SARDAR PATEL UNIVERSITY
VALLABH VIDYANAGAR

Programme: MSC (CBCS)
Syllabus with effective from: 2018-19

BIOTECHNOLOGY
Semester IV

PS04CBIT21: Animal and Plant Biotechnology

Unit I : Animal Cell Culture

Brief history of animal cell culture; cell culture media and reagents; culture of mammalian cells, tissues and organs; primary culture, secondary culture, continuous cell lines, suspension cultures; application of animal cell culture for virus isolation and *in vitro* testing of drugs, testing of toxicity of environmental pollutants in cell culture, application of cell culture technology in production of human and animal viral vaccines and pharmaceutical proteins.

Unit II: Animal Reproductive Biotechnology and Vaccinology

Animal reproductive biotechnology: structure of sperms and ovum; cryopreservation of sperms and ova of livestock; artificial insemination; super ovulation, embryo recovery and *in vitro* fertilization; culture of embryos; cryopreservation of embryos; application of transgenic animal biotechnology; animal cloning- basic concept, cloning for conservation for conservation endangered species.
Vaccinology: history of development of vaccines, introduction to the concept of vaccines, conventional methods of animal vaccine production, recombinant approaches to vaccine production, modern vaccines.

Unit III: Plant Tissue Culture

Historical perspective; totipotency; Callus, In vitro Morphogenesis - organogenesis; somatic embryogenesis; establishment of cultures- callus culture, cell suspension culture, media preparation-nutrients and plant hormones; sterilization techniques; application of tissue culture- micropropagation; somaclonal variation; androgenesis; zygotic embryogenesis and its applications in genetics and plant breeding; germplasm conservation and cryopreservation; synthetic seed production; protoplast culture and somatic hybridization – protoplast isolation; culture and usage; somatic hybridization-methods and applications; cybrids and somatic cell genetics; plant cell cultures for secondary metabolite production.

Unit IV: Plant Genetic Manipulation

Genetic engineering: *Agrobacterium*-plant interaction; virulence; Ti and Ri plasmids; opines and their significance; T-DNA transfer; disarmed Ti plasmid; Genetic transformation – *Agrobacterium*-mediated gene delivery; cointegrate and binary vectors and their utility; direct gene transfer – PEG – mediated, electroporation, particle bombardment and alternative methods; screenable and selectable markers; characterization of transgenics; chloroplast transformation; marker-free methodologies; advanced methodologies- cisgenesis, intragenesis and genome editing; molecular pharming- concept of plants as biofactories, production of industrial enzymes and pharmaceutically important compounds.

References:

1. Slater,A., Scott,N. And Fowler,M.R. 2008. Plant Biotechnology: An introduction to Genetic Engineering. Oxford University Press.
2. Umesha,S. 2013. Plant Biotechnology: The energy and resources
3. Slater,A., Scott,N. And Fowler,M.R. 2003. Plant Biotechnology: The genetic manipulation of plants.
4. Razdan,M.K. 2003. Introduction to plant tissue culture. Enfield, NH. Science
5. Primrose, S.B and Twyman, R.M. 2006. Principles of gene manipulation and genomics. Malden, MA., Blackwell Publications.
6. Gordon,I. 2005. Reproductive techniques in farm animals. Oxford. CAB international
7. Levine, M.M. 1997. New Generation vaccines. New York. M.Dekker.
8. Portner, R. 2007. Animal Cell Biotechnology: Methods and protocols. Totowa. NJ. Humana Press.

PS04CBIT22: Environmental Biotechnology

Unit 1

Waste water treatment- Waste water characterization and its significance: COD, BOD, TOC, TOD, Inorganic constituents, solids, biological components.
Principles and aims of biological wastewater treatment processes: Primary, secondary and tertiary treatment of waste water.
Biochemistry and microbiology of inorganic phosphorus and nitrogen removal from waste water.
Suspended growth processes:
Activated sludge process: Biology of activated sludge, flocculation and sludge settling, problems of sludge settling, modified processes for inorganic nitrogen and phosphorous removal
Oxidation ditches and Waste stabilization ponds.
Fixed film processes: Biofilm formation and slaughing, Trickling filters, Rotating biological contactors, fluidized bed and submerged aerated filters.

Unit 2

Anaerobic digestion: microbiological and biochemical fundamentals, factors influencing anaerobic digestion.
Anaerobic waste water treatment systems: Upflow anaerobic sludge blanket , rotating biological contactors, anaerobic filters. Merits and demerits of anaerobic treatment of waste.
Composting: Objectives, fundamentals, microbiology, factors influencing composting and composting systems, Compost quality and uses, Vermicomposting.
Toxicity testing in waste water treatment plants using microorganisms:
Monitoring environmental processes with biosensors: BOD biosensor, Pesticide biosensor

Unit 3

Biodegradation of organic pollutants: Xenobiotic and recalcitrant organic compounds, mechanisms of biodegradation, factors affecting biodegradation, Acclimation phase in biodegradation. Biodegradation of simple aliphatic, aromatic, polycyclic aromatic hydrocarbons, halogenated hydrocarbons, azo dyes and lignin.
Bioremediation approaches: Intrinsic bioremediation, Biostimulation, Bioaugmentation: Use of genetically modified organisms.. *In situ* and *ex situ* bioremediation technologies with examples.
Bioremediation of heavy metal pollution, Phytoremediation.
Biological treatment of waste gas (polluted air): biofilters, bioscrubbers, membrane bioreactors, biotrickling filters.

Unit 4

Bioleaching of metals: Characteristics of commercially important microbes, mechanisms of bioleaching, factors affecting bioleaching and current biomining processes. Biobeneficiation of gold ores.
Biodesulfurization of coal: Removal of organic and inorganic sulfur from coal.
Microbially enhanced oil recovery.
Microbial Insecticides: Bacterial, fungal and viral insecticides in pest management.
Biofertilizers: applications of nitrogen fixing and phosphate solubilising/ mobilizing biofertilizers.

Reference Books:

- Comprehensive Biotechnology Vol-4, Murray Moo Young.
- Biotechnology-Rehm and Reid.
- Waste water microbiology by G. Bitton
- Biodegradation and bioremediation by M.Alexander
- Waste water treatment for pollution control, 2nd edition. Arceivala
- Environmental Biotechnology by H. Jordening and Josef Winter
- Handbook of water and waste water Microbiology by Horan
- Topic related review articles

PS04CBIT23: Lab I (Practicals based on PS04CBIT21 and PS04CBIT22)

PS04EBIT21: Lab II (Practicals based on PS04EBIT2X and PS04EBIT2X)

PS04EBIT22: Dissertation

PS04EBIT23: Microbial Physiology

Unit-I

Bacterial Cell Structure and its type, Bacterial Cell surfaces, Bacterial Cell wall structure function and synthesis, Membrane transport in bacteria-simple, group translocation, ABC transporters, Protein export in bacteria–Type 1,2,3,4, Protein export pathways.
Bacterial capsules structure and importance.
Bacterial organs for locomotion: Flagella: structure, synthesis, function and mechanism of locomotion, Swarming motility, Motility in spirochetes, Gliding motility, Twitching.
Chemotaxis: Molecular mechanism and physiological significance.
Two component signal transduction in prokaryotes

Unit-II

Bacterial differentiation: endospore formation, physiological and genetic aspects of sporulation, Sporulation inducing signals & events in sporulation
Bacterial cell division: molecular mechanisms involved in formation of Z-ring, Cell division machinery.
Yeast cell division: Growth and cell division coordination, Cell division events, molecular basis of cell cycle and control.
Microbial stress responses: Oxygen toxicity, pH, Heat shock, Osmotic pressure, Osmolarity regulation in *E.coli* (Omp system) Phosphate assimilation in *E.coli* (Pho system), Nitrogen fixation in *Klebsiella & Rhizobium* (Ntr system).
Metabolism in Autotrophs, Methylotrophs and Photoautotrophs

Unit-III

Bioluminescence: process, biochemistry, genetics and significance.
Mechanism of action of antibiotics and mechanisms of drug resistance.
Bacteriocins: Structure, Classification and physiological significance of it.
Microbial reserve compounds: Types, Synthesis and Applications
Siderophores; structure, function and significance
Bacterial biofilms formation steps, dispersion and control strategies

Unit-IV

Quorum sensing process in gram positive and gram negative bacteria.
Microbial fuel cells: Energy generation principle and application.
Microbial production of Hydrogen.
Host Parasite interactions: Structures and functions involved in Host-parasite interactions, Bacterial damages to host upon infection. Structure and Mechanism of Endotoxin, Exotoxin and Exoenzymes formed by bacteria.
The prokaryotic “immune system”, CRISPR/Cas

References:

- Bacterial signalling, Kramar and Jung
- Microbial Physiology, Moat, Foster and Spector
- The Physiology and Biochemistry of prokaryotes, David White
- Bacterial physiology: A molecular approach, W. E. Sharoud

Topic related review articles

PS04EBIT24: Food and Dairy Microbiology

Unit I:

Scope of food microbiology

Food as a substrate

a) Microorganisms important in food microbiology – Bacteria, yeasts and moulds.

b) Factors influencing microbial growth in food.

Food Spoilage

a) General principles underlying food spoilage and contamination.

b) Spoilage of canned food, sugar products, vegetables, fruits, meat and meat products, milk and milk products fish, seafood and poultry

Unit II:

Food poisoning

a) Indicator food borne pathogens

b) Bacterial food borne infections and intoxications-*Brucella, Campylobacter, Clostridium, Escherichia* (ETEC/EHEC/EPEC/EAEC), *Salmonella, Shigella, Listeria, Vibrio, and Yersinia.*

c) Non- bacterial food borne infections and intoxications- Nematodes, protozoa, algae, fungi, and viruses.

d) Culture and non-culture based detection of food pathogens and viruses

e) General methods for diagnosis of infections, intoxications and preventive measures.

Unit III:

Food preservation

Principles of food preservation – Physical and chemical preservation methods, Bio preservatives

Food fermentations

Starter cultures for fermented foods: Biochemical activities in fermentation of foods.

Oriental fermented foods: Shoyu, Temph, Kimchi etc

Fermented milk products: Yogurt, Kefir, Koumiss etc.

Fermented vegetables – Sauerkraut

Bread manufacture

Application of microbial enzymes in food industry

Unit IV:

Genetically modified foods. Biosensors in food

Food research organizations/institutes in India

Recent foodborne outbreaks

Food sanitation – Microbiology of food plant sanitation, water and milk testing

Food laws and quality control – HACCP, Codex alimentarius, PFA, FPO, MFPO, BIS, AGMARK.

Books recommended

1. Food Microbiology, Frazier and Westhoff
2. Food microbiology, Adam and Moss
3. Dairy Microbiology by Robinson. Volume II and I.
4. Fundamental Food Microbiology, Bibek Ray and ArunBhuniya

PS04EBIT25: IPR and Biosafety

UNIT-I

Biotechnology and society: Biotechnology and social responsibility, public acceptance issues in biotechnology, issues of access, ownership, monopoly, traditional knowledge, biodiversity, benefit sharing, environmental sustainability, public vs private funding. Social and ethical issues in biotechnology. Principles of bioethics. Ethical conflicts in biotechnology- interference with nature, unequal distribution of risk and benefits of biotechnology, bioethics vs business ethics.

UNIT-II

Bio- safety: Definition of bio-safety, Biotechnology and bio-safety concerns at the level of individuals, institutions, society, region, country and world.
Bio-safety in laboratory institution: laboratory associated infection and other hazards, assessment of biological hazards and level of biosafety.
Bio safety regulation: handling of recombinant DNA products and process in industry and in institutions.

UNIT-III

IPR I: Introduction to IPR: Forms of IPR and Intellectual property protection. Concept of property with respect to intellectual creativity, Tangible and Intangible property.
WTO: agency controlling trade among nations, WTO with reference to biotechnological affairs, TRIPs. WIPO, EPO.

UNIT-IV

IPR II: Concept related to patents novelty, non-obviousness, utility, anticipation, prior art etc. Type of patents. Indian patent act and foreign patents.
Patentability, Patent application, Revocation of patent, Infringement and Litigation with case studies on patent, Commercialization and Licensing.

References:

1. Fleming, D.A., Hunt, D.L., (2000). Biotechnology and Safety Assessment (3rd Ed) Academic press.ISBN-1555811804,9781555811808.
2. Thomas, J.A., Fuch, R.L. (1999). Biotechnology and safety assessment (3rd Ed). CRC press, Washington. ISBN: 1560327219, 9781560327219
3. Law and Strategy of biotechnological patents by Sibley. Butterworth publication.(2007) ISBN: 075069440, 9780750694445.
4. Intellectual property rights- Ganguli-Tat McGrawhill. (2001) ISBN-10: 0074638602,
5. Intellectual Property Right- Wattal- Oxford Publicatiopn House.(1997) ISBN:0195905024.
6. Biotechnology - A comprehensive treatise (Vol. 12). Legal economic and ethical dimensions VCH. (2nd ed) ISBN-10 3527304320.
7. Encyclopedia of Bioethics 5 vol set, (2003) ISBN-10: 0028657748.
8. Thomas, J.A., Fuch, R.L. (2002). Biotechnology and safety Assessment (3rd Ed) Academic press.
9. B.D. Singh. Biotechnology expanding horizons.
10. H.K.Das. Text book of biotechnology 3rd edition.

PS04EBIT26: Pharmacognosy

Unit-I

Plants as sources of drugs, pharmaceauticals and pharmaceutical aids.
Ethnomedicobotany: Basic approaches to study traditional knowledge on herbal medicine; Scope and potential applications.

Unit –II

Collection methods of ethnomedicobotanical data: Field methods and scrutiny of Herbarium specimens and folklore; verification of data; collection of materials for voucher specimen and for phytochemical screening; application of ethnomedicobotany.
Creating indigenous knowledge base of traditional medicines of plant origin.

Unit-III

Pharmacognosy of drugs derived from alkaloids, glycosides, volatile oils, lipids, gums, resins, tannins and saponins. Drugs of botanical origin: Structure, physical properties and chemistry of secondary metabolites: phenols, phenolic glycosides, saponins, steroids, alkaloids.

Unit-IV

Vitamins and hormones and natural antibiotics.
Biosynthesis of important secondary metabolites such as Glycosides, alkaloids, terpenes and phenols in plants.
Methods for screening natural sources for bioactive principles.

References Books:

Dennis, D. T., D. H. Turpin, D. D. Lefebvre and D. B. Layzell : Plant Metabolism. Addison Wesley Longman Ltd. England.
Doby, G. : Plant Biochemistry. Inter Science Publishers, New York
Dey, P. M. and J. B. Horborne: Plant Biochemistry. Academic Press, London.
Lehninger, A. L., D. L. Nelson and M. M. cox 2000: Principles of Biochemistry. CBS Publishers and Distributors, New Delhi.
Sadasivam, S. and A. Manickam : Biochemical Methods. 2nd edition. New Age International (P) Ltd. New Delh.
Voet, D., J. G. Voet and C. W. Pratt : Fundamentals of Biochemistry. John Wiley & sons, Inc. New York.
Zubay, G. : Biochemistry. Vol. 1 – 3. Wm. C. brown Publishers, Oxford, England
Chadwick,D.J. & Marsh, J.:Bioactive compounds from plants
Wiley Chichester, CIBA Foundation Symposium 185: Ethnobotany and the search for new drugs
J.B. Harborne: Phytochemical methods
J.C. Willis: Pharmacognosy
C.K. Kokate: Pharmacognosy
Trease, G.E and Evans, W.C.: Pharmacogonosy

PS04CBIT27: Endocrinology

UNIT I

General Principles of Endocrine Physiology:

- Endocrine, paracrine, and autocrine; Definition of hormone, target cell, and receptor.
- Mechanisms of action of peptides, steroids, and thyroid hormones; hormone actions exerted via plasma membrane receptors with those mediated via intracellular receptors.
- The role of hormone-binding proteins.
- The feedback control mechanisms of hormone secretion.
- The effects of secretion, degradation, and excretion on plasma hormone concentrations - the basis of hormone measurements and their interpretation.

The Hypothalamus and Posterior Pituitary Gland:

- The physiologic and anatomic relationships between the hypothalamus and the anterior and the posterior pituitary.
- The appropriate hypothalamic releasing and inhibitory factors controlling the secretion of each of the anterior pituitary hormones.
- Differences between the routes of transport of hypothalamic neuropeptides to the posterior and anterior pituitary.
- The mechanisms that control the release of oxytocin and ADH (arginine vasopressin, AVP); the cellular mechanisms of oxytocin and AVP action.

UNIT II

Thyroid Gland:

- The steps and control factors of thyroid hormone biosynthesis, storage, and release; the distribution of iodine and the metabolic pathway involved in thyroid hormone synthesis.
- Explain the importance of thyroid hormone binding in blood for free and total thyroid hormone levels.
- The significance of the conversion of tetraiodothyronine (T_4) to triiodothyronine (T_3) and reverse T_3 (rT_3) in extrathyroidal tissues.
- Cellular effects of thyroid hormones; their effects on development and metabolism; the causes and consequences of excess and deficiency of thyroid hormones.

Parathyroid Gland and Ca^{2+} and PO_4^- Regulation

- The origin, target organs and cell types, and physiologic effects of parathyroid hormone.
- The functions of osteoblasts and osteoclasts in bone remodeling and the factors that regulate their activities.
- The regulation of parathyroid hormone secretion and the role of the calcium-sensing receptor.
- The sources of vitamin D and the biosynthetic pathway involved in modifying it to its biologically active form and cellular mechanisms of action of vitamin D.
- The negative feedback relationship between parathyroid hormone and the biologically active form of vitamin D.
- The causes and consequences of excess or deficiency of parathyroid hormone and of vitamin D.
- The regulation of calcitonin release and the cell of origin and target organs for calcitonin action.

UNIT III

Adrenal Gland :

- The functional anatomy and zones of the adrenal glands and the principal hormones secreted from each zone.

- The regulation of synthesis and release of the adrenal steroid hormones (glucocorticoids, mineralocorticoids, and androgens) and the consequences of abnormalities in their biosynthetic pathways.
- The cellular mechanism of action of adrenal cortical hormones and their major physiologic actions, particularly during injury and stress.
- The regulation of mineralocorticoid secretion and relate this to the regulation of sodium and potassium excretion.
- The causes and consequences of oversecretion and undersecretion of glucocorticoids, mineralocorticoids, and adrenal androgens.
- The chemical nature of catecholamines and their biosynthesis and metabolic fate.
- The biologic consequences of sympatho-adrenal medulla activation and identify the target organs or tissues for catecholamine effects along with the receptor types that mediate their actions.
- The interactions of adrenal medullary and cortical hormones in response to stress.
- Diseases caused by oversecretion of adrenal catecholamines.

Endocrine Pancreas :

- The principal hormones secreted from the endocrine pancreas, their cells of origin, and their chemical nature.
- Understand the nutrient, neural, and hormonal mechanisms that regulate pancreatic hormone release.
- Insulin and glucagon action and their major physiologic effects;; The disease states caused by oversecretion, undersecretion, or decreased sensitivity to insulin.

UNIT IV

<u>Reproductive Endocrinology:</u>

Male Reproductive System:

- The physiologic functions of the principal components of the male reproductive system.
- The endocrine regulation of testicular function by gonadotropin-releasing hormone, follicle-stimulating hormone, luteinizing hormone, testosterone, and inhibin.
- The cell of origin for testosterone, its biosynthesis, mechanism of transport within the blood, metabolism, and clearance. List other physiologically produced androgens.
- List of the target organs or cell types, the cellular mechanisms of action, and the physiologic effects of testosterone.
- Spermatogenesis and the role of different cell types in this process; the neural, vascular, and endocrine factors involved in the erection and ejaculation response.
- The causes and consequences of androgen oversecretion and undersecretion in prepubertal and postpubescent adult males.

Female Reproductive System:

- Oogenesis, its relationship to follicular maturation, and the roles of pituitary and ovarian factors in their regulation.
- Gonadotropin control of ovarian function.
- The target organs and principal physiologic actions of estrogen and progesterone and how they interact with each other.
- The cellular mechanisms of action for estrogen and progesterone.
- The menstrual cycle.
- The pathways of sperm and egg transport required for fertilization and for movement of the embryo to the uterus.

- The principal endocrine functions of the placenta, particularly in rescue of the corpus luteum and maintenance of pregnancy, and the fetal adrenal-placental interactions involved in estrogen production.
- The roles of oxytocin, relaxin, and prostaglandins in the initiation and maintenance of parturition.
- The hormonal regulation of mammary gland development during puberty, pregnancy, and lactation, and explain the mechanisms
- Control of milk production and secretion.
- The physiologic basis for the effects of steroid hormone contraceptive methods.
- The age-related changes in the female reproductive system, including the mechanisms responsible for these changes, throughout life from fetal development to senescence.

Basic Text and Reference Books:

6. Molina P.A. (2013). ***Endocrine Physiology*** (4^{th}Edn). Mcgraw Hill Lange
7. Bolander, F(2004) **Molecular Endocrinology** Third Edition. Academic press. SanDiego.
8. Holt, E.H. and Peery, H., (2010) **Basic medical endocrinology**. Academic Press.
9. Gard, P. R. (2002). ***Human endocrinology***. CRC Press.