas of Histology with Functional correlations. XII Edition. Lippincott W. & Wilkins.
4. Vander A, Sherman J. and Luciano D. (2014). Vander's Human Physiology: The Mechanism of Body Function. XIII Edition, McGraw Hills
5. Cox, M.M and Nelson, D.L. (2008). *Lehninger Principles of Biochemistry*, V Edition, W.H. Freeman and Co., New York.
6. Berg, J.M., Tymoczko, J.L. and Stryer, L. (2007). *Biochemistry*, VI Edition, W.H. Freeman and Co., New York.
7. Murray, R.K., Bender, D.A., Botham, K.M., Kennelly, P.J., Rodwell, V.W. and Well, P.A. (2009). *Harper's Illustrated Biochemistry*, XXVIII Edition, International Edition, The McGraw-Hill Companies Inc.

<b>BSZUGCC11</b>	<b>Immunology</b>
<u>Theory (Credit 4)</u>	

**Unit 1: Overview of Immune System**

Historical perspective of Immunology, Early theories of Immunology, Cells and organs of the Immune system

**Unit 2: Innate and Adaptive Immunity**

Anatomical barriers, Inflammation, Cell and molecules involved in innate immunity, Adaptive immunity (Cell mediated and humoral), Passive: Artificial and natural Immunity, Active: Artificial and natural Immunity, Immune dysfunctions (brief account of autoimmunity with reference to Rheumatoid Arthritis and tolerance, AIDS).

**Unit 3: Antigens**

Antigenicity and immunogenicity, Immunogens, Adjuvants and haptens, Factors influencing immunogenicity, B and T-Cell epitopes

**Unit 4: Immunoglobulins**

Structure and functions of different classes of immunoglobulins, Antigen-antibody interactions (Precipitation, Agglutination), Immunoassays (Immunodiffusion, Immunoelectrophoresis, RIA, ELISA, immuno blotting, Immunofluorescence), Polyclonal sera, Hybridoma technology: Monoclonal antibodies in therapeutics and diagnosis.

**Unit 5: Major Histocompatibility Complex**

Structure and functions of MHC molecules; Endogenous and exogenous pathways of antigen processing and presentation

**Unit 6: Cytokines**

Properties and functions of cytokines, Therapeutics Cytokines

**Unit 7: Complement System**

Components and pathways of complement activation

**Unit 8: Hypersensitivity**

Gell and Coombs' classification and brief description of various types of hypersensitivities

**Unit 9: Vaccines**

Various types of vaccines

**Practicals (Credits: 2)**

1. \*Demonstration of lymphoid organs.
2. Histological study of spleen, thymus and lymph nodes through slides/photographs.
3. Preparation of stained blood film to study various types of blood cells.
4. Agglutination assay.
5. ABO blood group determination.
6. Separate serum from the blood sample (demonstration).
7. \*Cell counting and viability test from splenocytes of farm bred animals/cell lines.
8. Demonstration of: ELISA, Dot blotting, Immunodiffusion by Ouchterlony method/Radial Immunodiffusion method. Immunoelectrophoresis.

*(\*The experiments can be performed depending upon usage of animals in UG courses)*

**Suggested Readings**

1. Abbas AK, Lichtman AH, Pillai S. (2007). Cellular and Molecular Immunology. 6th edition Saunders Publication, Philadelphia.
2. Delves P, Martin S, Burton D, Roitt IM. (2006). Roitt's Essential Immunology. 11th edition WileyBlackwell Scientific Publication, Oxford.
3. Goldsby RA, Kindt TJ, Osborne BA. (2007). Kuby's Immunology. 6th edition W.H. Freeman and Company, New York.
4. Murphy K, Travers P, Walport M. (2008). Janeway's Immunobiology. 7th edition Garland Science Publishers, New York.
5. Peakman M, and Vergani D. (2009). Basic and Clinical Immunology. 2nd edition Churchill Livingstone Publishers, Edinburgh.
6. Richard C and Geiffrey S. (2009). Immunology. 6th edition. Wiley Blackwell Publication.
7. Fahim H. Khan (2012) The Elements of Immunology. Second Imp, Pearson Education Inc.

<b>BSZUGCC12</b>	<b>Principles of Genetics</b>
<u>Theory (Credit 4)</u>	

**Unit 1: Mendelian Genetics and its Extension**

Principles of inheritance, Incomplete dominance and co-dominance, Multiple alleles, Lethal alleles, Epistasis, Pleiotropy, Sex-linked, sex influenced and sex-limited characters inheritance.

**Unit 2: Linkage, Crossing Over and Chromosomal Mapping**

Linkage and crossing over, Cytological basis of crossing over, Molecular mechanisms of crossing over including models of recombination, Recombination frequency as a measure of linkage intensity, Two factor and three factor crosses, Interference and coincidence, Somatic cell hybridization.

**Unit 3: Mutations**

Types of gene mutations (Classification), Types of chromosomal aberrations (Classification, figures and with one suitable example of each), Molecular basis of mutations in relation to UV light and chemical mutagens; Detection of mutations: CLB method, attached X method.

**Unit 4: Sex Determination**

Chromosomal mechanisms of sex determination in *Drosophila* and Man

**Unit 5: Extra-chromosomal Inheritance**

Criteria for extra-chromosomal inheritance, Antibiotic resistance in *Chlamydomonas*, Mitochondrial mutations in *Saccharomyces*, Infective heredity in *Paramecium* and Maternal effects.

**Unit 6: Polygenic Inheritance**

Polygenic inheritance with suitable examples; simple numericals based on it.

**Unit 7: Recombination in Bacteria and Viruses**

Conjugation, Transformation, Transduction, Complementation test in Bacteriophage

**Unit 8: Transposable Genetic Elements**

Transposons in bacteria, Ac-Ds elements in maize and P elements in *Drosophila*, Transposons in humans

**Practicals (Credits: 2)**

1. To study the Mendelian laws and gene interactions.
2. Chi-square analyses using seeds/beads/*Drosophila*.
3. Linkage maps based on data from conjugation, transformation and transduction.
4. Linkage maps based on data from *Drosophila* crosses.
5. Study of human karyotype (normal and abnormal).
6. Pedigree analysis of some human inherited traits.

**Suggested Readings**

1. Gardner, E.J., Simmons, M.J., Snustad, D.P. (2008). *Principles of Genetics*. VIII Edition. Wiley India.
2. Snustad, D.P., Simmons, M.J. (2009). *Principles of Genetics*. V Edition. John Wiley and Sons Inc.
3. Klug, W.S., Cummings, M.R., Spencer, C.A. (2012). *Concepts of Genetics*. X Edition. Benjamin Cummings.
4. Russell, P. J. (2009). *Genetics- A Molecular Approach*. III Edition. Benjamin Cummings.
5. Griffiths, A.J.F., Wessler, S.R., Lewontin, R.C. and Carroll, S.B. *Introduction to Genetic Analysis*. IX Edition. W. H. Freeman and Co.

<b>BSZUGCC13</b>	<b>Developmental Biology</b>
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Theory (Credit 4)

**Unit 1: Introduction**

Historical perspective and basic concepts: Phases of development, Cell-Cell interaction, Pattern formation, Differentiation and growth, Differential gene expression, Cytoplasmic determinants and asymmetric cell division.

**Unit 2: Early Embryonic Development**

Gametogenesis, Spermatogenesis, Oogenesis; Types of eggs, Egg membranes; Fertilization (External and Internal): Changes in gametes, Blocks to polyspermy; Planes and patterns of cleavage; Types of Blastula; Fate maps (including Techniques); Early development of frog and chick upto gastrulation; Embryonic induction and organizers

**Unit 3: Late Embryonic Development**

Fate of Germ Layers; Extra-embryonic membranes in birds; Implantation of embryo in humans, Placenta (Structure, types and functions of placenta)

**Unit 4: Post Embryonic Development**

Metamorphosis: Changes, hormonal regulations in amphibians and insects; Regeneration: Modes of regeneration, epimorphosis, morphallaxis and compensatory regeneration (with one example each); Ageing: Concepts and Theories.

**Unit 5: Implications of Developmental Biology**

Teratogenesis: Teratogenic agents and their effects on embryonic development; *In vitro* fertilization, Stem cell (ESC), Amniocentesis

**Practicals (Credits: 2)**

1. Study of whole mounts and sections of developmental stages of frog through permanent slides: Cleavage stages, blastula, gastrula, neurula, tail-bud stage, tadpole (external and internal gill stages).
2. Study of whole mounts of developmental stages of chick through permanent slides: Primitive streak (13 and 18 hours), 21, 24, 28, 33, 36, 48, 72, and 96hours of incubation (Hamilton and Hamburger stages).
3. Study of the developmental stages and life cycle of *Drosophila* from stock culture.
4. Study of different sections of placenta (photomicrograph/ slides).
5. Project report on *Drosophila* culture/chick embryo development.

**Suggested Readings**

1. Gilbert, S. F. (2010). Developmental Biology, IX Edition, Sinauer Associates, Inc., Publishers, Sunderland, Massachusetts, USA.
2. Balinsky B. I. and Fabian B. C. (1981). An Introduction to Embryology, V Edition, International Thompson Computer Press.
3. Carlson, R. F. Patten's Foundations of Embryology.
4. Kalthoff (2008). Analysis of Biological Development, II Edition, McGraw-Hill Publishers.
5. Lewis Wolpert (2002). Principles of Development. II Edition, Oxford University Press.

<b>BSZUGCC14</b>	<b>Evolutionary Biology</b>
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Theory (Credit 4)

**Unit 1: Life's Beginnings**

Chemogeny, RNA world, Biogeny, Origin of photosynthesis, Evolution of eukaryotes.

**Unit 2: Historical review of evolutionary concept**

Lamarckism, Darwinism, Neo-Darwinism.

**Unit 3: Evidences of Evolution**

Fossil record (types of fossils, transitional forms, geological time scale, evolution of horse, Molecular (universality of genetic code and protein synthesizing machinery, three domains of life, neutral theory of molecular evolution, molecular clock, example of globin gene family, rRNA/cyt c.

**Unit 4: Sources of variations**

Heritable variations and their role in evolution

**Unit 5: Population genetics**

Hardy-Weinberg Law (statement and derivation of equation, application of law to human Population); Evolutionary forces upsetting H-W equilibrium; Natural selection (concept of fitness, selection coefficient, derivation of one unit of selection for a dominant allele, genetic load, mechanism of working, types of selection, density-dependent selection, heterozygous superiority, kin selection, adaptive resemblances, sexual selection. Genetic Drift (mechanism, founder's effect, bottle neck phenomenon; Role of Migration and Mutation in changing allele frequencies

**Unit 6: Product of evolution**

Micro evolutionary changes (inter-population variations, clines, races, Species concept, Isolating mechanisms, modes of speciation-allopatric, sympatric, Adaptive radiation / macroevolution (exemplified by Galapagos finches.

**Unit 7: Extinctions**

Back ground and mass extinctions (causes and effects), detailed example of K-T extinction

**Unit 8: Origin and evolution of man**

Unique hominin characteristics contrasted with primate characteristics, primate phylogeny from *Dryopithecus* leading to *Homo sapiens*, molecular analysis of human origin.

**Unit 9: Phylogenetic trees**

Multiple sequence alignment, construction of phylogenetic trees, interpretation of trees.

**Practicals (Credits: 2)**

1. Study of fossils from models/ pictures.
2. Study of homology and analogy from suitable specimens.
3. Study and verification of Hardy-Weinberg Law by chi square analysis.
4. Demonstration of role of natural selection and genetic drift in changing allele frequencies using simulation studies.
5. Graphical representation and interpretation of data of height/ weight of a sample of 100 humans in relation to their age and sex.
6. Construction of phylogenetic trees with the help of bioinformatics tools (Clustal X, Phylip, NJ) and its interpretation.

***Suggested Readings***

1. Ridley, M (2004) Evolution III Edition Blackwell publishing
2. Hall, B.K. and Hallgrimson, B (2008). Evolution IV Edition. Jones and Barlett Publishers.
3. Campbell, N.A. and Reece J.B (2011). Biology. IX Edition. Pearson, Benjamin, Cummings.
4. Douglas, J. Futuyma (1997). Evolutionary Biology. Sinauer Associates.
5. Snustad. S Principles of Genetics.
6. Pevsner, J (2009). Bioinformatics and Functional Genomics. II Edition WileyBlackwell



**B) Discipline Specific Electives**

<b>BSZUGDS01</b>	<b>Bioinformatics</b>
<u>Theory (Credit 4)</u>	

**Unit 1: Introduction to Bioinformatics**

Introduction, Branches of Bioinformatics, Aim, Scope and Research areas of Bioinformatics.

**Unit 2: Databases**

Introduction, Biological Databases, Classification format of Biological Databases, Biological Database Retrieval System

**Unit 3: Biological Sequence Databases**

National Center for Biotechnology Information (NCBI): Tools and Databases of NCBI, Database Retrieval Tool, Sequence Submission to NCBI, Basic local alignment search tool (BLAST), Nucleotide Database, Protein Database, Gene Expression Database. EMBL Nucleotide Sequence Database (EMBL-Bank): Introduction, Sequence Retrieval, Sequence Submission to EMBL, Sequence analysis tools. DNA Data Bank of Japan (DDBJ): Introduction, Resources at DDBJ, Data Submission at DDBJ. Protein Information Resource (PIR): About PIR, Resources of PIR, Databases of PIR, Data Retrieval in PIR. Swiss-Prot: Introduction and Salient Features.

**Unit 4: Sequence Alignments**

Introduction, Concept of Alignment, Multiple Sequence Alignment (MSA), MSA by CLUSTALW, Scoring Matrices, Percent Accepted Mutation (PAM), Blocks of Amino Acid Substitution Matrix (BLOSUM)

**Unit 5: Molecular Phylogeny**

Methods of Phylogeny, Software for Phylogenetic Analyses, Consistency of Molecular Phylogenetic Prediction

**Unit 6: Applications of Bioinformatics (7 Lectures)**

Structural Bioinformatics in Drug Discovery, Quantitative structure-activity relationship (QSAR) techniques in Drug Design

**Practical (Credits: 2)**

1. Introduction to different operating systems - UNIX, LINUX and Windows
2. Introduction to bioinformatics databases (any three): NCBI/PDB/DDBJ/PDB
3. Sequence retrieval using BLAST
4. Sequence alignment & phylogenetic analysis using clustalW&phylip
5. Picking out a given gene from genomes using Genscan or other softwares (promoter region identification, repeat in genome, ORF prediction). Gene finding tools (Glimmer, GENSCAN), Primer designing, Genscan/Genetool
6. Protein structure prediction: primary structure analysis, secondary structure prediction using psipred, homology modeling using Swissmodel. Molecular visualization using jmol, Protein structure model evaluation (PROCHECK)
7. Prediction of different features of a functional gene.

**Suggested Readings**

1. Bioinformatics: Sequence and Genome analysis, 2nd edition (2004), David W. Mount, Cold Spring Harbour Laboratory Press. ISBN-13: 978-0879697129.
2. Bioinformatics: A practical guide to the analysis of genes and proteins, 3rd edition (2004), Andreas D. Baxevanis and B.F. Francis Ouellette, John Wiley and Sons.
3. Introduction to Medicinal Chemistry, 4th edition (2009), Graham I. Patrick, Oxford University Press
4. The Process of New Drug Discovery and Development, 2nd edition (2006), C.G. Smith and J.T.O'Donnell, Informa Healthcare, ISBN-13: 978-0849327797.
5. Cheminformatics (2003), J. Gasteiger, Thomas Engel; Wiley-VCH. ISBN: 9783527618279.
6. Molecular modeling - Principles and Applications, 2nd edition (2003), A. R. Leach, Pearson Education Limited, UK. ISBN 13: 9780582382107.
7. Cheminformatics in Drug Discovery (2006), edited by. T.I. Opera; Wiley Publishers, ISBN: 9783527604203.
8. Goel D & Prashar S (2013). IPR, Biosafety and Bioethics. Pearson
9. Senthil Kumar Sadhasivam and Mohammed Jaabir, M. S. 2008. IPR, Biosafety and biotechnology Management. Jasen Publications, Tiruchirappalli, India

**BSZUGDS02****Reproductive Biology**Theory (Credits 4)**Unit 1: Reproductive Endocrinology**

Gonadal hormones and mechanism of hormone action, steroids, glycoprotein hormones, and prostaglandins, hypothalamo – hypophyseal – gonadal axis, regulation of gonadotrophin secretion in male and female; Reproductive System: Development and differentiation of gonads, genital ducts, external genitalia, mechanism of sex differentiation.

**Unit 2: Functional anatomy of male reproduction**

Outline and histological of male reproductive system in rat and human; Testis: Cellular functions, germ cell, system cell renewal; Spermatogenesis: kinetics and hormonal regulation; Androgen synthesis and metabolism; Epididymal function and sperm maturation; Accessory glands functions; Sperm transportation in male tract.

**Unit 3: Functional anatomy of female reproduction**

Outline and histological of female reproductive system in rat and human; Ovary: folliculogenesis, ovulation, corpus luteum formation and regression; Steroidogenesis and secretion of ovarian hormones; Reproductive cycles (rat and human) and their regulation, changes in the female tract; Ovum transport in the fallopian tubes; Sperm transport in the female tract, fertilization; Hormonal control of implantation; Hormonal regulation of gestation, pregnancy diagnosis, foeto– maternal relationship; Mechanism of parturition and its hormonal regulation; Lactation and its regulation.

**Unit 4: Reproductive Health**

Infertility in male and female: causes, diagnosis and management; Assisted Reproductive Technology: sex selection, sperm banks, frozen embryos, in vitro fertilization, ET, EFT,IUT, ZIFT, GIFT, ICSI, PROST; Modern contraceptive technologies; Demographic terminology used in family planning.

**Practicals (Credits: 2)**

1. Study of animal house: set up and maintenance of animal house, breeding techniques, care of normal and experimental animals.
2. Examination of vaginal smear rats from live animals.
3. Surgical techniques: principles of surgery in endocrinology. Ovarectomy, hysterectomy, castration and vasectomy in rats.
4. Examination of histological sections from photomicrographs/ permanent slides of rat/human: testis, epididymis and accessory glands of male reproductive systems; Sections of ovary, fallopian tube, uterus (proliferative and secretory stages), cervix and vagina.
5. Human vaginal exfoliate cytology.
6. Sperm count and sperm motility in rat.
7. Study of modern contraceptive devices.

**Suggested Readings**

1. Austin, C.R. and Short, R.V. reproduction in Mammals. Cambridge University Press.
2. Degroot, L.J. and Jameson, J.L. (eds). Endocrinology. W.B. Saunders and Company.
3. Knobil, E. et al. (eds). The Physiology of Reproduction. Raven Press Ltd.
4. Hatcher, R.A. et al. The Essentials of Contraceptive Technology. Population Information Programme.

**BSZUGDS03****Biostatistics & Biotechniques**Theory (Credits: 4)**Unit 1: Bioenergetics**

First and Second Laws of Thermodynamics; Definition of Gibb's Free Energy, Enthalpy, and Entropy; Mathematical Relationships Among Them; Standard Free Energy Change and Equilibrium Constant; Coupled Reactions And Additive Nature of Standard Free Energy Change; Energy Rich Compounds: Phosphoenolpyruvate, 1,3-Bisphosphoglycerate, Thioesters, ATP.

**Unit 2: Microscopy: Principles and applications**

Principles and applications of - Light microscopy: brightfield and darkfield, Phase contrast microscopy, Fluorescence Microscopy, Confocal Microscopy, Electron Microscopy (Scanning and Transmission Electron Microscopy); Micrometry.

**Unit 3. Electromagnetic radiation and Spectrophotometry**

*Basic principles of electromagnetic radiation:* Energy, wavelength, wave numbers and frequency, review of electronic structure of molecules.

*UV-visible spectrophotometry:* Beer Lambert law, light absorption and its transmittance, factors affecting absorption properties of a chromophore, Principle and use of study of absorption spectra of biomolecules; structural analyses of DNA/ protein using absorption of UV light. Colorimetry and turbidometry

*Fluorescence spectroscopy:* Theory of fluorescence, static and dynamic quenching, resonance energy transfer, fluorescent probes in the study of protein and nucleic acids.

*Mass spectrometry (MALDI-TOF):* Physical basis and uses of MS in the analysis of proteins/ nucleic acids.

#### **Unit 4: Radiation Biology**

Concept of radioisotopes, types of radioactive decay (gamma and beta emitter), half-life, detection and measurement of radioactivity: methods based upon ionization (GM counter), methods based upon excitation (scintillation counter). Autoradiography, radioisotopes in diagnosis and radiotherapy. Effect of radiations (ionizing and non-ionizing) on living systems, precautions and safety measures in handling radioisotopes

#### **Unit 5: Chromatography**

Principles and applications of paper chromatography (including Descending and 2-D), Thin layer chromatography, Column chromatography: packing and fraction collection. Gel filtration chromatography, ion exchange chromatography and affinity chromatography; GLC, HPLC.

#### **Unit 6: Electrophoresis**

Principle and applications of native polyacrylamide gel electrophoresis, SDS polyacrylamide gel electrophoresis, Isoelectric focusing, 2D gel electrophoresis; Zymogram preparation; Principle and applications of Agarose gel electrophoresis.

#### **Unit 7: Hydrodynamic methods**

*Viscosity:* Methods of measurement of viscosity, specific and intrinsic viscosity, relationship between viscosity and molecular weight, measurement of viscoelasticity of DNA.

*Sedimentation:* Principle of centrifugation; Svedberg equation, RCF and sedimentation coefficient; relationship between RPM and RCF; differential and density gradient centrifugation, preparative and analytical ultracentrifugation techniques, fractionation of cellular components using centrifugation with examples.

*Flow Cytometry:* Basic principle of flow cytometry and cell sorting, detection strategies in flow cytometry.

#### **Unit 8: Biostatistics**

Introduction to biostatistics & its use. Basic idea on variables, frequency distribution and sampling. Measures of central tendency: mean, median, mode. Measures of distributions: variance, range, quartile deviation. Standard deviation and standard error - problems and application. Student's t-test and Chi square test- problems and application. Correlation and Regression

#### **Practical (Credits: 2)**

1. Study of fluorescent micrographs to visualize bacterial cells.
2. Ray diagrams of phase contrast microscopy and Electron microscopy.
3. Study of structural changes of proteins at different pH/Temperature using UV spectrophotometry.
4. Determination of melting temperature of DNA.
5. Separation of mixtures by paper / thin layer chromatography.
6. Demonstration of column packing in any form of column chromatography.
7. Separation of protein mixtures by any form of chromatography.
8. Separation of protein mixtures by Polyacrylamide Gel Electrophoresis (PAGE).
9. Preparation of agarose gel and loading of sample.
10. Determination of  $\lambda_{max}$  for an unknown sample and calculation of extinction coefficient.
11. Study the effect of temperature on the viscosity of a macromolecule (Protein/DNA).
12. Separation of components of a given mixture using a laboratory scale centrifuge.

#### **Suggested Readings**

1. Wilson K and Walker J. (2010). Principles and Techniques of Biochemistry and Molecular Biology. 7<sup>th</sup>Ed. Cambridge University Press.
2. David Freifelder (1982) Physical Biochemistry: Applications to Biochemistry and Molecular Biology, 2<sup>nd</sup> Ed., W.H. Freeman and Company.
3. Nelson DL and Cox MM. (2008). Lehninger Principles of Biochemistry, 5<sup>th</sup>Ed. W.H. Freeman and Company.
4. Willey MJ, Sherwood LM & Woollverton C J. (2013). Prescott, Harley and Klein's Microbiology. 9<sup>th</sup>Ed. McGrawHill.
5. Karp G. (2010) Cell and Molecular Biology: Concepts and Experiments. 6th edition. John Wiley & Sons. Inc.

- De Robertis EDP and De Robertis EMF. (2006). Cell and Molecular Biology. 8th edition. Lipincott Williams and Wilkins, Philadelphia.
- Cooper G.M. and Hausman R.E. (2009). The Cell: A Molecular Approach. 5<sup>th</sup> Edition. ASM Press & Sunderland, Washington D.C., Sinauer Associates, MA.
- Nigam A and Ayyagari A. 2007. Lab Manual in Biochemistry, Immunology and Biotechnology. Tata McGraw Hill.
- A. Edmondson and D. Druce : Advanced Biology Statistics, Oxford University Press; 1996.
- W. Danial : Biostatistics : A foundation for Analysis in Health Sciences, John Wiley and Sons Inc; 2004.

<b>BSZUGDS04</b>	<b>Fisheries and Entomology</b>
<u>Theory (Credit 4)</u>	

**Unit 1: Introduction**

General Features of Insects; Distribution and Success of Insects on the Earth. Basis of insect classification; Classification of insects up to orders

**Unit 2: General Morphology of Insects**

External Features; Head – Eyes, Types of antennae, Mouth parts w.r.t. feeding habits. Thorax: Wings and wing articulation, Types of Legs adapted to diverse habitat. Abdominal appendages and genitalia

**Unit 3: Physiology of Insects**

Structure and physiology of Insect body systems - Integumentary, digestive, excretory, circulatory, respiratory, endocrine, reproductive, and nervous system; Sensory receptors; Metamorphosis.

**Unit 4: Insect Society**

Group of social insects and their social life; Social organization and social behaviour (with example)

**Unit 5: Insects as Pests / Vectors**

Insects as plant pests; Insects as mechanical and Biological vectors. Brief discussion on houseflies and mosquitoes as important insect vectors

**Unit 6: Introduction and Classification of Fishes**

General description of fish; Account of systematic classification of fishes (upto classes); Classification based on feeding habit, habitat and manner of reproduction.

**Unit 7: Morphology and Physiology**

Types of fins and their modifications; Locomotion in fishes; Hydrodynamics; Types of Scales, Use of scales in Classification and determination of age of fish; Gills and gas exchange; Swim Bladder: Types and role in Respiration, buoyancy; Osmoregulation in Elasmobranchs; Reproductive strategies (special reference to Indian fishes); Electric organs; Bioluminescence; Mechanoreceptors; Schooling; Parental care; Migration.

**Unit 8: Fisheries & Aquaculture**

Inland Fisheries; Marine Fisheries; Environmental factors influencing the seasonal variations in fish catches in the Arabian Sea and the Bay of Bengal; Fishing crafts and Gears; Sustainable Aquaculture; Extensive, semi-intensive and intensive culture of fish; Pen and cage culture; Polyculture; Composite fish culture; Brood stock management; Induced breeding of fish; Management of finfish hatcheries; Preparation of compound diets for fish; Role of water quality in aquaculture; Fish diseases: Bacterial, viral and parasitic; Preservation and processing of harvested fish, Fishery by-products.

**Practical (Credits: 2)**

- Study of one specimen from each insect order
- Study of different kinds of antennae, legs and mouth parts of insects
- Study of head and sclerites of any one insect
- Study of insect wings and their venation.
- Study of insect spiracles
- Methodology of collection, preservation and identification of insects.
- Morphological studies of various castes of Apis, Camponotus and Odontotermes
- Study of any three insect pests and their damages
- Study of any three beneficial insects and their products
- Morphometric and meristic characters of fishes
- Study of *Petromyzon*, *Myxine*, *Pristis*, *Chimaera*, *Exocoetus*, *Hippocampus*, *Gambusia*, *Labeo*, *Heteropneustes*, *Anabas*

12. Study of different types of scales (through permanent slides/ photographs).
13. Study of crafts and gears used in Fisheries
14. Water quality criteria for Aquaculture: Assessment of pH, conductivity, Total solids, Total dissolved solids
15. Study of air breathing organs in *Channa*, *Heteropneustes*, *Anabas* and *Clarias*
16. Demonstration of induced breeding in Fishes (video)
17. Demonstration of parental care in fishes (video)

(Any 10 of the above practicals will be performed)

#### **Suggested Readings**

1. D. H. Evans and J. D. Claiborne, The Physiology of Fishes, Taylor and Francis Group, CRC Press, UK von der Emde, R.J. Mogdans and B.G. Kapoor. The Senses of Fish: Adaptations for the Reception of Natural Stimuli, Springer, Netherlands
2. C.B.L. Srivastava, Fish Biology, Narendra Publishing House
3. S.S. Khanna and H.R. Singh, A text book of Fish Biology and Fisheries, Narendra Publishing House.
4. A general text book of entomology, Imms, A. D., Chapman & Hall, UK
5. Principles of Insect Morphology, Snodgrass, R. E., Cornell Univ. Press, USA
6. Introduction to the study of insects, Borror, D. J., Triplehorn, C. A., and Johnson, N. F., M Saunders College Publication, USA
7. The Insect Societies, Wilson, E. O., Harvard Univ. Press, UK
8. Physiological system in Insects, Klowden, M. J., Academic Press, USA

<b>BSZUGDS05</b>	<b>Animal Biotechnology</b>
	<u>Theory (Credits 4)</u>

#### **Unit 1: Introduction**

Concept and scope of biotechnology

#### **Unit 2: Molecular Techniques in Gene manipulation**

Cloning vectors: Plasmids, Cosmids, Phagemids, Lambda Bacteriophage, M13, BAC, YAC, MAC and Expression vectors (characteristics). Restriction enzymes: Nomenclature, detailed study of Type II. Transformation techniques: Calcium chloride method and electroporation. Construction of genomic and cDNA libraries and screening by colony and plaque hybridization, Southern, Northern and Western blotting DNA sequencing: Sanger method Polymerase Chain Reaction, DNA Finger Printing and DNA micro array.

#### **Unit 3: Genetically Modified Organisms**

Production of cloned and transgenic animals: Nuclear Transplantation, Retroviral Method, DNA microinjection. Applications of transgenic animals: Production of pharmaceuticals, production of donor organs, knock-out mice. Production of transgenic plants: *Agrobacterium* mediated transformation. Applications of transgenic plants: insect and herbicide resistant plants.

#### **Unit 4: Culture Techniques and Applications**

Animal cell culture, Expressing cloned genes in mammalian cells, Molecular diagnosis of genetic diseases (Cystic fibrosis, Sickle cell anemia) Recombinant DNA in medicines: Recombinant insulin and human growth hormone, Gene therapy.

#### **Practical (Credits: 2)**

1. Genomic DNA isolation from *E. coli*.
2. Plasmid DNA isolation (pUC 18/19) from *E. coli*
3. Restriction digestion of plasmid DNA.
4. Construction of circular and linear restriction map from the data provided
5. Calculation of transformation efficiency from the data provided
6. To study following techniques through photographs
  - a. Southern Blotting
  - b. Northern Blotting
  - c. Western Blotting
  - d. DNA Sequencing (Sanger's Method)
  - e. PCR
  - f. DNA fingerprinting
7. Project report on animal cell culture.

#### **Suggested Readings**

1. Brown, T.A. (1998). *Molecular Biology Labfax II: Gene Cloning and DNA Analysis*. II Edition, Academic Press, California, USA.

- Glick, B.R. and Pasternak, J.J. (2009). *Molecular Biotechnology - Principles and Applications of Recombinant DNA*. IV Edition, ASM press, Washington, USA.
- Griffiths, A.J.F., J.H. Miller, Suzuki, D.T., Lewontin, R.C. and Gelbart, W.M. (2009). *An Introduction to Genetic Analysis*. IX Edition. Freeman and Co., N.Y., USA.
- Snustad, D.P. and Simmons, M.J. (2009). *Principles of Genetics*. V Edition, John Wiley and Sons Inc.
- Watson, J.D., Myers, R.M., Caudy, A. and Witkowski, J.K. (2007). *Recombinant DNA- Genes and Genomes- A Short Course*. III Edition, Freeman and Co., N.Y., USA.
- Beauchamp, T.I. and Childress, J.F. (2008). *Principles of Biomedical Ethics*. VI Edition, Oxford University Press.

BSZUGDS06

Basics of Neuroscience

Theory (Credit 4)**Unit 1: Introduction to Neuroscience**

Origins of Neuroscience; Neuroanatomy, Neurophysiology, and Systems Neurobiology

**Unit 2: The Nervous system-An Introduction**

Introduction to the structure and function of the nervous system: Cellular components: Neurons; Neuroglia; Neuron doctrine; The prototypical neuron- axons and dendrites as unique structural components of neurons. The ionic bases of resting membrane potential; The action potential- its generation and properties; The action potential conduction.

**Unit 3: Cellular and Molecular Neurobiology**

Molecular and cellular approaches used to study the CNS at the level of single molecules, Synapse: Synaptic transmission, Types of synapses; synaptic function; Principles of chemical synaptic transmission; Principles of synaptic integration; EPSPs and IPSPs. Ion channels, Neural transmission,

**Unit 4: Neurotransmitters**

Different types of neurotransmitters- catecholamines, amino acidergic and peptidergic neurotransmitters; Transmitter gated channels; G-protein coupled receptors and effectors, neurotransmitter receptors; Ionotropic and metabotropic receptors.

**Unit 5: Neurobiology and Neuropharmacology of Behaviour**

The principles of signal transduction and information processing in the vertebrate central nervous system, and the relationship of functional properties of neural systems with perception and behavior; sensory systems, molecular basis of behavior including learning and memory. Molecular pathogenesis of pain and neurodegenerative diseases such as Parkinson's, Alzheimer's, psychological disorders, addiction, etc

**Practical (Credits: 2)**

- Dissection and study of *Drosophila* nervous system using GFP reporter.
- Observation and quantitation of *Drosophila* photoreceptor neurons in healthy and diseased condition.
- Nerve Cell preparation from the spinal cord.
- Study of neurons and/ or myelin by Nissl, Giemsa or Luxol Fast Blue staining.
- Study of olfaction in *Drosophila*.
- Study of novelty, anxiety and spatial learning in mice.

**Suggested Readings**

- Neuroscience: Exploring the brain by Mark F. Baer; Barry W. Connors. 2015.
- From Molecules to Networks: An Introduction to Cellular and Molecular Neuroscience by John H. Byrne, Ruth Heidelberg and M. Neal Waxham.
- Neuroscience-Eds. Dale Purves et al. (3rd Edn)-Sinauer Associates, Inc.-2004.
- Principles of Neural Science-4th Edn-Eds. Kandel, Schwartz and Jessell- McGrawHill Companies-2000.
- Nerve Cells and Animal Behaviour-2nd Edn-Peter J Simmons and David Young CUP-2003.
- Essential Psychopharmacology- Neuroscientific Basis and Practical Applications-2nd Edn.-Stephan M. Stahl-CUP-2000.
- Phantoms in the Brain - Vilayanur S. Ramachandran and Sandra Blakeslee-1998.
- The Human Brain Book - Rita Carter-2009

**C) Skill Enhancement Courses**

<b>BSZUGSE01</b>	<b>Apiculture</b>
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(Credits: 4)

**Unit 1: Biology of Bees**

History, Classification and Biology of Honey Bees. Social Organization of Bee Colony

**Unit 2: Rearing of Bees**

Artificial Bee rearing (Apiary), Beehives – Newton and Langstroth. Bee Pasturage; Selection of Bee Species for Apiculture; Bee Keeping Equipment; Methods of Extraction of Honey (Indigenous and Modern)

**Unit 3: Diseases and Enemies**

Bee Diseases and Enemies Control and Preventive measures

**Unit 4: Bee Economy**

Products of Apiculture Industry and its Uses (Honey, Bees Wax, Propolis), Pollenetc

**Unit 5: Entrepreneurship in Apiculture**

Bee Keeping Industry – Recent Efforts, Modern Methods in employing artificial; Beehives for cross pollination in horticultural gardens.

**Suggested Readings**

1. Prost, P. J. (1962). *Apiculture*. Oxford and IBH, New Delhi..
2. Bisht D.S., *Apiculture*, ICAR Publication.
3. Singh S., *Beekeeping in India*, Indian council of Agricultural Research, NewDelhi.

<b>BSZUGSE02</b>	<b>Medical Diagnostics</b>
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(Credits: 4)

**Unit 1: Introduction to Medical Diagnostics and its Importance****Unit 2: Diagnostics Methods Used for Analysis of Blood**

Blood composition, Preparation of blood smear and Differential Leucocyte Count (D.L.C) using Leishman's stain, Platelet count using haemocytometer, Erythrocyte. Sedimentary Rate (E.S.R), Packed Cell Volume (P.C.V.)

**Unit 3: Diagnostic Methods Used for Urine Analysis**

Urine Analysis: Physical characteristics; Abnormal constituents.

**Unit 4: Non-infectious Diseases**

Causes, types, symptoms, complications, diagnosis and prevention of Diabetes (Type I and Type II), Hypertension (Primary and secondary), Testing of blood glucose using Glucometer/Kit

**Unit 5: Infectious Diseases**

Causes, types, symptoms, diagnosis and prevention of Tuberculosis and Hepatitis

**Unit 6: Tumours**

Types (Benign/Malignant), Detection and metastasis; Medical imaging: X-Ray of Bone fracture, PET, MRI and CT Scan (using photographs).

**Suggested Readings**

1. Park, K. (2007), *Preventive and Social Medicine*, B.B. Publishers
2. Godkar P.B. and Godkar D.P. *Textbook of Medical Laboratory Technology*, II Edition, Bhalani Publishing House.
3. Cheesbrough M., *A Laboratory Manual for Rural Tropical Hospitals, A Basis for Training Courses*.
4. Guyton A.C. and Hall J.E. *Textbook of Medical Physiology*, Saunders.
5. Robbins and Cortan, *Pathologic Basis of Disease*, VIII Edition, Saunders.
6. Prakash, G. (2012), *Lab Manual on Blood Analysis and Medical Diagnostics*, S. Chand and Co. Ltd.



<b>BSZUGSE03</b>	<b>Sericulture</b>
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(Credits: 4)

**Unit 1: Introduction**

Sericulture: Definition, history and present status; Silk route Types of silkworms, Distribution and Races. Exotic and indigenous races; Mulberry and non-mulberry Sericulture

**Unit 2: Biology of Silkworm**

Life cycle of *Bombyxmori* Structure of silk gland and secretion of silk

**Unit 3: Rearing of Silkworms**

Selection of mulberry variety and establishment of mulberry garden Rearing house and rearing appliances; Disinfectants: Formalin, bleaching powder, Silkworm rearing technology: Early age and Late age rearing. Types of mountages; Spinning, harvesting and storage of cocoons

**Unit 4: Pests and Diseases**

Pests of silkworm: Uzi fly, dermestid beetles and vertebrates; Pathogenesis of silkworm diseases: Protozoan, viral, fungal and bacterial; Control and prevention of pests and diseases.

**Unit 5: Entrepreneurship in Sericulture**

Prospectus of Sericulture in India: Sericulture industry in different states, employment, potential in mulberry and non-mulberry sericulture. Visit to various sericulture centres.

**Suggested Readings**

1. Manual on Sericulture; Food and Agriculture Organisation, Rome 1976
2. Handbook of Practical Sericulture: S.R. Ullal and M.N. Narasimhanna CSB, Bangalore.
3. Silkworm Rearing and Disease of Silkworm, 1956, Ptd. By Director of Ptg., Stn.& Pub. Govt. Press, Bangalore
4. Appropriate Sericultural Techniques; Ed. M. S. Jolly, Director, CSR & TI, Mysore.
5. Handbook of Silkworm Rearing: Agriculture and Technical Manual-1, Fuzi Pub. Co. Ltd., Tokyo, Japan 1972.
6. Manual of Silkworm Egg Production; M. N. Narasimhanna, CSB, Bangalore 1988.
7. Silkworm Rearing; Wupang—Chun and Chen Da-Chung, Pub. By FAO, Rome 1988.



**D) Generic Electives to be Offered**

BSZUGGE01

Animal Diversity

Theory (Credits 4)**Unit 1. Protista**

General characters of Protozoa; Life cycle of Plasmodium

**Unit 2. Porifera**

General characters and canal system in Porifera

**Unit 3. Radiata**

General characters of Cnidarians and polymorphism

**Unit 4. Aceolomates**General characters of Helminthes; Life cycle of *Taeniasolium***Unit 5. Pseudocoelomates**

General characters of Nemethehelminthes; Parasitic adaptations

**Unit 6. Coelomate Protostomes**

General characters of Annelida; Metamerism.

**Unit 7. Arthropoda**

General characters. Social life in insects

**Unit 8. Mollusca**

General characters of mollusca; Pearl Formation

**Unit 9. Coelomate Deuterostomes**

General characters of Echinodermata, Water Vascular system in Starfish

**Unit 10. Protochordata**

Salient features

**Unit 11. Pisces**

Osmoregulation, Migration of Fishes

**Unit 12. Amphibia**

General characters, Adaptations for terrestrial life, Parental care in Amphibia.

**Unit 13.**

Amniotes; Origin of reptiles. Terrestrial adaptations in reptiles

**Unit 14. Aves:**

The origin of birds; Flight adaptations

**Unit 15. Mammalia**

Early evolution of mammals; Primates; Dentition in mammals

**Practical (Credits: 2)**

1. Study of following specimens:
  - a. **Non Chordates:** *Euglena, Noctiluca, Paramecium, Sycon, Physalia, Tubipora, Metridium, Taenia, Ascaris, Nereis, Aphrodite, Leech, Peripatus, Limulus, Hermitcrab, Daphnia, Millipede, Centipede, Beetle, Chiton, Dentalium, Octopus, Asterias, and Antedon.*
  - b. **Chordates:** *Balanoglossus, Amphioxus, Petromyzon, Pristis, Hippocampus, Labeo, Ichthyophis/Uraeotyphlus, Salamander, Rhacophorus Draco, Uromastix, Naja, Viper, model of Archaeopteryx, any three common birds-(Crow, duck, Owl), Squirrel and Bat.*
2. Study of following Permanent Slides:
  - a. Cross section of Sycon, Sea anemone and *Ascaris* (male and female). T. S. of Earthworm passing through pharynx, gizzard, and typhlosolar intestine. Bipinnaria and Pluteus larva
3. Temporary mounts of
  - a. Septal & pharyngeal nephridia of earthworm.

- b. Unstained mounts of Placoid, cycloid and ctenoid scales.
4. Dissections of
  - a. Digestive and nervous system of Cockroach.
  - b. Urinogenital system of Rat

**Suggested Readings**

1. Barnes, R.D. (1992). Invertebrate Zoology. Saunders College Pub. USA.
2. Ruppert, Fox and Barnes (2006) Invertebrate Zoology. A functional Evolutionary Approach 7th Edition, Thomson Books/Cole.
3. Campbell & Reece (2005). Biology, Pearson Education, (Singapore) Pvt. Ltd.
4. Kardong, K. V. (2002). Vertebrates Comparative Anatomy. Function and Evolution. TataMcGraw Hill Publishing Company. New Delhi.
5. Raven, P. H. and Johnson, G. B. (2004). Biology, 6th edition, Tata McGraw Hill Publications. New Delhi.

BSZUGGE02

Human Physiology

Theory (Credits 4)

**Unit 1: Digestion and Absorption of Food**

Structure and function of digestive glands; Digestion and absorption of carbohydrates, fats and proteins; Nervous and hormonal control of digestion (*in brief*)

**Unit 2: Functioning of Excitable Tissue (Nerve and Muscle)**

Structure of neuron, Propagation of nerve impulse (myelinated and non-myelinated nerve fibre); Structure of skeletal muscle, Mechanism of muscle contraction (Sliding filament theory), Neuromuscular junction

**Unit 3: Respiratory Physiology**

Ventilation, External and internal Respiration, Transport of oxygen and carbon dioxide in blood, Factors affecting transport of gases.

**Unit 4: Renal Physiology**

Functional anatomy of kidney, Mechanism and regulation of urine formation

**Unit 5: Cardiovascular Physiology**

Structure of heart, Coordination of heartbeat, Cardiac cycle, ECG

**Unit 6: Endocrine and Reproductive Physiology**

Structure and function of endocrine glands (pituitary, thyroid, parathyroid, pancreas, adrenal, ovaries, and testes), Brief account of spermatogenesis and oogenesis, Menstrual cycle

**Practical (Credits: 2)**

1. Preparation of temporary mounts: Neurons and Blood film.
2. Preparation of haemin and haemochromogen crystals.
3. Estimation of haemoglobin using Sahli's haemoglobinometer.
4. Examination of permanent histological sections of mammalian oesophagus, stomach, duodenum, rectum, lung, kidney, thyroid, pancreas, adrenal, testis, ovary.

**Suggested Readings**

1. Tortora, G.J. and Derrickson, B.H. (2009). *Principles of Anatomy and Physiology*, XII Edition, John Wiley and Sons, Inc.
2. Widmaier, E.P., Raff, H. and Strang, K.T. (2008). *Vander's Human Physiology*, XI Edition, McGraw Hill.
3. Guyton, A.C. and Hall, J.E. (2011). *Textbook of Medical Physiology*, XII Edition, Harcourt Asia Pvt. Ltd/ W.B. Saunders Company.
4. Marieb, E. (1998). *Human Anatomy and Physiology*, IV Edition, Addison-Wesley.
5. Kesar, S. and Vashisht, N. (2007). *Experimental Physiology*, Heritage Publishers.
6. Prakash, G. (2012). *Lab Manual on Blood Analysis and Medical Diagnostics*, S. Chand and Company Ltd.

BSZUGGE03

Insect Vectors and Diseases

Theory (Credits 4)**Unit 1: Introduction to Insects**

General Features of Insects, Morphological features, Head – Eyes, Types of antennae, Mouth parts w.r.t. feeding habits.

**Unit 2: Concept of Vectors**

Brief introduction of Carrier and Vectors (mechanical and biological vector), Reservoirs, Host-vector relationship, Vectorial capacity, Adaptations as vectors, Host Specificity

**Unit 3: Insects as Vectors**

Classification of insects up to orders, detailed features of orders with insects as vectors-Diptera, Siphonaptera, Siphunculata, Hemiptera

**Unit 4: Dipteran as Disease Vectors**

Dipterans as important insect vectors – Mosquitoes, Sand fly, Houseflies; Study of mosquito-borne diseases – Malaria, Dengue, Chikungunya, Viralencephalitis, Filariasis; Control of mosquitoes; Study of sand fly-borne diseases – Visceral Leishmaniasis, Cutaneous Leishmaniasis, Phlebotomus fever; Control of Sand fly; Study of house fly as important mechanical vector, Myiasis, Control of house fly.

**Unit 5: Siphonaptera as Disease Vectors**

Fleas as important insect vectors; Host-specificity, Study of Flea-borne diseases- Plague, Typhus fever; Control of fleas

**Unit 6: Siphunculata as Disease Vectors**

Human louse (Head, Body and Pubic louse) as important insect vectors; Study of louse-borne diseases –Typhus fever, Relapsing fever, Trench fever, Vagabond's disease, Phthiriasis; Control of human louse.

**Unit 7: Hemiptera as Disease Vectors**

Bugs as insect vectors; Blood-sucking bugs; Chagas disease, Bed bugs as mechanical vectors, Control and prevention measures.

**Practical (Credits: 2)**

1. Study of different kinds of mouth parts of insects
2. Study of following insect vectors through permanent slides/ photographs:  
*Aedes*, *Culex*, *Anopheles*, *Pediculus humanuscapitis*, *Pediculus humanuscorporis*, *Phthirus pubis*, *Xenopsyllacheopsis*, *Cimex lectularius*, *Phlebotomusargentipes*, *Musca domestica*, through permanent slides/photographs.
3. Study of different diseases transmitted by above insect vectors

*Submission of a project report on any one of the insect vectors and disease transmitted*

**Suggested Readings**

1. Imms, A.D. (1977). A General Text Book of Entomology. Chapman & Hall, UK
2. Chapman, R.F. (1998). The Insects: Structure and Function. IV Edition, CambridgeUniversity Press, UK.
3. Pedigo L.P. (2002). Entomology and Pest Management. Prentice Hall Publication
4. Mathews, G. (2011). Integrated Vector Management: Controlling Vectors of Malaria and Other Insect Vector Borne Diseases. Wiley-Blackwell



## **BSc Honours in Microbiology (CBCS)**

### **Preamble**

Ministry of Human Resource Development (HRD), Govt. of India, has already initiated the process for developing New Education Policy (NEP) in our country to bring out reforms in Indian education system. University Grants Commission (UGC) participates more actively in developing National Education Policy, its execution and promotion of higher education in our country. The UGC has already initiated several steps to bring equity, efficiency and academic excellence in National Higher Education System. The important ones include innovation and improvement in course- curricula, introduction of paradigm shift in learning and teaching pedagogy, examination and education system. The education plays enormously significant role in building of a nation. There are quite a large number of educational institutions, engaged in imparting education in our country. Majority of them have entered recently into semester system to match with international educational pattern. However, our present education system produces young minds lacking knowledge, confidence, values and skills. It could be because of complete lack of relationship between education, employment and skill development in conventional education system. The present alarming situation necessitates transformation and/or redesigning of education system, not only by introducing innovations but developing “learner-centric approach in the entire education delivery mechanism and globally followed evaluation system as well. Majority of Indian higher education institutions have been following marks or percentage-based evaluation system, which obstructs the flexibility for the students to study the subjects/ courses of their choice and their mobility to different institutions. There is need to allow the flexibility in education system, so that students depending upon their interests and aims can choose interdisciplinary, intra-disciplinary and skill-based courses. This can only be possible when choice based credit system (CBCS), an internationally acknowledged system, is adopted. The choice based credit system not only offers opportunities and avenues to learn core subjects but also exploring additional avenues of learning beyond the core subjects for holistic development of an individual. The CBCS will undoubtedly facilitate us bench mark our courses with best international academic practices. The CBCS has more advantages than disadvantages.

#### **Advantages of the choice based credit system:**

- Shift in focus from the teacher-centric to student-centric education.
- Student may undertake as many credits as they can cope with (without repeating all courses in a given semester if they fail in one/ more courses).
- CBCS allows students to choose inter-disciplinary, intra-disciplinary courses, skill oriented papers (even from other disciplines according to their learning needs, interests and aptitude) and more flexibility for students).
- CBCS makes education broad-based and at par with global standards. One can take credits by combining unique combinations. For example, Physics with Economics, Microbiology with Chemistry or Environment Science etc.
- CBCS offers flexibility for students to study at different times and at different institutions to complete one course (ease mobility of students). Credits earned at one institution can be transferred.

#### **Disadvantages:**

- Difficult to estimate the exact marks
- Workload of teachers may fluctuate
- Demand good infrastructure for dissemination of education

**CHOICE BASED CREDIT SYSTEM (CBCS):** The CBCS provides an opportunity for the students to choose courses from the prescribed courses comprising core, elective/minor or skill based courses. The courses can be evaluated following the grading system, which is considered to be better than the conventional marks system. Therefore, it is necessary to introduce uniform grading system in the entire higher education in India. This will benefit the students to move across institutions within India to begin with and across countries. The uniform grading system will also enable potential employers in assessing the performance of the candidates. In order to bring uniformity in evaluation system and computation of the Cumulative Grade Point Average (CGPA) based on student's performance in examinations, the UGC has formulated the guidelines to be followed. Present syllabus is strictly in accordance with guidelines prescribed by UGC.

**Department of Biological Sciences, Aliah University**

**Outline for B Sc (H) Microbiology [Choice Based Credit System]**

Type of Paper	Sub Category	Theory Papers	Practical Papers	Credits	Total Credits
<b>Core Course (CC)</b>	Core Course(CC)	14		4 each	56
	Core Course (CC)		14	2 each	28
<b>Elective Course (EC)</b>	Generic Elective (GE)	04		4 each	16
	Generic Elective (GE)		04	2 each	08
	Discipline Specific Elective (DS)	04		4 each	16
	Discipline Specific Elective (DS)		04	2 each	08
<b>Skill Enhancement Course (SE)</b>	Skill Enhancement Course (SE)	02		4 each	08
<b>Ability Enhancement (AE)</b>	Ability Enhancement Compulsory (AE)	02		4 each	08
<b>Aliah University Non-credit compulsory course</b>	Arabic and Islamic Studies (AU)	01		Non credit	0
<b>Total Credits</b>					<b>148</b>

**Detailed Course Outline**

Sem	Paper Code	Paper Name	Credits (T+P)
<b>I</b>	BSMUGCC01	Introduction to Microbiology and Microbial Diversity	4+2
	BSMUGCC02	Biochemistry	4+2
	BSMUGAE01	EVS	4
	CHMUGGE01	Chemistry	4+2
<b>Semester Total</b>			<b>22</b>
<b>II</b>	BSMUGCC03	Bacteriology	4+2
	BSMUGCC04	Virology	4+2
	BSMUGAE02	Communicative English	4
	CHMUGGE02	Chemistry	4+2
	ARBUGAU02	Arabic and Islamic Studies	0
<b>Semester Total</b>			<b>22</b>
<b>III</b>	BSMUGCC05	Microbial Physiology and Metabolism	4+2
	BSMUGCC06	Cell Biology	4+2
	BSMUGCC07	Microbial Genetics	4+2
	BSMUGSE01	Biofertilizers and Biopesticides	4
	BSBUGGE01	Plant Physiology	4+2
<b>Semester Total</b>			<b>28</b>
<b>IV</b>	BSMUGCC08	Molecular Biology	4+2
	BSMUGCC09	Environmental Microbiology	4+2
	BSMUGCC10	Food and Dairy Microbiology	4+2
	BSMUGSE02	Microbial Quality Control in Food/Pharma Industries	4
	BSZUGGE02	Human Physiology	4+2
<b>Semester Total</b>			<b>28</b>
<b>V</b>	BSMUGCC11	Immunology	4+2
	BSMUGCC12	Medical Microbiology	4+2
	BSMUGDS01	Bioinformatics	4+2
	BSMUGDS02	Microbes in Sustainable Agriculture and Development	4+2
<b>Semester Total</b>			<b>24</b>
<b>VI</b>	BSMUGCC13	Industrial Microbiology	4+2
	BSMUGCC14	Recombinant DNA Technology	4+2
	BSMUGDS03	Biostatistics & Biotechniques	4+2
	BSMUGDS04	Biosafety and Intellectual Property Rights	4+2
<b>Semester Total</b>			<b>24</b>
<b>Grand Total</b>			<b>148</b>

**List of Papers with Respective Codes****Core Papers**

S No	Paper Code	Paper Name
1	BSMUGCC01	Introduction to Microbiology and Microbial Diversity
2	BSMUGCC02	Biochemistry
3	BSMUGCC03	Bacteriology
4	BSMUGCC04	Virology
5	BSMUGCC05	Microbial Physiology and Metabolism
6	BSMUGCC06	Cell Biology
7	BSMUGCC07	Microbial Genetics
8	BSMUGCC08	Molecular Biology
9	BSMUGCC09	Environmental Microbiology
10	BSMUGCC10	Food and Dairy Microbiology
11	BSMUGCC11	Immunology
12	BSMUGCC12	Medical Microbiology
13	BSMUGCC13	Industrial Microbiology
14	BSMUGCC14	Recombinant DNA Technology

**List of Discipline Specific Electives**

S No	Code	Paper Name
1	BSMUGDS01	Bioinformatics
2	BSMUGDS02	Microbes in Sustainable Agriculture and Development
3	BSMUGDS03	Biostatistics & Biotechniques
4	BSMUGDS04	Biosafety and Intellectual Property Rights
5	BSMUGDS05	Inheritance Biology
6	BSMUGDS06	Advances in Microbiology

**List of Skill Enhancement Courses**

S No	Paper Code	Paper Name
1	BSMUGSE01	Biofertilizers and Biopesticides
2	BSMUGSE02	Microbial Quality Control in Food/Pharma Industries
3	BSMUGSE03	Food Fermentation Techniques

**Generic Electives to be Offered**

S No	Paper Code	Paper Name
1	BSMUGGE01	Introduction and Scope of Microbiology
2	BSMUGGE02	Microbial Metabolism
3	BSMUGGE03	Microbes in Environment

## Detailed Syllabus of Papers

### E) Core Papers

<b>BSMUGCC01</b>	<b>Introduction to Microbiology and Microbial Diversity</b>
	<u>Theory (Credits: 4)</u>

#### **Unit 1 History of Development and Scope of Microbiology**

Development of microbiology as a discipline; spontaneous generation vs. Biogenesis. Contributions of Anton von Leeuwenhoek, Louis Pasteur, Robert Koch, Joseph Lister, Alexander Fleming. Role of microorganisms in fermentation, Germ theory of disease, Development of various microbiological techniques and golden era of microbiology. Development of the field of soil microbiology: Contributions of Martinus W. Beijerinck, Sergei N. Winogradsky, Selman A. Waksman. Establishment of fields of medical microbiology and immunology through the work of Paul Ehrlich, Elie Metchnikoff, Edward Jenner. An overview of Scope of Microbiology

#### **Unit 2 Diversity of Microbial World**

##### **A. Systems of classification**

Binomial Nomenclature, Whittaker's five kingdom and Carl Woese's three domain classification systems and their utility. Difference between prokaryotic and eukaryotic microorganisms

##### **B. General characteristics of different groups:**

**Acellular** microorganisms (Viruses, Viroids, Prions); **Cellular** microorganisms (Bacteria, Algae, Fungi and Protozoa) with emphasis on distribution and occurrence, morphology, mode of reproduction and economic importance

**Algae:** General characteristics of algae including occurrence, thallus organization, algae cell ultra-structure, pigments, flagella, eyespot, food reserves and vegetative, asexual and sexual reproduction. Different types of life cycles in algae with suitable examples: Haplobiontic, Haplontic, Diplontic, Diplobiontic and Diplo-haplontic lifecycles. Applications of algae in agriculture, industry, environment and food

**Fungi:** General characteristics of fungi including habitat, distribution, nutritional requirements, fungal cell ultra-structure, thallus organization and aggregation, fungal wall structure and synthesis, asexual reproduction, sexual reproduction, heterokaryosis, heterothallism and parasexual mechanism. Economic importance of fungi with examples in agriculture, environment, Industry, medicine, food, biodeterioration and mycotoxins.

**Protozoa:** General characteristics with special reference to *Amoeba*, *Paramecium*, *Plasmodium*, *Leishmania* and *Giardia*.

#### **Practical (Credits: 2)**

1. Microbiology Good Laboratory Practices and Biosafety.
2. To study the principle and applications of important instruments (biological safety cabinets, autoclave, incubator, BOD incubator, hot air oven, light microscope, pH meter) used in the microbiology laboratory.
3. Preparation of culture media for bacterial cultivation.
4. Sterilization of medium using Autoclave and assessment for sterility.
5. Sterilization of glassware using Hot Air Oven and assessment for sterility.
6. Sterilization of heat sensitive material by membrane filtration and assessment for sterility
7. Demonstration of the presence of microflora in the environment by exposing nutrient agar plates to air.
8. Study of *Rhizopus*, *Penicillium*, *Aspergillus* using permanent mounts.
9. Study of Spirogyra and *Chlamydomonas*, *Volvox* using permanent mounts.
10. Study of the following protozoans using permanent mounts/photographs: *Amoeba*, *Entamoeba*, *Paramecium* and *Plasmodium*.

#### **Suggested Reading**

1. Tortora GJ, Funke BR and Case CL. (2008). Microbiology: An Introduction. 9th edition. Pearson Education
2. Madigan MT, Martinko JM, Dunlap PV and Clark DP. (2014). Brock Biology of Microorganisms. 14th edition. Pearson International Edition
3. Cappucino J and Sherman N. (2010). Microbiology: A Laboratory Manual. 9th edition. Pearson Education Limited
4. Wiley JM, Sherwood LM and Woolverton CJ. (2013) Prescott's Microbiology. 9th Edition. McGraw Hill International.
5. Atlas RM. (1997). Principles of Microbiology. 2nd edition. W.M.T. Brown Publishers.
6. Pelczar MJ, Chan ECS and Krieg NR. (1993). Microbiology. 5th edition. McGraw Hill Book Company.



BSMUGCC02

Fundamentals of Biochemistry

Theory (Credits: 4)

**Unit 1: Water and Buffer**

Physical properties of water, structure of water molecules, Ionization of water, Bronsted – Lowry concept of acid and bases, Concept of pH of weak acids and weak bases, Henderson-Hasselbalch equation, concept of buffer, strength of buffer, buffer value, important biological buffers (with the help of numerical problems). Forces involved in biomolecular interactions with examples: Van der Waals interactions, electrostatic interactions, hydrogen bond and hydrophobic interaction. Configuration versus conformation

**Unit 2: Stereochemistry**

General concepts on: Plane of symmetry, centre and axis of symmetry; Concepts of chirality; optical isomerism; geometrical isomerism; DL, RS nomenclature; Projection formula (Fischer & Howarth); Isomers: anomers, epimers; Stereochemistry of cyclohexane: idea of axial & equatorial bonds (related to chair form conformation).

**Unit 3: Carbohydrates**

Structure and Biological importance: Monosaccharides, Disaccharides, Polysaccharides and Glycoconjugates.

**Unit 4: Lipids**

Structure and Significance: Physiologically important saturated and unsaturated fatty acids, Tri-acylglycerols, Phospholipids, Glycolipids, Steroids

**Unit 5: Proteins**

Amino acids: Structure, Classification and General Properties of  $\alpha$ -amino acids; Physiological importance of essential and non-essential  $\alpha$ -amino acids; Proteins: Bonds stabilizing protein structure; Levels of organization in proteins; Denaturation; Introduction to simple and conjugate proteins.

**Unit 6: Nucleic Acids**

Structure: Purines and pyrimidines, Nucleosides, Nucleotides, Nucleic acids; Cot Curves: Base pairing, Denaturation and Renaturation of DNA. Types of DNA and RNA, Complementarity of DNA, Hypo-Hyperchromaticity of DNA

**Unit 7: Enzymes**

Nomenclature and classification; Cofactors; Specificity of enzyme action; Isozymes; Mechanism of enzyme action; Enzyme kinetics; Factors affecting rate of enzyme-catalyzed reactions; Derivation of Michaelis-Menten equation, Concept of  $K_m$  and  $V_{max}$ , Lineweaver-Burk plot; Multi-substrate reactions; Enzyme inhibition; Allosteric enzymes and their kinetics; Regulation of enzyme Action.

**Unit 8: Vitamins**

Classification and characteristics with suitable examples, sources and importance

**Practical (Credits: 2)**

1. Concept of molarity, normality, percentage, dilutions, pH and buffers, Preparation of buffers and Numerical problems to explain the concepts.
2. Qualitative tests of functional groups in carbohydrates, proteins and lipids.
3. Paper chromatography of amino acids.
4. Action of salivary amylase under optimum conditions.
5. Effect of pH, temperature and inhibitors on the action of salivary amylase.
6. Demonstration of proteins separation by SDS-PAGE.

**Suggested Readings**

1. Cox, M.M and Nelson, D.L. (2008). Lehninger's Principles of Biochemistry, V Edition, W.H. Freeman and Co., New York.
2. Berg, J.M., Tymoczko, J.L. and Stryer, L. (2007). Biochemistry, VI Edition, W.H. Freeman and Co., New York.
3. Murray, R.K., Bender, D.A., Botham, K.M., Kennelly, P.J., Rodwell, V.W. and Well, P.A. (2009). Harper's Illustrated Biochemistry, XXVIII Edition, International Edition, The McGraw- Hill Companies Inc.
4. Hames, B.D. and Hooper, N.M. (2000). Instant Notes in Biochemistry, II Edition, BIOS Scientific Publishers Ltd., U.K.
5. Watson, J.D., Baker, T.A., Bell, S.P., Gann, A., Levine, M. and Losick, R. (2008). Molecular Biology of the Gene, VI Edition, Cold Spring Harbor Lab Press, Pearson Pub.
6. Voet, D. and Voet J.G (2004) Biochemistry 3rd edition, John Wiley and Sons

<b>BSMUGCC03</b>	<b>Bacteriology</b>
<u>Theory (Credits: 4)</u>	

**Unit 1: Cell organization**

Cell size, shape and arrangement, glycocalyx, capsule, flagella, endoflagella, fimbriae and pili. Cell-wall: Composition and detailed structure of Gram-positive and Gram-negative cell walls, Archaeobacterial cell wall, Gram and acid fast staining mechanisms, lipopolysaccharide (LPS), sphaeroplasts, protoplasts, and L-forms. Effect of antibiotics and enzymes on the cell wall. Cell Membrane: Structure, function and chemical composition of bacterial and archaeal cell membranes. Cytoplasm: Ribosomes, mesosomes, inclusion bodies, nucleoid, chromosome and plasmids Endospore: Structure, formation, stages of sporulation.

**Unit 2: Bacteriological techniques**

Pure culture isolation: Streaking, serial dilution and plating methods; cultivation, maintenance and preservation/stocking of pure cultures; cultivation of anaerobic bacteria, and accessing non-culturable bacteria.

**Unit 3: Basics of Staining and Microscopy**

Classification/types of stains; Acidic and Basic dyes, Simple and differential staining, negative staining. Mordants and Chromophores; Principles of Light microscopy: brightfield and darkfield, Phase contrast microscopy.

**Unit 4: Nutrition, Media and Control of Microbial Growth**

Nutritional requirements in bacteria and nutritional categories; Culture media: components of media, natural and synthetic media, chemically defined media, complex media, selective, differential, indicator, enriched and enrichment media. Physical methods of microbial control: heat, low temperature, high pressure, filtration, desiccation, osmotic pressure, radiation. Chemical methods of microbial control: disinfectants, types and mode of action.

**Unit 5: Bacterial Systematics**

Aim and principles of classification, systematics and taxonomy, concept of species, taxa, strain; conventional, molecular and recent approaches to polyphasic bacterial taxonomy, evolutionary chronometers, rRNA oligonucleotide sequencing, signature sequences, and protein sequences. Differences between eubacteria and archaeobacteria

**Unit 6: Important archaeal and eubacterial groups**

**Archaeobacteria:** General characteristics, phylogenetic overview, genera belonging to Nanoarchaeota (*Nanoarchaeum*), Crenarchaeota (*Sulfolobus*, *Thermoproteus*) and Euryarchaeota [Methanogens (*Methanobacterium*, *Methanocaldococcus*), thermophiles (*Thermococcus*, *Pyrococcus*, *Thermoplasma*), and Halophiles (*Halobacterium*, *Halococcus*)]

**Eubacteria:** Morphology, metabolism, ecological significance and economic importance of Non-Proteobacterial and Proteobacterial classes of Gram negative bacteria; Low G+ C (Firmicutes) and High G+C (Actinobacteria) members of Gram positive bacteria; **and Cyanobacteria.**

**Practical (Credits: 2)**

1. Preparation of different media: synthetic media BG-11, Complex media-Nutrientagar, McConkey agar, EMB agar.
2. Simple staining
3. Negative staining
4. Gram's staining
5. Acid fast staining-permanent slide only.
6. Capsule staining
7. Endospore staining.
8. Isolation of pure cultures of bacteria by streaking method.
9. Preservation of bacterial cultures by various techniques.
10. Estimation of CFU count by spread plate method/pour plate method.
11. Motility by hanging drop method.

**Suggested Readings**

1. Atlas RM. (1997). Principles of Microbiology. 2nd edition. W.M.T. Brown Publishers.
2. Black JG. (2008). Microbiology: Principles and Explorations. 7th edition. Prentice Hall
3. Madigan MT, and Martinko JM. (2014). Brock Biology of Microorganisms. 14<sup>th</sup> edition. Parker J. Prentice Hall International, Inc.
4. Pelczar Jr MJ, Chan ECS, and Krieg NR. (2004). Microbiology. 5th edition Tata McGraw Hill.
5. Srivastava S and Srivastava PS. (2003). Understanding Bacteria. Kluwer Academic Publishers, Dordrecht
6. Stanier RY, Ingraham JL, Wheelis ML and Painter PR. (2005). General Microbiology. 5th edition McMillan.
7. Tortora GJ, Funke BR, and Case CL. (2008). Microbiology: An Introduction. 9<sup>th</sup> edition Pearson Education.

- Wiley JM, Sherwood LM, and Woolverton CJ. (2013). Prescott's Microbiology. 9<sup>th</sup> edition. McGraw Hill Higher Education.
- Cappucino J and Sherman N. (2010). Microbiology: A Laboratory Manual. 9th edition. Pearson Education Limited.

<b>BSMUGCC04</b>	<b>Virology</b>
Theory (Credits: 4)	

#### **Unit 1: Nature and Properties of Viruses**

Introduction: Discovery of viruses, nature and definition of viruses, general properties, concept of viroids, virusoids, satellite viruses and Prions. Theories of viral origin Structure of Viruses: Capsid symmetry, enveloped and non-enveloped viruses. Isolation, purification and cultivation of viruses. Viral taxonomy: Classification and nomenclature of different groups of viruses.

#### **Unit 2: Bacteriophages**

Diversity, classification, one step multiplication curve, lytic and lysogenic phages (lambda phage) concept of early and late proteins, regulation of transcription in lambda phage.

#### **Unit 3: Viral Transmission, Salient features of viral nucleic acids and Replication**

Modes of viral transmission: Persistent, non-persistent, vertical and horizontal. Salient features of viral Nucleic acid: Unusual bases (TMV, T4 phage), overlapping genes ( $\phi$ X174, Hepatitis B virus), alternate splicing (HIV), terminal redundancy (T4 phage), terminal cohesive ends (lambda phage), partial double stranded genomes (Hepatitis B), long terminal repeats (retrovirus), segmented (Influenza virus), and non-segmented genomes (picornavirus), capping and tailing (TMV). Viral multiplication and replication strategies: Interaction of viruses with cellular receptors and entry of viruses. Replication strategies of viruses as per Baltimore classification ( $\phi$ X174, Retroviridae, Vaccinia, Picorna), assembly, maturation and release of virions

#### **Unit 4: Viruses and Cancer**

Introduction to oncogenic viruses. Types of oncogenic DNA and RNA viruses: Concepts of oncogenes and proto-oncogenes.

#### **Unit 5: Prevention & control of viral diseases**

Antiviral compounds and their mode of action. Interferon and their mode of action. General principles of viral vaccination

#### **Unit 6: Applications of Virology**

Use of viral vectors in cloning and expression, Gene therapy and Phage display

#### **Practical (Credits: 2)**

- Study of the structure of important animal viruses (rhabdo, influenza, paramyxo hepatitis B and retroviruses) using electron micrographs.
- Study of the structure of important plant viruses (caulimo, Gemini, tobacco ring spot, cucumber mosaic and alpha-alpha mosaic viruses) using electron micrographs.
- Study of the structure of important bacterial viruses ( $\phi$ X174, T4,  $\lambda$ ) using electron micrograph.
- Isolation and enumeration of bacteriophages (PFU) from water/sewage sample using double agar layer technique.
- Studying isolation and propagation of animal viruses by chick embryo technique
- Study of cytopathic effects of viruses using photographs.
- Perform local lesion technique for assaying plant viruses.

#### ***Suggested Reading***

- Dimmock, NJ, Easton, AL, Leppard, KN (2007). Introduction to Modern Virology. 6th edition, Blackwell Publishing Ltd.
- Carter J and Saunders V (2007). Virology: Principles and Applications. John Wiley and Sons.
- Flint SJ, Enquist, LW, Krug, RM, Racaniello, VR, Skalka, AM (2004). Principles of Virology, Molecular biology, Pathogenesis and Control. 2nd edition. ASM press Washington DC.
- Levy JA, Conrat HF, Owens RA. (2000). Virology. 3rd edition. Prentice Hall publication, New Jersey.
- Wagner EK, Hewlett MJ. (2004). Basic Virology. 2nd edition. Blackwell Publishing.
- Mathews. (2004). Plant Virology. Hull R. Academic Press, New York.
- Nayudu MV. (2008). Plant Viruses. Tata McGrawHill, India.
- Bos L. (1999) Plant viruses-A text book of plant virology by. Backhuys Publishers.
- Versteeg J. (1985). A Color Atlas of Virology. Wolfe Medical Publication.

BSMUGCC05

Microbial Physiology and Metabolism

Theory (Credits: 4)

**Unit 1: Microbial Growth and Effect of Factors on Microbial Growth**

Asexual methods of reproduction, Definitions of growth, logarithmic representation of bacterial populations, phases of growth, calculation of generation time and specific growth rate, measurement of microbial growth, Batch culture, Continuous culture, synchronous growth, diauxic growth curve. Microbial growth in response to environment -Temperature (psychrophiles, mesophiles, thermophiles, extremophiles, thermodurics, psychrotrophs), pH (acidophiles, alkaliphiles), solute and water activity (halophiles, xerophiles, osmophilic), Oxygen (aerobic, anaerobic, microaerophilic, facultative aerobe, facultative anaerobe), barophilic. Microbial growth in response to nutrition and energy – Autotroph/Phototroph, heterotrophy, Chemolithoautotroph, Chemolithoheterotroph, Chemoheterotroph, photolithoautotroph, Photo-organoheterotroph

**Unit 2: Nutrient uptake and Transport**

Passive and facilitated diffusion; Primary and secondary active transport, concept of uniport, symport and antiport, Group translocation, Iron uptake.

**Unit 3: Chemoheterotrophic Metabolism - Aerobic Respiration**

Concept of aerobic respiration, anaerobic respiration and fermentation, Sugar degradation pathways i.e. EMP, ED, Pentose phosphate pathway, TCA cycle, Electron transport chain: components of respiratory chain, comparison of mitochondrial and bacterial ETC, electron transport phosphorylation, uncouplers and inhibitors

**Unit 4: Chemoheterotrophic Metabolism- Anaerobic respiration and fermentation**

Anaerobic respiration with special reference to dissimilatory nitrate reduction (Denitrification; nitrate/nitrite and nitrate/ammonia respiration; fermentative nitrate reduction), Fermentation - Alcohol fermentation and Pasteur effect; Lactate fermentation (homofermentative and heterofermentative pathways), concept of linear and branched fermentation pathways.

**Unit 5: Chemolithotrophic and Phototrophic Metabolism**

Introduction to aerobic and anaerobic chemolithotrophy with example. Hydrogen oxidation (definition and reaction) and methanogenesis (definition and reaction). Introduction to phototrophic metabolism - groups of phototrophic microorganisms, anoxygenic vs. oxygenic photosynthesis with reference to photosynthesis in green bacteria, purple bacteria and cyanobacteria.

**Unit 6 Nitrogen Metabolism - an overview**

Introduction to biological nitrogen fixation; Ammonia assimilation, Assimilatory nitrate reduction, dissimilatory nitrate reduction, denitrification

**Practical (Credits: 2)**

1. Study and plot the growth curve of *E. coli* by turbidometric and standard plate count methods.
2. Calculations of generation time and specific growthrate of bacteria from the graph plotted with the given data.
3. Effect of temperature on growth of *E. coli*
4. Effect of pH on growth of *E. coli*
5. Effect of carbon and nitrogen sources on growth of *E. coli*
6. Effect of salt on growth of *E. coli*
7. Demonstration of alcoholic fermentation
8. Demonstration of the thermal death time and decimal reduction time of *E. coli*.

**Suggested Readings**

1. Madigan MT, and Martinko JM (2014).Brock Biology of Microorganisms.14th edition.PrenticeHall International Inc.
2. Moat AG and Foster JW. (2002). Microbial Physiology.4th edition. John Wiley & Sons
3. Reddy SR and Reddy SM. (2005). Microbial Physiology. Scientific Publishers India
4. Gottschalk G. (1986). Bacterial Metabolism.2nd edition. Springer Verlag
5. Stanier RY, Ingrahm JI, Wheelis ML and Painter PR. (1987). General Microbiology. 5th edition, McMillan Press.
6. Willey JM, Sherwood LM, and Woolverton CJ. (2013). Prescott's Microbiology.9th edition. McGraw Hill Higher Education

<b>BSMUGCC06</b>	<b>Cell Biology</b>
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Theory (Credits: 4)

#### **Unit 1: Structure and organization of Cell**

Cell Organization – Eukaryotic (Plant and animal cells) and prokaryotic

Plasma membrane: Structure and transport across membranes: Active and Passive transport, Facilitated transport; Cell junctions: Tight junctions, Desmosomes, Gap junctions; Cell Wall: Eukaryotic cell wall, Extra cellular matrix and cell matrix interactions, Cell-Cell Interactions - adhesion junctions, tight junctions, gap junctions, and plasmodesmata (only structural aspects); Mitochondria, chloroplasts and peroxisomes; Cytoskeleton: Structure and organization of actin filaments, association of actin filaments with plasma membrane, cell surface protrusions, intermediate filaments, microtubules

#### **Unit 2: Nucleus**

Nuclear envelope, nuclear pore complex and nuclear lamina; Chromatin – Molecular organization, Nucleolus

#### **Unit 3: Protein Sorting and Transport**

Ribosomes, Endoplasmic Reticulum – Structure, targeting and insertion of proteins in the ER; Golgi Apparatus – Organization, protein glycosylation, protein sorting and export from Golgi Apparatus Lysosomes

#### **Unit 4 Cell Signalling**

Signalling molecules and their receptors

Function of cell surface receptors

Pathways of intra-cellular receptors – Cyclic AMP pathway

#### **Unit 5 Cell Cycle, Cell Death and Cell Renewal**

Eukaryotic cell cycle and its regulation, Mitosis and Meiosis

Cancer, causes and types, Programmed cell death, Stem cells, Embryonic stem cell, induced pluripotent stem cells

#### **Practical (Credits: 2)**

1. Study a representative plant and animal cell by microscopy.
2. Study of the structure of cell organelles through electron micrographs
3. Cytochemical staining of DNA – Feulgen
4. Demonstration of the presence of mitochondria in striated muscle cells/ cheek epithelial cell using vital stain Janus Green B
5. Study of polyploidy in Onion root tip by colchicine treatment.
6. Identification and study of cancer cells by photomicrographs.
7. Study of different stages of Mitosis.
8. Study of different stages of Meiosis.

#### ***Suggested Reading***

1. Hardin J, Bertoni G and Kleinsmith LJ. (2010). Becker's World of the Cell. 8th edition. Pearson.
2. Karp G. (2010) Cell and Molecular Biology: Concepts and Experiments. 6th edition. John Wiley & Sons. Inc.
3. De Robertis, EDP and De Robertis EMF. (2006). Cell and Molecular Biology. 8th edition. Lipincott Williams and Wilkins, Philadelphia.
4. Cooper, G.M. and Hausman, R.E. (2009). The Cell: A Molecular Approach. 5th Edition. ASM Press & Sunderland, Washington, D.C.; Sinauer Associates, MA.

<b>BSMUGCC07</b>	<b>Microbial Genetics</b>
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Theory (Credits: 4)

#### **Unit 1: Genome Organization and Mutations**

Genome organization: *E. coli*, *Saccharomyces*, *Tetrahymena*

Mutations and mutagenesis: Definition and types of Mutations; Physical and chemical mutagens; Molecular basis of mutations; Functional mutants (loss and gain of function mutants); Uses of mutations. Reversion and suppression: True revertants; Intra- and inter-genic suppression; Ames test; Mutator genes.

#### **Unit 2: Plasmids**

Types of plasmids – F plasmid, R Plasmids, colicinogenic plasmids, Ti plasmids, linear plasmids, yeast- 2 $\mu$ plasmid, Plasmid replication and partitioning, Host range, plasmid-incompatibility, plasmid amplification, Regulation of copy number, curing of plasmids.

**Unit 3: Mechanisms of Genetic Exchange**

Transformation - Discovery, mechanism of natural competence. Conjugation - Discovery, mechanism, Hfr and F' strains, Interrupted mating technique and time of entry mapping. Transduction - Generalized transduction, specialized transduction, LFT & HFT lysates, Mapping by recombination and co-transduction of markers

**Unit 4: Phage Genetics**

Features of T4 genetics, Genetic basis of lytic versus lysogenic switch of phage lambda

**Unit 5: Transposable elements**

Prokaryotic transposable elements – Insertion Sequences, composite and non-composite transposons, Replicative and Non replicative transposition, Mu transposon. Eukaryotic transposable elements - Yeast (Ty retrotransposon), Drosophila (P elements), Maize (Ac/Ds), Uses of transposons and transposition.

**Practical (Credits: 2)**

1. Preparation of Master and Replica Plates.
2. Study the effect of chemical (HNO<sub>2</sub>) and physical (UV) mutagens on bacterial cells.
3. Study survival curve of bacteria after exposure to ultraviolet (UV) light.
4. Isolation of Plasmid DNA from *E. coli*.
5. Study different conformations of plasmid DNA through Agarose gel electrophoresis.
6. Demonstration of Bacterial Conjugation.
7. Demonstration of bacterial transformation and transduction.
8. Demonstration of AMES test.

**Suggested Reading**

1. Klug WS, Cummings MR, Spencer, C, Palladino, M (2011). Concepts of Genetics, 10th Ed. Benjamin Cummings
2. Krebs J, Goldstein E, Kilpatrick S (2013). Lewin's Essential Genes, 3rd Ed., Jones and Bartlett Learning
3. Pierce BA (2011) Genetics: A Conceptual Approach, 4th Ed., Macmillan Higher Education Learning
4. Watson JD, Baker TA, Bell SP et al. (2008) Molecular Biology of the Gene, 6th Ed., Benjamin Cummings
5. Gardner EJ, Simmons MJ, Snustad DP (2008). Principles of Genetics. 8th Ed. Wiley-India.
6. Russell PJ. (2009). i Genetics- A Molecular Approach. 3rd Ed, Benjamin Cummings.
7. Sambrook J and Russell DW. (2001). Molecular Cloning: A Laboratory Manual. 4<sup>th</sup> Edition, Cold Spring Harbour Laboratory press.
8. Maloy SR, Cronan JE and Friefelder D (2004) Microbial Genetics 2nd EDITION., Jones and Barlett Publishers

BSMUGCC08	Molecular Biology
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**Theory (Credits: 4)****Unit 1: Nucleic acids: Carriers of genetic information**

Historical perspective; DNA as the carrier of genetic information (Griffith's, Hershey & Chase, Avery, McLeod & McCarty)

**Unit 2: The Structures of DNA and RNA**

DNA Structure: Miescher to Watson and Crick- historic perspective, DNA structure, Salient features of double helix, Types of DNA, Types of genetic material, denaturation and renaturation, cot curves; Organization of DNA- Prokaryotes, Viruses, Eukaryotes. RNA Structure\_Organelle DNA -- mitochondria and chloroplast DNA. The Nucleosome\_Chromatin structure- Euchromatin, Heterochromatin- Constitutive and Facultative heterochromatin.

**Unit 3: The replication of DNA**

Chemistry of DNA synthesis (Kornberg's discovery); General principles – bidirectional, semiconservative and semi discontinuous replication, RNA priming; Various models of DNA replication, including rolling circle,  $\theta$  (theta) mode of replication, replication of linear ds-DNA, replication of the 5' end of linear chromosome; Enzymes involved in DNA replication.

**Unit 4: Central dogma and genetic code**

Key experiments establishing-The Central Dogma (Adaptor hypothesis and discovery of mRNA template), Genetic code (deciphering & salient features)

**Unit 5: Transcription**

Transcription: Definition, difference from replication, promoter - concept and strength of promoter RNA Polymerase and the transcription unit; Transcription in Eukaryotes: RNA polymerases, general Transcription factors

**Unit 6: Processing and modification of RNA**

Split genes-concept of introns and exons, removal of introns, spliceosome machinery, splicing pathways, group I and group II intron splicing, alternative splicing eukaryotic mRNA processing (5' cap, 3' polyA tail); Ribozymes; RNA editing and mRNA transport.

**Unit 7: Translation**

Ribosome structure and assembly, mRNA; Charging of tRNA, aminoacyl tRNA synthetases; Various steps in protein synthesis, proteins involved in initiation, elongation and termination of polypeptides; Fidelity of translation; Inhibitors of protein synthesis; Post-translational modifications of proteins.

**Practical (Credits: 2)**

1. Preparation of LB medium and raising *E. Coli*.
2. Isolation of genomic DNA from *E. Coli*.
3. DNA isolation from cauliflower head.
4. DNA estimation by diphenylamine reagent/UV Spectrophotometry.
5. Study of DNA replication mechanisms through photographs (Rolling circle, Theta replication and semi-discontinuous replication).
6. Study of structures of prokaryotic RNA polymerase and eukaryotic RNA polymerase II through photographs.
7. Photographs establishing nucleic acid as genetic material (Messelson and Stahl's, Avery et al, Griffith's, Hershey & Chase's and Fraenkel & Conrat's experiments)
8. Study of the following through photographs: Assembly of Spliceosome machinery; Splicing mechanism in group I & group II introns; Ribozyme and Alternative splicing.

**Suggested Readings**

1. Watson J.D., Baker, T.A., Bell, S.P., Gann, A., Levine, M., Losick, R. (2007). Molecular Biology of the Gene, Pearson Benjamin Cummings, CSHL Press, New York, U.S.A. 6th edition.
2. Snustad, D.P. and Simmons, M.J. (2010). Principles of Genetics. John Wiley and Sons Inc., U.S.A. 5th edition.
3. Klug, W.S., Cummings, M.R., Spencer, C.A. (2009). Concepts of Genetics. Benjamin Cummings. U.S.A. 9th edition.
4. Russell, P. J. (2010). i-Genetics- A Molecular Approach. Benjamin Cummings, U.S.A. 3<sup>rd</sup> edition.
5. Griffiths, A.J.F., Wessler, S.R., Carroll, S.B., Doebley, J. (2010). Introduction to Genetic Analysis. W. H. Freeman and Co., U.S.A. 10th edition.

<b>BSMUGCC09</b>	<b>Environmental Microbiology</b>
<u>Theory (Credits: 4)</u>	

**Unit 1: Microorganisms and their Habitats**

Structure and function of ecosystems. Terrestrial Environment: Soil profile and soil microflora. Aquatic Environment: Microflora of fresh water and marine habitats. Atmosphere: Aeromicroflora and dispersal of microbes. Animal Environment: Microbes in/on human body (Microbiomics) & animal (ruminants) body. Extreme Habitats: Extremophiles: Microbes thriving at high & low temperatures, pH, high hydrostatic & osmotic pressures, salinity, & low nutrient levels. Microbial succession in decomposition of plant organic matter

**Unit 2: Microbial Interactions**

Microbe interactions: Mutualism, synergism, commensalism, competition, amensalism, parasitism, predation. Microbe-Plant interaction: Symbiotic and non-symbiotic interactions. Microbe-animal interaction: Microbes in ruminants, nematophagus fungi and symbiotic luminescent bacteria.

**Unit 3: Biogeochemical Cycling**

Carbon cycle: Microbial degradation of cellulose, hemicelluloses, lignin and chitin. Nitrogen cycle: Nitrogen fixation, ammonification, nitrification, denitrification and nitrate reduction. Phosphorus cycle: Phosphate immobilization and solubilisation. Sulphur cycle: Microbes involved in sulphur cycle. Other elemental cycles: Iron and manganese

**Unit 4: Waste Management**

Solid Waste management: Sources and types of solid waste, Methods of solid waste disposal (composting and sanitary landfill). Liquid waste management: Composition and strength of sewage (BOD and COD), Primary, Secondary (oxidation ponds, trickling filter, activated sludge process and septic tank) and tertiary sewage treatment.



**Unit 5: Microbial Bioremediation**

Principles and degradation of common pesticides, organic (hydrocarbons, oil spills) and inorganic (metals) matter, biosurfactants

**Unit 6 Water Potability**

Treatment and safety of drinking (potable) water, methods to detect potability of water samples: (a) standard qualitative procedure: presumptive test/MPN test, confirmed and completed tests for faecal coliforms (b) Membrane filter technique and (c) Presence/absence tests.

**Practical (Credits: 2)**

1. Analysis of soil - pH, moisture content, water holding capacity, percolation, capillary action.
2. Isolation of microbes (bacteria & fungi) from soil (28°C & 45°C).
3. Isolation of microbes (bacteria & fungi) from rhizosphere and rhizoplane.
4. Assessment of microbiological quality of water.
5. Determination of BOD of waste water sample.
6. Study the presence of microbial activity by detecting (qualitatively) enzymes (dehydrogenase, amylase, urease) in soil.
7. Isolation of Rhizobium from root nodules.

***Suggested Readings***

1. Atlas RM and Bartha R. (2000). Microbial Ecology: Fundamentals & Applications. 4th edition. Benjamin/Cummings Science Publishing, USA
2. Madigan MT, Martinko JM and Parker J. (2014). Brock Biology of Microorganisms. 14th edition. Pearson/Benjamin Cummings
3. Maier RM, Pepper IL and Gerba CP. (2009). Environmental Microbiology. 2nd edition, Academic Press
4. Okafor, N (2011). Environmental Microbiology of Aquatic & Waste systems. 1st edition, Springer, New York
5. Singh A, Kuhad, RC & Ward OP (2009). Advances in Applied Bioremediation. Volume 17, Springer-Verlag, Berlin Heidelberg
6. Coyne MS. (2001). Soil Microbiology: An Exploratory Approach. Delmar Thomson Learning.
7. Lynch JM & Hobbie JE. (1988). Microorganisms in Action: Concepts & Application in Microbial Ecology. Blackwell Scientific Publication, U.K.
8. Martin A. (1977). An Introduction to Soil Microbiology. 2<sup>nd</sup> edition. John Wiley & Sons Inc. New York & London.
9. Stolp H. (1988). Microbial Ecology: Organisms Habitats Activities. Cambridge University Press, Cambridge, England.
10. Subba Rao NS. (1999). Soil Microbiology. 4th edition. Oxford & IBH Publishing Co. New Delhi.
11. Willey JM, Sherwood LM, and Woolverton CJ. (2013). Prescott's Microbiology. 9th edition. McGraw Hill Higher Education.

<b>BSMUGCC10</b>	<b>Food and Dairy Microbiology</b>
<u>Theory (Credits: 4)</u>	

**Unit 1: Foods as a substrate for microorganisms**

Intrinsic and extrinsic factors that affect growth and survival of microbes in foods, natural flora and source of contamination of foods in general

**Unit 2: Microbial spoilage of various foods**

Principles, Spoilage of vegetables, fruits, meat, eggs, milk and butter, bread, canned Foods.

**Unit 3: Principles and methods of food preservation**

Principles, physical methods of food preservation: temperature (low, high, canning, and drying), irradiation, hydrostatic pressure, high voltage pulse, microwave processing and aseptic packaging, chemical methods of food preservation: salt, sugar, organic acids, SO<sub>2</sub>, nitrite and nitrates, ethylene oxide, antibiotics and bacteriocins.

**Unit 4: Fermented foods**

Dairy starter cultures, fermented dairy products: yogurt, acidophilus milk, kumiss, kefir, dahi and cheese, other fermented foods: dosa, sauerkraut, soy sauce and tampeh. Probiotics: Health benefits, types of microorganisms used, probiotic foods available in market.



**Unit 5: Food borne diseases (causative agents, foods involved, symptoms and preventive measures)**

Food intoxications: *Staphylococcus aureus*, *Clostridium botulinum* and mycotoxins; Food infections: *Bacillus cereus*, *Vibrio parahaemolyticus*, *Escherichia coli*, Salmonellosis, Shigellosis, *Yersinia enterocolitica*, *Listeria monocytogenes* and *Campylobacter jejuni*.

**Unit 6: Food sanitation and control**

HACCP, Indices of food sanitary quality and sanitizers.

**Unit 7: Cultural and rapid detection methods** of food borne pathogens in foods and introduction to predictive microbiology.

**Practical (Credits: 2)**

1. MBRT of milk samples and their standard plate count.
2. Alkaline phosphatase test to check the efficiency of pasteurization of milk.
3. Isolation of any food borne bacteria from food products.
4. Isolation of spoilage microorganisms from spoiled vegetables/fruits.
5. Isolation of spoilage microorganisms from bread.
6. Preparation of Yogurt/Dahi.

**Suggested Readings**

1. Adams MR and Moss MO. (1995). Food Microbiology. 4th edition, New Age International (P)Limited Publishers, New Delhi, India.
2. Banwart JM. (1987). Basic Food Microbiology. 1st edition. CBS Publishers and Distributors, Delhi, India.
3. Davidson PM and Brannen AL. (1993). Antimicrobials in Foods. Marcel Dekker, New York.
4. Dillion VM and Board RG. (1996). Natural Antimicrobial Systems and Food Preservation. CAB International, Wallingford, Oxon.
5. Frazier WC and Westhoff DC. (1992). Food Microbiology. 3rd edition. Tata McGraw-Hill Publishing Company Ltd, New Delhi, India.
6. Gould GW. (1995). New Methods of Food Preservation. Blackie Academic and Professional, London.
7. Jay JM, Loessner MJ and Golden DA. (2005). Modern Food Microbiology. 7<sup>th</sup> edition, CBS Publishers and Distributors, Delhi, India.
8. Lund BM, Baird Parker AC, and Gould GW. (2000). The Microbiological Safety and Quality of Foods. Vol.1-2, ASPEN Publication, Gaithersberg, MD.

BSMUGCC11

Immunology

Theory (Credits: 4)

**Unit 1: Overview of Immune System**

Historical perspective of Immunology, Early theories of Immunology, Cells and organs of the Immune system

**Unit 2: Innate and Adaptive Immunity**

Anatomical barriers, Inflammation, Cell and molecules involved in innate immunity, Adaptive immunity (Cell mediated and humoral), Passive: Artificial and natural Immunity, Active: Artificial and natural Immunity, Immune dysfunctions (brief account of autoimmunity with reference to Rheumatoid Arthritis and tolerance, AIDS).

**Unit 3: Antigens**

Antigenicity and immunogenicity, Immunogens, Adjuvants and haptens, Factors influencing immunogenicity, B and T-Cell epitopes

**Unit 4: Immunoglobulins**

Structure and functions of different classes of immunoglobulins, Antigen-antibody interactions (Precipitation, Agglutination), Immunoassays (Immunodiffusion, Immunoelectrophoresis, RIA, ELISA, immuno blotting, Immunofluorescence), Polyclonal sera, Hybridoma technology: Monoclonal antibodies in therapeutics and diagnosis.

**Unit 5: Major Histocompatibility Complex**

Structure and functions of MHC molecules. Endogenous and exogenous pathways of antigen processing and presentation

**Unit 6: Cytokines**

Properties and functions of cytokines, Therapeutics Cytokines

**Unit 7: Complement System**

Components and pathways of complement activation.

**Unit 8: Hypersensitivity**

Gell and Coombs' classification and brief description of various types of hypersensitivities

**Unit 9: Vaccines**

Various types of vaccines.

**Practical (Credits: 2)**

1. \*Demonstration of lymphoid organs.
2. Histological study of spleen, thymus and lymph nodes through slides/photographs.
3. Preparation of stained blood film to study various types of blood cells.
4. Agglutination assay.
5. ABO blood group determination.
6. Separate serum from the blood sample (demonstration).
7. \*Cell counting and viability test from splenocytes of farm bred animals/cell lines.
8. Demonstration of :ELISA, Dot blotting, Immunodiffusion by Ouchterlony method / Radial Immunodiffusion method. Immunoelectrophoresis.

*\*The experiments can be performed depending upon usage of animals in UGcourses.*

**Suggested Readings**

1. Abbas AK, Lichtman AH, Pillai S. (2007). Cellular and Molecular Immunology. 6th edition Saunders Publication, Philadelphia.
2. Delves P, Martin S, Burton D, Roitt IM. (2006). Roitt's Essential Immunology. 11th edition WileyBlackwell Scientific Publication, Oxford.
3. Goldsby RA, Kindt TJ, Osborne BA. (2007). Kuby's Immunology. 6th edition W.H. Freeman and Company, New York.
4. Murphy K, Travers P, Walport M. (2008). Janeway's Immunobiology. 7th edition Garland Science Publishers, New York.
5. Peakman M, and Vergani D. (2009). Basic and Clinical Immunology. 2nd edition Churchill Livingstone Publishers, Edinberg.
6. Richard C and Geiffrey S. (2009). Immunology. 6th edition. Wiley Blackwell Publication.
7. Fahim H. Khan (2012) The Elements of Immunology. Second Imp, Pearson Education Inc.

<b>BSMUGCC12</b>	<b>Medical Microbiology</b>
<u>Theory (Credits: 4)</u>	

**Unit 1: Normal microflora of the human body and host pathogen interaction**

Normal microflora of the human body: Importance of normal microflora, normal microflora of skin, throat, gastrointestinal tract, urogenital tract. Host pathogen interaction: Definitions - Infection, Invasion, Pathogen, Pathogenicity, Virulence. Toxigenicity, Carriers and their types, Opportunistic infections, Nosocomial infections. Transmission of infection, Pathophysiologic effects of LPS.

**Unit 2: Sample collection, transport and diagnosis**

Collection, transport and culturing of clinical samples, principles of different diagnostic tests (ELISA, Immunofluorescence, Agglutination based tests, Complement fixation, PCR, DNA probes).

**Unit 3: Bacterial diseases**

List of diseases of various organ systems and their causative agents. The following diseases in detail with Symptoms, mode of transmission, prophylaxis and control: Respiratory Diseases: *Streptococcus pyogenes*, *Haemophilus influenzae*, *Mycobacterium tuberculosis*; Gastrointestinal Diseases: *Escherichia coli*, *Salmonella typhi*, *Vibrio cholerae*, *Helicobacter pylori*. Others: *Staphylococcus aureus*, *Bacillus anthracis*, *Clostridium tetani*, *Treponema pallidum*, *Clostridium difficile*

**Unit 4: Viral diseases**

List of diseases of various organ systems and their causative agents. The following diseases in detail with Symptoms, mode of transmission, prophylaxis and control Polio, Herpes, Hepatitis, Rabies, Dengue, AIDS, Influenza with brief description of swine flu, Ebola, Chikungunya, Japanese Encephalitis.

**Unit 5: Protozoan diseases**

List of diseases of various organ systems and their causative agents. The following diseases in detail with Symptoms, mode of transmission, prophylaxis and control: Malaria, Kala-azar

**Unit 6: Fungal diseases**

Brief description of each of the following types of mycoses and one representative disease to be studied with respect to transmission, symptoms and prevention: Cutaneous mycoses: Tinea pedis (Athlete's foot); Systemic mycoses: Histoplasmosis; Opportunistic mycoses: Candidiasis

**Unit 7 Antimicrobial agents: General characteristics and mode of action**

Antibacterial agents: Five modes of action with one example each: Inhibitor of nucleic acid synthesis; Inhibitor of cell wall synthesis; Inhibitor of cell membrane function; Inhibitor of protein synthesis; Inhibitor of metabolism. Antifungal agents: Mechanism of action of Amphotericin B, Griseofulvin; Antiviral agents: Mechanism of action of Amantadine, Acyclovir, Azidothymidine; Antibiotic resistance, MDR, XDR, MRSA, NDM-1.

**Practical (Credits: 2)**

1. Identify bacteria (any three of *E. coli*, *Salmonella*, *Pseudomonas*, *Staphylococcus*, *Bacillus*) using laboratory strains on the basis of cultural, morphological and biochemical characteristics: IMViC, TSI, nitrate reduction, urease production and catalase tests.
2. Study of composition and use of important differential media for identification of bacteria: EMB Agar, McConkey agar, Mannitol salt agar, Deoxycholate citrate agar, TCBS.
3. Study of bacterial flora of skin by swab method.
4. Perform antibacterial sensitivity by Kirby-Bauer method.
5. Determination of minimal inhibitory concentration (MIC) of an antibiotic.
6. Study symptoms of the diseases with the help of photographs: Polio, anthrax, herpes, chicken pox, HPV warts, AIDS (candidiasis), dermatomycoses (ring worms).
7. Study of various stages of malarial parasite in RBCs using permanent mounts.

**Suggested Reading**

1. Ananthanarayan R. and Paniker C.K.J. (2009) Textbook of Microbiology. 8th edition, University Press Publication.
2. Brooks G.F., Carroll K.C., Butel J.S., Morse S.A. and Mietzner, T.A. (2013) Jawetz, Melnick and Adelberg's Medical Microbiology. 26th edition. McGraw Hill Publication.
3. Goering R., Dockrell H., Zuckerman M. and Wakelin D. (2007) Mims' Medical Microbiology. 4th edition. Elsevier.
4. Willey JM, Sherwood LM, and Woolverton CJ. (2013) Prescott, Harley and Klein's Microbiology. 9th edition. McGraw Hill Higher Education.
5. Madigan MT, Martinko JM, Dunlap PV and Clark DP. (2014). Brock Biology of Microorganisms. 14th edition. Pearson International Edition

BSMUGCC13	<b>Industrial Microbiology</b>
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**Theory (Credits: 4)****Unit 1: Introduction to industrial microbiology**

Brief history and developments in industrial microbiology

**Unit 2: Isolation of industrially important microbial strains and fermentation media**

Sources of industrially important microbes and methods for their isolation, preservation and maintenance of industrial strains, strain improvement, Crude and synthetic media; molasses, cornsteep liquor, sulphite waste liquor, whey, yeast extract and protein hydrolysates.

**Unit 3: Types of fermentation processes, bio-reactors and measurement of fermentation parameters**

Types of fermentation processes - Solid-state and liquid-state (stationary and submerged) fermentations; batch, fed-batch (eg. baker's yeast) and continuous fermentations; Components of a typical bio-reactor, Types of bioreactors-Laboratory, pilot- scale and production fermenters, constantly stirred tank and air-lift fermenters, Measurement and control of fermentation parameters - pH, temperature, dissolved oxygen, foaming and aeration.

**Unit 4: Down-stream processing**

Cell disruption, filtration, centrifugation, solvent extraction, precipitation, lyophilization and spray drying

**Unit 5: Microbial production of industrial products (micro-organisms involved, media, fermentation conditions, downstream processing and uses)**

Citric acid, ethanol, penicillin, glutamic acid, Vitamin B12; Enzymes (amylase, protease, lipase); Wine, beer

**Unit 6: Enzyme immobilization**

Methods of immobilization, advantages and applications of immobilization, large scale applications of immobilized enzymes (glucose isomerase and penicillin acylase)

**Practical (Credits: 2)**

1. Study different parts of fermenter
2. Microbial fermentations for the production and estimation (qualitative and quantitative) of:
  - a. Enzymes: Protease;
  - b. Amino acid: Glutamic acid;
  - c. Organic acid: Citric acid;
  - d. Alcohol: Ethanol
3. A visit to any educational institute/industry to see an industrial fermenter, and other downstream processing operations.

**Suggested Readings**

1. Patel A.H. (1996). Industrial Microbiology. 1st edition, Macmillan India Limited
2. Okafor N. (2007). Modern Industrial Microbiology and Biotechnology. 1st edition. Bios Scientific Publishers Limited. USA
3. Waites M.J., Morgan N.L., Rockey J.S. and Higton G. (2001). Industrial Microbiology: An Introduction. 1<sup>st</sup> edition. Wiley – Blackwell
4. Glaze A.N. and Nikaido H. (1995). Microbial Biotechnology: Fundamentals of Applied Microbiology. 1st edition. W.H. Freeman and Company
5. Casida LE. (1991). Industrial Microbiology. 1st edition. Wiley Eastern Limited.
6. Crueger W and Crueger A. (2000). Biotechnology: A textbook of Industrial Microbiology. 2<sup>nd</sup> edition. Panima Publishing Co. New Delhi.
7. Stanbury PF, Whitaker A and Hall SJ. (2006). Principles of Fermentation Technology. 2<sup>nd</sup> edition, Elsevier Science Ltd.

<b>BSMUGCC14</b>	<b>Recombinant DNA Technology</b>
<u>Theory (Credits: 4)</u>	

**Unit 1: Introduction to Genetic Engineering**

Milestones in genetic engineering and biotechnology

**Unit 2: Molecular Cloning- Tools and Strategies**

Cloning Tools; Restriction modification systems: Types I, II and III. Mode of action, nomenclature, applications of Type II restriction enzymes in genetic engineering. DNA modifying enzymes and their applications: DNA polymerases. Terminal deoxynucleotidyl transferase, kinases and phosphatases, and DNA ligases. Cloning Vectors: Definition and Properties; Plasmid vectors: pBR and pUC series; Bacteriophage lambda and M13 based vectors; Cosmids, BACs, YACs; Use of linkers and adaptors; Expression vectors: *E.coli* lac and T7 promoter-based vectors, yeast YIp, YE<sub>p</sub> and YC<sub>p</sub> vectors, Baculovirus based vectors, mammalian SV40-based expression vectors.

**Unit 3: Methods in Molecular Cloning**

Transformation of DNA: Chemical method, Electroporation; Gene delivery: Microinjection, electroporation, biolistic method (gene gun), liposome and viral mediated delivery, Agrobacterium - mediated delivery; DNA, RNA and Protein analysis: Agarose gel electrophoresis, Southern - and Northern - blotting techniques, dot blot, DNA microarray analysis, SDS-PAGE and Western blotting.

**Unit 4: DNA Amplification and DNA sequencing**

PCR: Basics of PCR, RT-PCR, Real-Time PCR; Sanger's method of DNA Sequencing: traditional and automated sequencing; Primer walking and shotgun sequencing;

**Unit 5: Construction and Screening of Genomic and cDNA libraries**

Genomic and cDNA libraries: Preparation and uses, Screening of libraries: Colony hybridization and colony PCR, Chromosome walking and chromosome jumping.

**Unit 6: Applications of Recombinant DNA Technology**

Products of recombinant DNA technology: Products of human therapeutic interest - insulin, hGH, antisense molecules. *Bt* transgenic - cotton, brinjal, Gene therapy, recombinant vaccines, protein engineering and site directed mutagenesis.

**Practical (Credits: 2)**

1. Preparation of competent cells for transformation
2. Demonstration of Bacterial Transformation and calculation of transformation efficiency.
3. Digestion of DNA using restriction enzymes and analysis by agarose gel electrophoresis

4. Ligation of DNA fragments
5. Cloning of DNA insert and Blue white screening of recombinants.
6. Interpretation of sequencing gel electropherograms
7. Designing of primers for DNA amplification
8. Amplification of DNA by PCR
9. Demonstration of Southern blotting

**Suggested Reading**

1. Brown TA. (2010). Gene Cloning and DNA Analysis. 6th edition. Blackwell Publishing, Oxford, U.K.
2. Primrose SB and Twyman RM. (2006). Principles of Gene Manipulation and Genomics, 7th edition. Blackwell Publishing, Oxford, U.K.
3. Sambrook J and Russell D. (2001). Molecular Cloning-A Laboratory Manual. 3rd edition. Cold Spring Harbor Laboratory Press.
4. Brown TA. (2007). Genomes-3. Garland Science Publishers

**F) Discipline Specific Electives**

<b>BSMUGDS01</b>	<b>Bioinformatics</b>
Theory (Credits: 4)	

**Unit 1: Introduction to Bioinformatics**

Introduction, Branches of Bioinformatics, Aim, Scope and Research areas of Bioinformatics.

**Unit 2: Databases**

Introduction, Biological Databases, Classification format of Biological Databases, Biological Database Retrieval System

**Unit 3: Biological Sequence Databases**

National Center for Biotechnology Information (NCBI): Tools and Databases of NCBI, Database Retrieval Tool, Sequence Submission to NCBI, Basic local alignment search tool (BLAST), Nucleotide Database, Protein Database, Gene Expression Database. EMBL Nucleotide Sequence Database (EMBL-Bank): Introduction, Sequence Retrieval, Sequence Submission to EMBL, Sequence analysis tools. DNA Data Bank of Japan (DDBJ): Introduction, Resources at DDBJ, Data Submission at DDBJ. Protein Information Resource (PIR): About PIR, Resources of PIR, Databases of PIR, Data Retrieval in PIR. Swiss-Prot: Introduction and Salient Features.

**Unit 4: Sequence Alignments**

Introduction, Concept of Alignment, Multiple Sequence Alignment (MSA), MSA by CLUSTALW, Scoring Matrices, Percent Accepted Mutation (PAM), Blocks of Amino Acid Substitution Matrix (BLOSUM)

**Unit 5: Molecular Phylogeny**

Methods of Phylogeny, Software for Phylogenetic Analyses, Consistency of Molecular Phylogenetic Prediction

**Unit 6: Applications of Bioinformatics**

Structural Bioinformatics in Drug Discovery, Quantitative structure-activity relationship (QSAR) techniques in Drug Design

**Practical (Credits: 2)**

1. Introduction to different operating systems - UNIX, LINUX and Windows
2. Introduction to bioinformatics databases (any three): NCBI/PDB/DDBJ/PDB
3. Sequence retrieval using BLAST
4. Sequence alignment & phylogenetic analysis using clustal W & phylip
5. Picking out a given gene from genomes using Genscan or other softwares (promoter region identification, repeat in genome, ORF prediction). Gene finding tools (Glimmer, GENSCAN), Primer designing, Genscan/Genetool
6. Protein structure prediction: primary structure analysis, secondary structure prediction using psipred, homology modeling using Swiss model. Molecular visualization using jmol, Protein structure model evaluation (PROCHECK)
7. Prediction of different features of a functional gene.

**Suggested Readings**

1. Bioinformatics: Sequence and Genome analysis, 2nd edition (2004), David W. Mount, Cold Spring Harbour Laboratory Press. ISBN-13: 978-0879697129.
2. Bioinformatics: A practical guide to the analysis of genes and proteins, 3rd edition (2004), Andreas D. Baxevanis and B.F. Francis Ouellette, John Wiley and Sons.
3. Introduction to Medicinal Chemistry, 4th edition (2009), Graham I. Patrick, Oxford University Press
4. The Process of New Drug Discovery and Development, 2nd edition (2006), C.G. Smith and J.T.O'Donnell, Informa Healthcare, ISBN-13: 978-0849327797.
5. Cheminformatics (2003), J. Gasteiger, Thomas Engel; Wiley-VCH. ISBN: 9783527618279.
6. Molecular modeling - Principles and Applications, 2nd edition (2003), A. R. Leach, Pearson Education Limited, UK. ISBN 13: 9780582382107.
7. Cheminformatics in Drug Discovery (2006), edited by. T.I. Opera; Wiley Publishers, ISBN: 9783527604203.
8. Goel D & Prashar S (2013). IPR, Biosafety and Bioethics. Pearson
9. Senthil Kumar Sadhasivam and Mohammed Jaabir, M. S. 2008. IPR, Biosafety and biotechnology Management. Jasen Publications, Tiruchirappalli, India.

<b>BSMUGDS02</b>	<b>Microbes in Sustainable Agriculture and Development</b>
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Theory (Credits: 4)

**Unit 1: Soil Microbiology**

Soil as Microbial Habitat, Soil profile and properties, Soil formation, Diversity and distribution of microorganisms in soil

**Unit 2: Mineralization of Organic & Inorganic Matter in Soil**

Mineralization of cellulose, hemicelluloses, lignocelluloses, lignin and humus, phosphate, nitrate, silica, potassium

**Unit 3: Microbial Activity in Soil and Green House Gases**

Carbon dioxide, methane, nitrous oxide, nitric oxide – production and control

**Unit 4: Microbial Control of Soil Borne Plant Pathogens**

Biocontrol mechanisms and ways, Microorganisms used as biocontrol agents against Microbial plant pathogens, Insects, Weeds

**Unit 5: Biofertilization, Phytostimulation, Bioinsecticides**

Plant growth promoting bacteria, biofertilizers – symbiotic (*Bradyrhizobium*, *Rhizobium*, *Frankia*), Non Symbiotic (*Azospirillum*, *Azotobacter*, Mycorrhizae, MHBs, Phosphate solubilizers, algae), Novel combination of microbes as biofertilizers, PGPRs

**Unit 6: Secondary Agriculture Biotechnology**

Biotech feed, Silage, Biomanure, biogas, biofuels – advantages and processing parameters

**Unit 7: GM crops**

Advantages, social and environmental aspects, Bt crops, golden rice, transgenics.

**Practical (Credits: 2)**

1. Study soil profile
2. Study microflora of different types of soils
3. *Rhizobium* as soil inoculants characteristics and field application
4. *Azotobacter* as soil inoculants characteristics and field application
5. Design and functioning of a biogas plant
6. Isolation of cellulose degrading organisms

***Suggested Readings***

1. Reddy, S.M. (2002). Bioinoculants for Sustainable Agriculture and Forestry, Sci Pub
2. Saleem F and Shakoori AR (2012) Development of Bioinsecticide, Lap Lambert Acad Pub

<b>BSMUGDS03</b>	<b>Biostatistics and Biotechniques</b>
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Theory (Credits: 4)

**Unit 1: Bioenergetics**

First and Second Laws of Thermodynamics; Definition of Gibb's Free Energy, Enthalpy, and Entropy; Mathematical Relationships Among Them; Standard Free Energy Change and Equilibrium Constant; Coupled Reactions And Additive Nature of Standard Free Energy Change; Energy Rich Compounds: Phosphoenolpyruvate, 1,3-Bisphosphoglycerate, Thioesters, ATP.

**Unit 2: Microscopy: Principles and applications**

Principles and applications of - Light microscopy: brightfield and darkfield, Phase contrast microscopy, Fluorescence Microscopy, Confocal Microscopy, Electron Microscopy (Scanning and Transmission Electron Microscopy); Micrometry.

**Unit 3. Electromagnetic radiation and Spectrophotometry**

*Basic principles of electromagnetic radiation:* Energy, wavelength, wave numbers and frequency, review of electronic structure of molecules.

*UV-visible spectrophotometry:* Beer Lambert law, light absorption and its transmittance, factors affecting absorption properties of a chromophore, Principle and use of study of absorption spectra of biomolecules; structural analyses of DNA/ protein using absorption of UV light. Colorimetry and turbidometry

*Fluorescence spectroscopy:* Theory of fluorescence, static and dynamic quenching, resonance energy transfer, fluorescent probes in the study of protein and nucleic acids.



*Mass spectrometry* (MALDI-TOF): Physical basis and uses of MS in the analysis of proteins/ nucleic acids.

#### **Unit 4: Radiation Biology**

Concept of radioisotopes, types of radioactive decay (gamma and beta emitter), half-life, detection and measurement of radioactivity: methods based upon ionization (GM counter), methods based upon excitation (scintillation counter). Autoradiography, radioisotopes in diagnosis and radiotherapy. Effect of radiations (ionizing and non-ionizing) on living systems, precautions and safety measures in handling radioisotopes.

#### **Unit 5: Chromatography**

Principles and applications of paper chromatography (including Descending and 2-D), Thin layer chromatography, Column chromatography: packing and fraction collection. Gel filtration chromatography, ion exchange chromatography and affinity chromatography; GLC, HPLC.

#### **Unit 6: Electrophoresis**

Principle and applications of native polyacrylamide gel electrophoresis, SDS polyacrylamide gel electrophoresis, Isoelectric focusing, 2D gel electrophoresis; Zymogram preparation; Principle and applications of Agarose gel electrophoresis.

#### **Unit 7: Hydrodynamic methods**

*Viscosity*: Methods of measurement of viscosity, specific and intrinsic viscosity, relationship between viscosity and molecular weight, measurement of viscoelasticity of DNA.

*Sedimentation*: Principle of centrifugation; Svedberg equation, RCF and sedimentation coefficient; relationship between RPM and RCF; differential and density gradient centrifugation, preparative and analytical ultracentrifugation techniques, fractionation of cellular components using centrifugation with examples.

*Flow Cytometry*: Basic principle of flow cytometry and cell sorting, detection strategies in flow cytometry.

#### **Unit 8: Biostatistics**

Introduction to biostatistics & its use. Basic idea on variables, frequency distribution and sampling. Measures of central tendency: mean, median, mode. Measures of distributions: variance, range, quartile deviation. Standard deviation and standard error - problems and application. Student's t-test and Chi square test- problems and application. Correlation and Regression.

#### **Practical (Credits: 2)**

1. Study of fluorescent micrographs to visualize bacterial cells.
2. Ray diagrams of phase contrast microscopy and Electron microscopy.
3. Study of structural changes of proteins at different pH/Temperature using UV spectrophotometry.
4. Determination of melting temperature of DNA.
5. Separation of mixtures by paper / thin layer chromatography.
6. Demonstration of column packing in any form of column chromatography.
7. Separation of protein mixtures by any form of chromatography.
8. Separation of protein mixtures by Polyacrylamide Gel Electrophoresis (PAGE).
9. Preparation of agarose gel and loading of sample.
10. Determination of  $\lambda_{max}$  for an unknown sample and calculation of extinction coefficient.
11. Study the effect of temperature on the viscosity of a macromolecule (Protein/DNA).
12. Separation of components of a given mixture using a laboratory scale centrifuge.

#### ***Suggested Readings***

1. Wilson K and Walker J. (2010). Principles and Techniques of Biochemistry and Molecular Biology. 7<sup>th</sup> Ed., Cambridge University Press.
2. David Freifelder (1982) Physical Biochemistry: Applications to Biochemistry and Molecular Biology, 2<sup>nd</sup> Ed., W.H. Freeman and Company.
3. Nelson DL and Cox MM. (2008). Lehninger Principles of Biochemistry, 5<sup>th</sup> Ed., W.H. Freeman and Company.
4. Willey MJ, Sherwood LM & Woolverton C J. (2013). Prescott, Harley and Klein's Microbiology. 9<sup>th</sup> Ed., McGrawHill.
5. Karp G. (2010) Cell and Molecular Biology: Concepts and Experiments. 6th edition. John Wiley & Sons. Inc.
6. De Robertis EDP and De Robertis EMF. (2006). Cell and Molecular Biology. 8th edition. Lipincott Williams and Wilkins, Philadelphia.
7. Nigam A and Ayyagari A. 2007. Lab Manual in Biochemistry, Immunology and Biotechnology. Tata McGraw Hill.
8. A. Edmondson and D. Druce: Advanced Biology Statistics, Oxford University Press; 1996.
9. W. Danial: Biostatistics: A foundation for Analysis in Health Sciences, John Wiley and Sons Inc; 2004.



<b>BSMUGDS04</b>	<b>Biosafety and Intellectual Property Rights</b>
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Theory (Credits: 4)

**Unit 1: Biosafety**

Introduction; biosafety issues in biotechnology; Biological Safety Cabinets & their types; Primary Containment for Biohazards; Biosafety Levels of Specific Microorganisms.

**Unit 2: Biosafety Guidelines**

Biosafety guidelines and regulations (National and International); GMOs/LMOs- Concerns and Challenges; Role of Institutional Biosafety Committees (IBSC), RCGM, GEAC etc. for GMO applications in food and agriculture; Environmental release of GMOs; Risk Analysis; Risk Assessment; Risk management and communication; Overview of International Agreements - Cartagena Protocol.

**Unit 3**

AERB/RSD/RES guidelines for using radioisotopes in laboratories and precautions

**Unit 4: Introduction to Intellectual Property**

Patents, Types, Trademarks, Copyright & Related Rights, Industrial Design and Rights, Traditional Knowledge, Geographical Indications- importance of IPR – patentable and non patentables – patenting life – legal protection of biotechnological inventions – World Intellectual Property Rights Organization (WIPO).

**Unit 5: Grant of Patent and Patenting Authorities**

Types of patent applications: Ordinary, PCT, Conventional, Divisional and Patent of Addition; An introduction to Patent Filing Procedures; Patent licensing and agreement; Patent infringement- meaning, scope, litigation, case studies, Rights and Duties of patent owner.

**Unit 6: Agreements and Treaties**

GATT, TRIPS Agreements; Role of Madrid Agreement; Hague Agreement; WIPO Treaties; Budapest Treaty on international recognition of the deposit of microorganisms; UPOV & Brene conventions; Patent Co-operation Treaty (PCT); Indian Patent Act 1970 & recent amendments.

**Practical (Credits: 2)**

1. Study of components and design of a BSL-III laboratory
2. Filing applications for approval from biosafety committee
3. Filing primary applications for patents
4. Study of steps of a patenting process
5. A case study

**Suggested Readings**

1. Bare Act, 2007. Indian Patent Act 1970 Acts & Rules, Universal Law Publishing Co. Pvt. Ltd., New Delhi.
2. Kankanala C (2007). Genetic Patent Law & Strategy, 1st Edition, Manupatra Information Solution Pvt. Ltd. New Delhi.
3. Mittal, D.P. (1999). Indian Patents Law, Taxmann, Allied Services (p) Ltd.
4. Singh K K (2015). Biotechnology and Intellectual Property Rights: Legal and Social Implications, Springer India.
5. Goel D & Prashar S (2013). IPR, Biosafety and Bioethics. Pearson
6. Senthil Kumar Sadhasivam and Mohammed Jaabir, M. S. 2008. IPR, Biosafety and biotechnology Management. Jasen Publications, Tiruchirappalli, India.

<b>BSMUGDS05</b>	<b>Inheritance Biology</b>
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Theory (Credits: 4)

**Unit 1: Introduction to Genetics**

Historical developments, Model organisms in genetic analyses and experimentation: *Escherichia coli*, *Saccharomyces cerevisiae*, *Neurospora crassa*, *Caenorhabditis elegans*, *Drosophila melanogaster*, *Arabidopsis thaliana*

**Unit 2: Mendelian Principles**

Mendel's Laws: Dominance, segregation, independent assortment, deviation from Mendelian inheritance, Rediscovery of Mendel's principles, Chromosome theory of inheritance: Allele, multiple alleles, pseudoallele, complementation tests, Extensions of Mendelian genetics: Allelic interactions, concept of dominance, recessiveness, Incomplete dominance and co-dominance, Multiple alleles, Epistasis, penetrance and expressivity

**Unit 3: Linkage and Crossing over**

Linkage and recombination of genes, Cytological basis of crossing over, Crossing over at four-strand stage, Molecular mechanism of crossing over, mapping

**Unit 4: Extra-Chromosomal Inheritance**

Rules of extra nuclear inheritance, Organelle heredity - Chloroplast mutations in *Chlamydomonas*, mitochondrial mutations in *Saccharomyces*, Maternal effects – Shell coiling in *Limnaea peregra* Infectious heredity - Kappa particles in *Paramecium*

**Unit 5: Characteristics of Chromosomes**

Structural organization of chromosomes - centromeres, telomeres and repetitive DNA, Packaging DNA molecules into chromosomes, Concept of euchromatin and heterochromatin, Normal and abnormal karyotypes of human chromosomes, Chromosome banding, Giant chromosomes: Polytene and lampbrush chromosomes, Variations in chromosome structure: Deletion, duplication, inversion and translocation, Variation in chromosomal number and structural abnormalities - Klinefelter syndrome, Turner syndrome, Down syndrome

**Unit 6: Recombination**

Homologous and non-homologous recombination, including transposition, site-specific recombination

**Unit 7: Human genetics**

Pedigree analysis, lod score for linkage testing, karyotypes, genetic disorders.

**Unit 8: Quantitative genetics**

Polygenic inheritance, heritability and its measurements, QTL mapping.

**Practical (Credits: 2)**

1. Mendelian deviations in dihybrid crosses
2. Studying Barr Body with the temporary mount of human cheek cells
3. Studying *Rhoeo* translocation with the help of photographs
4. Karyotyping with the help of photographs
5. Chi-Square Analysis
6. Study of polytene chromosomes using temporary mounts of salivary glands of *Chiromonas /Drosophila* larvae
7. Study of pedigree analysis
8. Analysis of a representative quantitative trait

**Suggested Reading**

1. Gardner EJ, Simmons MJ, Snustad DP (2008). Principles of Genetics. 8th Ed. Wiley-India
2. Snustad DP, Simmons MJ (2011). Principles of Genetics. 6th Ed. John Wiley and Sons Inc.
3. Weaver RF, Hedrick PW (1997). Genetics. 3rd Ed. McGraw-Hill Education
4. Klug WS, Cummings MR, Spencer CA, Palladino M (2012). Concepts of Genetics. 10th Ed. Benjamin Cummings
5. Griffith AJF, Wessler SR, Lewontin RC, Carroll SB. (2007). Introduction to Genetic Analysis. 9<sup>th</sup> Ed. W.H.Freeman and Co., New York
6. Hartl DL, Jones EW (2009). Genetics: Analysis of Genes and Genomes. 7th Ed, Jones and Bartlett Publishers
7. Russell PJ. (2009). *i* Genetics - A Molecular Approach. 3rd Ed, Benjamin Cummings

BSMUGDS06

Advances in Microbiology

Theory (Credits: 4)**Unit 1: Evolution of Microbial Genomes**

Salient features of sequenced microbial genomes, core genome pool, flexible genome pool and concept of pangenome, Horizontal gene transfer (HGT), Evolution of bacterial virulence – Genomic islands, Pathogenicity islands (PAI) and their characteristics

**Unit 2: Metagenomics**

Brief history and development of metagenomics, Understanding bacterial diversity using metagenomics approach, Prospecting genes of biotechnological importance using metagenomics; Basic knowledge of viral metagenome, metatranscriptomics, metaproteomics and metabolomics.

**Unit 3: Molecular Basis of Host-Microbe Interactions**

Epiphytic fitness and its mechanism in plant pathogens, Hypersensitive response (HR) to plant pathogens and its mechanism, Type three secretion systems (TTSS) of plant and animal pathogens, Biofilms: types of microorganisms, molecular aspects and significance in environment, health care, virulence and antimicrobial resistance

**Unit 4: Systems and Synthetic Biology**

Networking in biological systems, Quorum sensing in bacteria, Co-ordinated regulation of bacterial virulence factors, Basics of synthesis of poliovirus in laboratory, Future implications of synthetic biology with respect to bacteria and viruses

**Practical (Credits: 2)**

1. Extraction of metagenomic DNA from soil
2. Understand the impediments in extracting metagenomic DNA from soil
3. PCR amplification of metagenomic DNA using universal 16s ribosomal gene primers
4. Case study to understand how the poliovirus genome was synthesized in the laboratory
5. Case study to understand how networking of metabolic pathways in bacteria takes place

***Suggested Reading***

1. Fraser CM, Read TD and Nelson KE. Microbial Genomes, 2004, Humana Press
2. Sangdun C. Introduction to Systems Biology, 2007, Humana Press
3. Klipp E, Liebermeister W. Systems Biology – A Textbook, 2009, Wiley –VCH Verlag
4. Wilson BA, Salyers AA Whitt DD and Winkler ME (2011) Bacterial Pathogenesis- A molecular Approach, 3rd edition, ASM Press,
5. Bouarab K, Brisson and Daayf F (2009) Molecular Plant-Microbe interaction CAB International

**G) Skill Enhancement Courses**

<b>BSMUGSE01</b>	<b>Biofertilizers and Biopesticides</b>
<u>Theory (Credits: 4)</u>	

**Unit 1: Biofertilizers**

General account of the microbes used as biofertilizers for various crop plants and their advantages over chemical fertilizers. Symbiotic N<sub>2</sub> fixers: *Rhizobium* - Isolation, characteristics, types, inoculum production and field application, legume/pulses plants *Frankia* - Isolation, characteristics, Alder, Casurina plants, non-leguminous crop symbiosis. Cyanobacteria, *Azolla* - Isolation, characterization, mass multiplication, Role in rice cultivation, Crop response, field application.

**Unit 2: Non - Symbiotic Nitrogen Fixers**

Free living *Azospirillum*, *Azotobacter* - free isolation, characteristics, mass inoculum, production and field application

**Unit 3: Phosphate Solubilizers**

Phosphate solubilizing microbes - Isolation, characterization, mass inoculum production, field application

**Unit 4: Mycorrhizal Biofertilizers**

Importance of mycorrhizal inoculum, types of mycorrhizae and associated plants, Mass inoculum production of VAM, field applications of Ectomycorrhizae and VAM.

**Unit 5: Bioinsecticides**

General account of microbes used as bioinsecticides and their advantages over synthetic pesticides, *Bacillus thuringiensis*, production, Field applications, Viruses – cultivation and field applications.

**Suggested Readings**

1. Kannaiyan, S. (2003). Bioethnology of Biofertilizers, CHIPS, Texas.
2. Mahendra K. Rai (2005). Hand book of Microbial biofertilizers, The Haworth Press, Inc. New York.
3. Reddy, S.M. et. al. (2002). Bioinoculants for sustainable agriculture and forestry, Scientific Publishers.
4. Subba Rao N.S (1995) Soil microorganisms and plant growth Oxford and IBH publishing co. Pvt. Ltd. NewDelhi.
5. Saleem F and Shakoori AR (2012) Development of Bioinsecticide, Lap Lambert Academic Publishing GmbH KG
6. Aggarwal SK (2005) Advanced Environmental Biotechnology, APH publication.

<b>BSMUGSE02</b>	<b>Microbial Quality Control in Food/Pharma Industries</b>
<u>Theory (Credits: 4)</u>	

**Unit 1: Microbiological Laboratory and Safe Practices**

Good laboratory practices - Good laboratory practices, Good microbiological practices Biosafety cabinets – Working of biosafety cabinets, using protective clothing, specification for BSL- 1, BSL-2, BSL-3. Discarding biohazardous waste – Methodology of Disinfection, Autoclaving & Incineration

**Unit 2: Determining Microbes in Food / Pharmaceutical Samples**

Culture and microscopic methods - Standard plate count, Most probable numbers, Direct microscopic counts, Biochemical and immunological methods: Limulus lysate test for endotoxin, gel diffusion, sterility testing for pharmaceutical products Molecular methods - Nucleic acid probes, PCR based detection, biosensors.

**Unit 3: Pathogenic Microorganisms of Importance in Food & Water**

Enrichment culture technique, Detection of specific microorganisms - on XLD agar, Salmonella Shigella Agar, Manitol salt agar, EMB agar, McConkey Agar, Saboraud Agar Ascertaining microbial quality of milk by MBRT, Rapid detection methods of microbiological quality of milk at milk collection centres (COB, 10 min Resazurin assay)

**Unit 4: HACCP for Food Safety and Microbial Standards**

Hazard analysis of critical control point (HACCP) - Principles, flow diagrams, limitations; Microbial Standards for Different Foods and Water – BIS standards for common foods and drinking water

**Suggested Reading**

1. Harrigan WF (1998) Laboratory Methods in Food Microbiology, 3rd ed. Academic Press

2. Garg N, Garg KL and Mukerji KG (2010) Laboratory Manual of Food Microbiology I K International Publishing House Pvt. Ltd.
3. Jay JM, Loessner MJ, Golden DA (2005) Modern Food Microbiology, 7th edition. Springer
4. Baird RM, Hodges NA and Denyer SP (2005) Handbook of Microbiological Quality control in Pharmaceutical and Medical Devices, Taylor and Francis Inc.

<b>BSMUGSE03</b>	<b>Food Fermentation Techniques</b>
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Theory (Credits: 4)

**Unit 1: Fermented Foods**

Definition, types, advantages and health benefits

**Unit 2: Milk Based Fermented Foods**

Dahi, Yogurt, Buttermilk (Chach) and cheese: Preparation of inoculums, types of microorganisms and production process

**Unit 3: Grain Based Fermented Foods**

Soy sauce, Bread, Idli and Dosa: Microorganisms and production process

**Unit 4: Vegetable Based Fermented Foods**

Pickels, Saeurkraut: Microorganisms and production process

**Unit 5: Fermented Meat and Fish**

Types, microorganisms involved, fermentation process

**Unit 6: Probiotic Foods**

Definition, types, microorganisms and health benefits

**Suggested Readings**

1. Hui YH, Meunier-Goddik L, Josephsen J, Nip WK, Stanfield PS (2004) Handbook of food and fermentation technology, CRC Press
2. Holzapfel W (2014) Advances in Fermented Foods and Beverages, Woodhead Publishing.
3. Yadav JS, Grover, S and Batish VK (1993) A comprehensive dairy microbiology, Metropolitan
4. Jay JM, Loessner MJ, Golden DA (2005) Modern Food Microbiology, 7th edition. Springer

**H) Generic Electives to be Offered**

<b>BSMUGGE01</b>	<b>Introduction and Scope of Microbiology</b> <u>Theory (Credits: 4)</u>
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**Unit 1: History of Development of Microbiology**

Development of microbiology as a discipline, Spontaneous generation *vs.* biogenesis. Contributions of Anton von Leeuwenhoek, Louis Pasteur, Robert Koch, Joseph Lister, Alexander Fleming Role of microorganisms in fermentation, Germ theory of disease, Development of various microbiological techniques and golden era of microbiology, Development of the field of soil microbiology: Contributions of Martinus W. Beijerinck, Sergei N. Winogradsky, Selman A. Waksman Establishment of fields of medical microbiology and immunology through the work of Paul Ehrlich, Elie Metchnikoff, Edward Jenner

**Unit 2: Diversity of Microorganisms**

Systems of classification: Binomial nomenclature, Whittaker's five kingdom and Carl Woese's three kingdom classification systems and their utility; General characteristics of different groups: Acellular microorganisms (Viruses, Viroids, Prions) and Cellular microorganisms (Prokarya: Archaea and Bacteria, Eukarya: Algae, Fungi and Protozoa) giving definitions and citing examples Protozoa: Methods of nutrition, locomotion & reproduction - *Amoeba*, *Paramecium* and *Plasmodium*

**Unit 3: Microscopy**

Bright Field Microscope, Dark Field Microscope, Phase Contrast Microscope, Fluorescence Microscope, Transmission Electron Microscope, Scanning Electron Microscope

**Unit 4: Sterilization**

Moist Heat, Autoclave, Dry Heat, Hot Air Oven, Tyndallization, Filtration.

**Unit 5: Microbes in Human Health & Environment**

**Medical microbiology and immunology:** List of important human diseases and their causative agents of various human systems. Definitions of immunity (active/passive), primary and secondary immune response, antigen, antibody and their types

**Environmental microbiology:** Definitions and examples of important microbial interactions – mutualism, commensalism, parasitism, Definitions and microorganisms used as biopesticides, biofertilizers, in biodegradation, biodeterioration and bioremediation (*e.g.* hydrocarbons in oil spills)

**Unit 6: Industrial Microbiology**

Definition of fermentation, primary and secondary metabolites, types of fermentations and fermenters and microbes producing important industrial products through fermentation.

**Unit 7: Food and Dairy Microbiology**

Microorganisms as food (SCP), microorganisms in food fermentations (dairy and non dairy based fermented food products) and probiotics. Microorganisms in food spoilage and food borne infections

**Practical (Credits: 2)**

1. Microbiology Laboratory Management and Biosafety.
2. To study the principle and applications of important instruments (biological safety cabinets, autoclave, incubator, BOD incubator, hot air oven, light microscope, pH meter) used in the microbiology laboratory
3. Preparation of culture media for bacterial cultivation
4. Sterilization of medium using Autoclave and assessment for sterility
5. Sterilization of glassware using Hot Air Oven and assessment for sterility
6. Sterilization of heat sensitive material by filtration and assessment for sterility
7. Demonstration of presence of microflora in the environment by exposing nutrient agar plates to air.
8. Study of different shapes of bacteria using permanent slides
9. Study of *Rhizopus* and *Penicillium* using permanent mounts
10. Study of *Spirogyra* and *Chlamydomonas* using permanent Mounts
11. Study of the following protozoans using permanent mounts/photographs: *Amoeba*, *Entamoeba*, *Paramecium* and *Plasmodium*

**Suggested Reading**

1. Tortora GJ, Funke BR and Case CL. (2008). Microbiology: An Introduction. 9th edition. Pearson Education

2. Madigan MT, Martinko JM, Dunlap PV and Clark DP. (2014). Brock Biology of Microorganisms. 14th edition. Pearson International Edition
3. Wiley JM, Sherwood LM and Woolverton CJ. (2013) Prescott's Microbiology. 9th Edition. McGraw Hill International.
4. Atlas RM. (1997). Principles of Microbiology. 2nd edition. W.M.T. Brown Publishers.
5. Pelczar MJ, Chan ECS and Krieg NR. (1993). Microbiology. 5th edition. McGraw Hill Book Company.
6. Stanier RY, Ingraham JL, Wheelis ML, and Painter PR. (2005). General Microbiology. 5th edition. McMillan.

<b>BSMUGGE02</b>	<b>Microbial Metabolism</b>
<u>Theory (Credits: 4)</u>	

#### **Unit 1: Microbial Growth and Effect of Environment on Microbial Growth**

Definitions of growth, Batch culture, Continuous culture, generation time and specific growth rate Temperature and temperature ranges of growth; pH and pH ranges of growth; Effect of solute and water activity on growth; Effect of oxygen concentration on growth; Nutritional categories of microorganisms

#### **Unit 2: Nutrient uptake and Transport**

Passive and facilitated diffusion; Primary and secondary active transport, concept of uniport, symport and antiport; Group translocation; Iron uptake

#### **Unit 3: Chemoheterotrophic Metabolism - Aerobic Respiration**

Concept of aerobic respiration, anaerobic respiration and fermentation

Sugar degradation pathways i.e. EMP, ED, Pentose phosphate pathway; TCA cycle; Electron transport chain: components of respiratory chain, comparison of mitochondrial and bacterial ETC, electron transport phosphorylation, uncouplers and inhibitors

#### **Unit 4: Chemoheterotrophic Metabolism- Anaerobic respiration and fermentation**

Anaerobic respiration with special reference to dissimilatory nitrate reduction (Denitrification; nitrate/nitrite and nitrate/ammonia respiration; fermentative nitrate reduction); Fermentation - Alcohol fermentation and Pasteur effect; Lactate fermentation (homofermentative and heterofermentative pathways), concept of linear and branched fermentation pathways

#### **Unit 5: Chemolithotrophic and Phototrophic Metabolism**

Introduction to aerobic and anaerobic chemolithotrophy with an example each. Hydrogen oxidation (definition and reaction) and methanogenesis (definition and reaction); Introduction to phototrophic metabolism - groups of phototrophic microorganisms, anoxygenic *vs.* oxygenic photosynthesis with reference to photosynthesis in green bacteria and cyanobacteria

#### **Unit 6: Nitrogen Metabolism - an overview**

Introduction to biological nitrogen fixation; Ammonia assimilation; Assimilatory nitrate reduction

#### **Practical (Credits: 2)**

1. Study and plot the growth curve of *E. coli* by turbidimetric and standard plate count methods.
2. Calculations of generation time and specific growth rate of bacteria from the graph plotted with the given data
3. Effect of temperature on growth of *E. coli*
4. Effect of pH on growth of *E. coli*
5. Effect of Nitrogen and Carbon sources on *E. Coli*
6. Effect of salt on growth of *E. coli*
7. Demonstration of alcoholic fermentation
8. Demonstration of the thermal death time and decimal reduction time of *E. coli*.

#### **Suggested Readings**

1. Madigan MT, and Martinko JM (2014). Brock Biology of Microorganisms. 14th edition. Prentice Hall International Inc.
2. Moat AG and Foster JW. (2002). Microbial Physiology. 4th edition. John Wiley & Sons
3. Reddy SR and Reddy SM. (2005). Microbial Physiology. Scientific Publishers India
4. Gottschalk G. (1986). Bacterial Metabolism. 2nd edition. Springer Verlag
5. Willey JM, Sherwood LM, and Woolverton CJ. (2013). Prescott's Microbiology. 9th edition. McGraw Hill Higher Education.

<b>BSMUGGE03</b>	<b>Microbes in Environment</b>
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Theory (Credits: 4)

**Unit 1: Microorganisms and their Habitats**

Structure and function of ecosystems; Terrestrial Environment: Soil profile and soil microflora; Aquatic Environment: Microflora of fresh water and marine habitats; Atmosphere: Aeromicroflora and dispersal of microbes Animal Environment: Microbes in/on human body (Microbiomics) & animal (ruminants) body. Extreme Habitats: Extremophiles: Microbes thriving at high & low temperatures, pH, high hydrostatic & osmotic pressures, salinity, & low nutrient levels.

**Unit 2: Microbial Interactions**

Microbe interactions: Mutualism, synergism, commensalism, competition, amensalism, parasitism, predation; Microbe-Plant interaction: Symbiotic and non symbiotic interactions; Microbe-animal interaction: Microbes in ruminants, nematophagus fungi and symbiotic luminescent bacteria

**Unit 3: Biogeochemical Cycling**

Carbon cycle: Microbial degradation of cellulose, hemicelluloses, lignin and chitin; Nitrogen cycle: Nitrogen fixation, ammonification, nitrification, denitrification and nitrate reduction; Phosphorus cycle: Phosphate immobilization and solubilization; Sulphur cycle: Microbes involved in sulphur cycle; Other elemental cycles: Iron and manganese

**Unit 4: Waste Management**

Solid Waste management: Sources and types of solid waste, Methods of solid waste disposal (composting and sanitary landfill); Liquid waste management: Composition and strength of sewage (BOD and COD), Primary, secondary (oxidation ponds, trickling filter, activated sludge process and septic tank) and tertiary sewage treatment

**Unit 5: Microbial Bioremediation**

Principles and degradation of common pesticides, hydrocarbons (oil spills)

**Unit 6: Water Potability**

Treatment and safety of drinking (potable) water, methods to detect potability of water samples: (a) standard qualitative procedure: presumptive test/MPN test, confirmed and completed tests for faecal coliforms (b) Membrane filter technique and (c) Presence/absence tests

**Practical (Credits: 2)**

1. Analysis of soil - pH, moisture content, water holding capacity, percolation, capillary action.
2. Isolation of microbes (bacteria & fungi) from soil (28°C & 45°C).
3. Isolation of microbes (bacteria & fungi) from rhizosphere and rhizoplane.
4. Assessment of microbiological quality of water.
5. Determination of BOD of waste water sample.
6. Study the presence of microbial activity by detecting (qualitatively) enzymes (dehydrogenase, amylase, urease) in soil.
7. Isolation of *Rhizobium* from root nodules.

**Suggested Readings**

1. Atlas RM and Bartha R. (2000). Microbial Ecology: Fundamentals & Applications. 4th edition. Benjamin/Cummings Science Publishing, USA
2. Maier RM, Pepper IL and Gerba CP. (2009). Environmental Microbiology. 2nd edition, Academic Press
3. Okafor, N (2011). Environmental Microbiology of Aquatic & Waste systems. 1st edition, Springer, New York
4. Singh A, Kuhad, RC & Ward OP (2009). Advances in Applied Bioremediation. Volume 17, Springer-Verlag, Berlin Heidelberg
5. Barton LL & Northup DE (2011). Microbial Ecology. 1st edition, Wiley Blackwell, USA Campbell RE. (1983). Microbial Ecology. Blackwell Scientific Publication, Oxford, England.
6. Coyne MS. (2001). Soil Microbiology: An Exploratory Approach. Delmar Thomson Learning.
7. Lynch JM & Hobbie JE. (1988). Microorganisms in Action: Concepts & Application in Microbial Ecology. Blackwell Scientific Publication, U.K.
8. Stolp H. (1988). Microbial Ecology: Organisms Habitats Activities. Cambridge University Press, Cambridge, England.
9. Subba Rao NS. (1999). Soil Microbiology. 4th edition. Oxford & IBH Publishing Co. New Delhi.
10. Willey JM, Sherwood LM, and Woolverton CJ. (2013). Prescott's Microbiology. 9th edition. McGraw Hill Higher Education.