D.Y. PATIL EDUCATION SOCIETY
[Deemed to be University], Kolhapur
Re-accredited by NAAC with 'A' Grade

Centre for Interdisciplinary Research (CIR)

Department of Stem Cell & Regerative Medicine and Medical Biotechnology

Syllabus For

M.Sc. Stem Cell & Regenerative Medicine

Choice Based Credit System

D. Y. PATIL EDUCATION SOCIETY, KOLHAPUR

(DEEMED TO BE UNIVERSITY)

Centre for Interdisciplinary Research (CIR)

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Year of Implementation : 2022-23
Year of Examination : 2023-24

BL-SC-01: Introduction

Department of Stem cell and Regenerative Medicine offer a specialized course on M.Sc in Stem cell and Regenerative Medicine since 2011 for the aspiring candidates who are interested in the field of stem cell and regenerative medicine. The course covers basic and applied science covering various aspects of cell, molecular and developmental biology with special emphasis on stem cell biology from its origins to its current and potential application in pre-clinical and clinical fields related to various disorders.

BL-SC-02: Vision, Mission and Goal

Vision

To cultivate a broad range of interdisciplinary stem cell research (i.e., basic and translational stem cell biology research) To train future leaders for education, research and delivery of novel therapies using stem cells. To serve as a best teaching and educational centre for stem cell biology and regenerative medicine. Develop experimental models for use of stem cells to alter physiological and developmental characteristics of tissues and organ systems involved in disease processes. To seek a leadership role in basic and translational stem cell research through developing innovative, multidisciplinary collaborative approaches. Outcome Extensive theoretical and practical knowledge on Stem cells and Regenerative medicine in a short period of time Wide Job opportunities in industries, companies, Universities and other laboratories Increases the opportunities to pursue higher studies in foreign countries. The course prepares students for leadership in the critically important and dynamic industries of stem cells, biotechnology and pharmaceuticals.

Mission

The mission of the course is to impart in-depth knowledge on different types of stem cells and its in-vitro and in-vivo applications, scope and hope of stem cells and so on effectively. To advance the fundamental knowledge of stem cells and their differentiation pathways, understand how stem cells interact with tissues and organ systems of the body, and develop stem cell-based research and therapies to treat human diseases and injuries. To develop an Interdisciplinary course works with a strong base for success in life.

Goal

They can go as lecturers/Asst professors in colleges of biotechnology, pharmacology, microbiology, and other biomedical sciences. They could get a vast idea about the research and development in this field, planning for their future research. They could get jobs in research centers and hospitals where stem cell clinical trials are on.

SEMESTER-I

Theory Papers	University Exam marks	Internal marks	Total marks	Credits
(Paper 1) SCRM.1.1.1 Biochemistry	80	20	100	4
(Paper 2) SCRM.1.1.2 Cell Biology and Developmental Biology	80	20	100	4
(Paper 3) SCRM.1.1.3 Genetics and Molecular Biology	80	20	100	4
(Paper 4) SCRM.1.1.4 Immunology and Virology	80	20	100	4
Practical				
(Practical 1) SCRM.1.1.P.1 Biochemistry	40	-	40	8
(Practical 2) SCRM.1.1.P.2 Genetics and Molecular Biology	40	-	40	
(Practical 3) SCRM.1.1.P.3 Cell Biology and Developmental Biology	40	-	40	
(Practical 4) SCRM.1.1.P.4 Immunology and Virology	40	-	40	
(Practical 5) SCRM.1.1.P.5 Industry visit and report	40	-	40	
Total	**520**	**80**	**600**	**24**

SEMESTER-II

Theory Papers	University Exam marks	Internal marks	Total marks	Credits
(Paper 5) SCRM.1.2.1 Metabolism and Clinical Biochemistry	80	20	100	4
(Paper 6) SCRM.1.2.2 Biostatistics and Bioinformatics	80	20	100	4
(Paper 7) SCRM.1.2.3 Biomedical Instrumentation and Nanobiotechnology	80	20	100	4
(Paper 8) SCRM.1.2.4 Stem Cell Biology	80	20	100	4
Practical				
(Practical 6) SCRM.1.2.P.1 Metabolism and Clinical Biochemistry	40	-	40	8
(Practical 7) SCRM.1.2.P.2 Biostatistics and Bioinformatics	40	-	40	
(Practical 8) SCRM.1.2.P.3 Biomedical Instrumentation and Nanobiotechnology	40	-	40	
(Practical 9) SCRM.1.2.P.4 Stem Cell Biology	40	-	40	
(Practical 10) SCRM.1.2.P.5 Industry Visit and Report	40	-	40	
Total	**520**	**80**	**600**	**24**

SEMESTER-III

Theory Papers	University Exam marks	Internal marks	Total marks	Credits
(Paper 9) SCRM 2.3.1 Regenerative Medicine and its applications in diseases	80	20	100	4
(Paper 10) SCRM 2.3.2 Biomaterials, Tissue Engineering and 3D Bio Printing	80	20	100	4
(Paper 11) SCRM 2.3.3 Elective I (Choose any one of the following) (Paper 11) SCRM 2.3.3 (A) Clinical research, bioethics and regulatory affairs (Paper 11) SCRM 2.3.3 (B) Nanobiotechnology	80	20	100	4
(Paper 12) SCRM 2.3.4 Elective II(Choose any one of the following) (Paper 12) SCRM 2.3.4 (A) Cell and Tissue banking and Cryopreservation (Paper 12) SCRM 2.3.4 (B) Environmental Sciences and Biodiversity	80	20	100	4
Practical				
(Practical 11) SCRM 2.3.P.1 Regenerative Medicine and its applications in diseases	40	-	40	8
(Practical 12) SCRM 2.3.P.2 Biomaterial, Tissue Engineering and 3D Bio Printing	40	-	40	
(Practical 13) SCRM 2.3.P.3 Elective I (Choose any one of the following) (Practical 13) SCRM 2.3.P.3 (A) Clinical research, bioethics and regulatory affairs (Practical 13) SCRM 2.3.P.3(B) Nanobiotechnology	40	-	40	
(Practical 14) SCRM 2.3.P.4Elective II(Choose any one of the following) (Practical 14) SCRM 2.3.P.4 (A) Cell and Tissue banking and Cryopreservation (Practical 14) SCRM 2.3.P.4 (B) Environmental Sciences and Biodiversity	40	-	40	
(Practical 15) SCRM 2.3.P.5 Research Project Synopsis	40	-	40	
Total	**520**	**80**	**600**	**24**

SEMESTER-IV

Theory Papers	University Exam marks	Internal marks	Total marks	Credits
(Practical 16) SCRM.2.4.P.1 Research Project				
Oral / Poster Presentation in conference/ workshop/ any other relevant program	-	100	100	4
Dissertation	200	-	200	8
Viva	200	-	200	8
Industry Visit and Report	100	-	100	4
Total	**500**	**100**	**600**	**24**

Program Outcome Programme outcome (PO)	
PO1	Knowledge and Skills
PO2	Planning and Problem-solving abilities
PO3	Communication
PO4	Research Aptitude
PO5	Professionalism and Ethics
PO6	Leadership
PO7	Societal Responsibilities
PO8	Environment and Sustainability
PO9	Lifelong Learner

Upon completion of the M. Sc. SCRM program, the student will be able to:

PO1: Get knowledge and skill of Stem Cell and Regenerative Medicine in Industry, Medical or hospital related organizations, Regulatory Agencies and Academia.

PO2: Develop Planning and Problem-solving abilities in Stem cell handling and preservation, molecular biology, disease diagnosis, handling and maintenance biological instrumentation, analytical methods, interpretation of experimental data.

PO3: Develop communication skills to communicate effectively in teaching, research project, interview, healthcare sectors, industries, academia for collaborative research by explaining his ideas with good interpersonal and workplace based skills.

PO4: Do research in Stem cryopreservation, transplantation, diagnosis and drug development for carrier as well as placement.

PO5: Develop understanding and implementation ethics in profession, research, society, animal experiment, biosafety, workplace, hospital, clinical research and human trial.

PO6: Develop leadership skills, logical reasoning, time management and values required for self-directed, lifelong learning, soft skills for professional development and execute their professional roles in society as stem cell professionals, employers and employees in various industries, academic institutions and research laboratories.

PO7: Develop character with good moral values, human values, good social behaviour, gratitude, honesty, ethics, safety, hygiene, responsibility, confidence, tolerance and critical thinking.

PO8: Contribute in sustainable development to achieve the national sustainable development goal 3.

PO9: This course is helpful for lifelong learning in Medical Science Stream.

Course Outcomes

Paper 1. Biochemistry

At the end of the course, the student will be able to:

CO1: Describe the Structure and properties of biomolecules like Nucleic acids, Proteins amino acids, estimation of biomolecules, Carbohydrates and Proteins and their role in metabolic and cellular pathways.

CO2: Describe the classification and functional properties of enzymes, enzyme kinetics and enzyme inhibition.

CO3: Explain about the role of vitamins and cofactors in enzyme activity.

CO4: Describe the metabolism of carbohydrates.

CO5: Describe the metabolism of lipids.

CO6: Describe the metabolic disorders in human.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9
CO1	3	3	1	3	2	3	3	2	2
CO2	3	3	2	2	1	1	2	1	1
CO3	3	2	3	2	1	1	1	1	2
CO4	3	2	2	1	1	1	2	3	1
CO5	3	2	1	3	1	1	1	2	3
CO6	3	2	2	3	2	2	1	1	2

Paper 2. Cell Biology and Developmental Biology

At the end of the course, the student will be able to:

CO1: Know basics concepts of cell biology including structure and function of different organelles.

CO2: Understand the transport mechanisms and Mechanism of cellular recognition and communication.

CO3: Develop the basics understanding of receptor, ligand and different types cell signalling and their mechanisms.

CO4: Explain the importance of development and development process.

CO5: Explain the Growth, Morphogenesis and Genetic assimilation.

CO6: Understand of role of stem cells in development of organisms and developmental anomalies.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9
CO1	3	3	1	3	2	3	3	2	2
CO2	3	3	2	2	1	1	2	1	1
CO3	3	1	3	2	1	1	1	1	2
CO4	3	2	1	1	1	1	2	3	1
CO5	3	3	1	3	2	3	1	2	3
CO6	3	1	1	1	1	2	1	1	2

Paper 3. Genetics and Molecular Biology

At the end of the course, the student will be able to:

CO1: Explain the mechanisms of DNA replication and repair, RNA synthesis and processing, and protein synthesis.

CO2: Contribute to the education of peers by actively engaging in small group sessions, and by clearly communicating information in an oral presentation based on a personal literature search on a specific genetic disease.

CO3: Critically evaluate one's performance in the course to identify strengths and personal limitations in either knowledge of molecular cell biology and genetics or study methods; develop learning goals to address any deficiencies and actively seek out assistance from appropriate sources to successfully remediate these deficiencies.

CO4: Explain the mechanisms of gene transcription and its regulation.

CO5: Explain the Gene mutations and human genetic disorders Consequences of mutation, Causes and occurrences.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9
CO1	3	3	1	1	1	1	3	2	2
CO2	3	3	2	2	2	2	2	1	1
CO3	2	3	2	2	2	2	1	1	2
CO4	2	2	2	3	3	3	2	3	1
CO5	2	2	2	3	3	3	1	2	3

Paper 4. Immunology and Virology

At the end of the course, the student will be able to:

CO1: Understand the role and importance of innate and adaptive immunity to host defence against micro-organisms and the processes involved in immune cell development.

CO2: Understandthe concepts of regulation of Immune responses.

CO3: Understanding of Immunologic basis of graft rejection and immunotherapies.

CO4: Acquire knowledge of viral diseases.

CO5: Understand the development of vaccines.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9
CO1	3	3	1	1	1	1	3	2	2
CO2	3	3	2	2	1	2	2	1	1
CO3	3	3	2	2	2	1	1	1	2
CO4	3	2	2	1	1	1	2	3	1
CO5	3	2	2	1	1	2	1	2	3

Paper 5.Metabolism and Clinical Biochemistry

At the end of the course, the student will be able to:

CO1: Understand the concepts of protein metabolism and understand the importance of clinically important enzymes and related pathophysiology.

CO2: To know about cause of metabolic diseases.

CO3: To learn biochemical methods for diagnosis of metabolic diseases.

CO4: The knowledge of metabolic disorders and organ system function test.

CO5: To get the knowledge metabolic disorders involved in metabolism.

CO6: To understand clinically important Enzymes.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9
CO1	3	3	1	1	1	1	3	2	2
CO2	3	3	2	2	1	2	2	1	1
CO3	3	3	2	2	2	1	1	1	2
CO4	3	2	2	1	1	1	2	3	1
CO5	3	3	2	2	1	2	1	2	3
CO6	3	3	2	2	2	1	1	1	2

Paper 6. Biostatistics and Bioinformatics

At the end of the course, the student will be able to :

CO1: Understand the basic concepts of bioinformatics and databases available for Bioinformatics study.

CO2: Apply the knowledge of bioinformatics for getting DNA sequence and protein sequence for desired gene.

CO3: To study the comparison of Nucleotides, Amino acids sequences between various organisms.

CO4: Understand the definition of statistics and its relation with biological sciences.

CO5: Use the knowledge of sampling techniques, probability distributions for research.

CO6: Apply the knowledge of sampling correlation and regression in problem solving.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9
CO1	2	3	1	2	3	2	3	2	2
CO2	3	3	2	2	1	1	2	1	1
CO3	3	3	2	2	2	1	1	1	2
CO4	3	2	2	1	2	2	2	3	1
CO5	3	3	2	2	2	2	1	2	3
CO6	2	3	2	2	2	1	1	1	2

Paper 7. Biomedical Instrumentation and Nanobiotechnology

At the end of the course, the student will be able to:

CO1: Understand the fundamental principles of Chromatography, electrophoresis, Spectrophotometry etc.

CO2: Development of technical Skills involved in Chromatography, electrophoresis, Spectrophotometry etc.

CO3: To understand principle and Instrumentation involved in PCR and Flow cytometry techniques.

CO4: To understand basic principles in nanobiotechnology.

CO5: Acquire knowledge about techniques used in nanobiotechnology.

CO6: Understand the applications of nanobiotechnology in Tissue engineering.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9
CO1	3	3	1	1	1	1	3	2	2
CO2	3	3	3	2	2	2	2	1	1
CO3	3	3	2	2	2	2	1	1	2
CO4	3	2	2	1	1	1	2	3	1
CO5	3	2	2	2	1	1	1	2	3
CO6	3	2	2	1	1	1	1	1	3

Paper 8. Stem Cell Biology

At the end of the course, the student will be able to:

CO1: Explain basic concepts of stem cells, and different types of stem cells.

CO2 Understand the Pluripotent stem cell and molecular mechanism of Self renewal and differentiation.

CO3: Demonstrate methods of isolation of stem cell types.

CO4: Understand the Hematopoietic stem cell, their Characterization, and Differentiation of hematopoietic stem cell lineages.

CO5: Explain basic concepts of endothelial progenitor cells, Multipotent adult progenitor cells.

CO6: Understand the Cancer stem cells and their regulation.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9
CO1	3	2	2	2	3	1	3	2	2
CO2	3	3	2	2	1	1	2	1	1
CO3	3	3	2	2	2	2	1	1	2
CO4	3	2	1	1	1	1	2	3	1
CO5	3	3	2	2	1	2	1	2	3
CO6	3	3	2	2	2	1	1	1	2

Paper 9. Regenerative Medicine and its applications in diseases

At the end of the course, the student will be able to:

CO1: Understand the concepts of regenerative medicine, stem cell therapy in degenerative neuronal disease and spinal cord regeneration.

CO2: Explain the role of stem cells in acute myocardial infarction and dilated cardiomyopathy.

CO3: Understand the role of stem cells in diabetes and muscular dystrophies.

CO4: Understand the role of stem cells in treatment of hereditary hemolytic anaemia.

CO5: Understand the CART cell therapy, NK & dendritic cell therapy for solid tumours.

CO6: Explain Role of Hematopoietic stem cell transplantation for malignancies, lymphoma, leukaemia and myeloma.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9
CO1	3	2	3	3	3	3	3	2	2
CO2	2	2	2	3	3	2	2	1	2
CO3	3	2	3	3	1	1	1	1	2
CO4	3	2	3	2	3	1	2	3	1
CO5	3	2	3	3	2	2	1	2	2
CO6	3	2	3	3	3	2	1	1	2

Paper 10.Biomaterials, Tissue engineering and 3D bioprinting.

At the end of the course, the student will be able to:

CO1: Understand the Properties of Materials, Classes of materials used in Tissue engineering.

CO2: Concepts of biomaterials used in medicine and their reactions with biological systems.

CO3: Demonstrate the Tissue engineering of organs like bone, cartilage, liver, cornea.

CO4: Explain Tissue engineering of organs and their clinical application.

CO5: Understand the advances of 3D Printing Technology and its clinical applications.

CO6: Explain the concepts of Bio ink for 3D printing of Bone, cartilage, skin, arteries and heart.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9
CO1	3	2	2	2	2	1	3	2	2
CO2	2	2	2	3	3	1	2	1	2
CO3	3	2	3	3	2	1	1	1	2
CO4	3	2	3	2	3	2	2	3	1
CO5	3	2	3	3	2	2	1	2	3
CO6	3	2	3	3	3	2	1	1	2

Paper 11 (A) Clinical Research, Bioethics and Regulatory Affairs

At the end of the course, the student will be able to:

CO1: Understand and Explain Clinical Research, Terminologies and definition in Clinical Research.

CO2: To know origin and History of Clinical Research, Difference between Clinical Research and Clinical Practice.

CO3: To understand and explain the Biosafety in laboratory institution: laboratory associated infection and other hazards, assessment of biological hazards and level of biosafety.

CO4: To understand and explain the rules and regulations involved in Clinical research.

CO5: To understand and explain concepts of Bioethics.

CO6: To understand and explain Intellectual property rights.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9
CO1	3	2	3	3	3	3	3	2	2
CO2	2	2	2	3	3	3	2	1	1
CO3	3	2	3	3	3	3	1	1	2
CO4	3	2	3	2	3	2	2	3	2
CO5	3	2	3	3	2	3	1	2	3
CO6	3	2	3	3	3	2	1	1	2

Paper 11 (B) Nanobiotechnology

At the end of the course, the student will be able to:

CO1: KnowDifferentformats of nanomaterials and applications with example for specific cases

CO2: Acquire knowledge about Cellular Nanostructures; Nanopores; Biomolecular motors; Bio-inspired Nanostructures, Synthesis and characterization of different nanomaterials.

CO3: Synthesize Nanoparticles for drug delivery, concepts, optimization of nanoparticle properties for suitability of administration through various routes of delivery.

CO4: Demonstratethe nanoThin films; Colloidal nanostructures; Self Assembly, Nanovesicles; Nanospheres; Nanocapsules and their characterization.

CO5: Know the applications of Nanoparticles for diagnostics and imaging (theranostics); concepts of smart stimuli responsive nanoparticles, implications in cancer therapy, nanodevices for biosensor development.

CO6: Aware of Safety of nanomaterials, Basics of nanotoxicity, Models and assays for Nanotoxicity assessment; Fate of nanomaterials in different stratas of environment; Ecotoxicity.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9
CO1	3	2	3	3	3	3	3	2	2
CO2	2	2	2	3	3	3	2	1	1
CO3	3	2	3	3	3	3	1	1	2
CO4	3	2	3	2	3	2	2	3	1
CO5	3	2	3	3	2	3	1	2	3
CO6	3	2	3	3	3	2	1	1	3

Paper 12 (A) Cell and Tissue Banking and Cryopreservation

At the end of the course, the student will be able to:

CO1: Understand the concepts of Cell and Tissue banking.

CO2: To know instrumentation for setting up of cell and organ tissue bank.

CO3: To understand the applications of cord blood banking.

CO4: To know advantages and disadvantages of transplantation.

CO5: Understand apply the knowledge of cryopreservation and cryoprotectants for cryopreservation.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9
CO1	3	2	3	1	1	2	3	2	2
CO2	3	2	3	3	3	2	2	1	2
CO3	3	2	2	2	2	1	1	1	2
CO4	3	1	1	1	1	1	2	3	1
CO5	3	2	2	2	1	1	1	2	3

Paper 12 (B) Environmental Sciences and Biodiversity

At the end of the course, the student will be able to:

CO1: Know types of pollution methods for management of the pollution, Environmental management, waste water treatment, Solid waste management.

CO2: Acquire knowledge of degradation of xenobiotics in Environment, Bioremediation of xenobiotics and heavy metals, Ozone depletion, greenhouse effect and acid rain. Use of genetically modified microbe for reducing the pollution.

CO3: Know the Principles and scope of ecology, Human ecology and Human settlement, Evolution, Origin of life and speciation.

CO4: Understand the Food Chains, Food web, Ecological pyramids. Ecological Succession, Population, Community ecology and Parasitism, Prey predator relationships.

CO5: Understand the air-borne diseases and allergies, Environmental Biotechnology, Fermentation Technology, Vermiculture technology, Biofertilizer technology.

CO6: Know the Biodiversity conservation Act 2002, Wildlife parks, wildlife reserves, privately owned wildlife reserves & Biosphere reserves , Single species / single habitat based conservation programmes (e.g. Project tiger, Valley of flowers), International conventions on conservation.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9
CO1	3	2	3	3	3	3	3	3	2
CO2	2	2	2	3	3	3	3	3	1
CO3	3	2	3	3	3	3	3	3	2
CO4	3	2	3	2	3	2	3	3	1
CO5	3	2	3	3	2	3	3	3	3
CO6	3	2	3	3	3	2	3	3	3

Semester I

(Paper 1) SCRM 1.1.1 Biochemistry (60 h)

Unit I. Amino acids, Proteins and Nucleic acids (15 h)

Amino acid: Classification, structure and properties, amphoteric nature, isoelectric point, peptide bond formation. Protein: Classification, properties and biological functions; Protein Structure: primary, secondary, tertiary and quaternary, structure and function of myoglobin, hemoglobin, collagen, Ribonuclease A, chymotrypsine; Protein folding, Chaperones. Structure of nucleoside, nucleotide. De novo and salvage pathways of nucleotide synthesis. Secondary structure of DNA, Watson and Crick model of DNA. A, B and Z forms of DNA, Tm and its relation to GC content Chemical and enzymatic degradation of nucleic acids. RNA-structure and types.

Unit II. Enzymes (15 h)

Enzymes: classification, Factors affecting the enzyme activity- Concentration, pH and temperature. Kinetics of a single-substrate enzyme catalysed reaction, Michealis-Menten Equation, Km, Vmax, L.B Plot, Turnover number, Kcat. Kinetics of Enzyme Inhibition. Kinetics Allosteric enzymes. Immobilization of enzymes, Role of Vitamins and Cofactors in enzyme activity.

Unit III. Carbohydrates (15 h)

Carbohydrates: Classification, properties and biological functions of, Monosaccharides: Classification, properties, functions, isomerism, D & L forms, Disaccharides: Glycosidic bond, classification, composition and biological importance. Polysaccharides: Classification, properties and functions; Photosynthesis; aerobic and anaerobic respiration.

Unit IV. Lipids (15 h)

Lipids: Classification, properties and functions; fatty acids: composition, classification, characteristics and functions; Simple lipids, Triglycerides Conjugated lipids, phospholipids and its functions, glycolipids lipoproteins, Cholesterol-structure, properties and functions, Liposomes, lipids, lipoproteins and apolipoproteins.

Books for study and references:

1. Jeremy M. Berg, Lubert Stryer, John L. Tymoczko, Gregory J. Gatto - Biochemistry, 8th edition (2015), WH Freeman publications.
2. Biochemistry by Voet Donald, Voet, Judith G. (2004) 3rd edition (J Wiley and Sons)
3. Lehninger's Principles of Biochemistry by D. L. Nelson and M. M. Cox, CBS Publications, 2000
4. Biochemistry by Lubert Stryer, 4th Edition.
5. Pharmaceutical Biotechnology (Kindle Edition) by S. P. Vyas, V. K. Dixit, CBS Publishers and distributors.

6. Meeting Educational Needs with "Course" Remodelled Biotech Curricula May, 2017 Copyright © Deptt. of Biotechnology Ministry of Science & Technology Government of India Compiled and Coordinated Ms. Shreya Malik, DM, BCIL Edited Dr. Suman Govil, Adviser, DBT Dr. Purnima Sharma, MD, BCIL.

(Paper 2) SCRM.1.1.2 Cell Biology and Developmental Biology (60 hrs)

Unit I. Work of Cells (15 hrs)

Membrane structure and function: Lipid bilayer and membrane protein diffusion, osmosis, ion channels, active transport, membrane pumps; Structural organization and function of intracellular organelles: Cell wall, nucleus, mitochondria, Golgi bodies, lysosomes, endoplasmic reticulum, peroxisomes; structure & function of cytoskeleton and its role in motility; Cell division and cell cycle: Mitosis and meiosis, their regulation, steps in cell cycle, regulation and control of cell cycle.

Unit II. Cell communication and Cell Signalling (15 hrs)

Hormones and their receptors, cell surface receptors, signaling through G-protein coupled receptors, Signal transduction pathways, second messengers, regulation of signaling pathways; General principles of cell communication, cell adhesion and roles of different adhesion molecules, gap junctions, extracellular matrix, and integrin.

Unit III. Basic concepts of development (15 hrs)

Potency, commitment, specification, induction, competence, determination and differentiation; morphogenetic gradients; cell fate and cell lineages; stem cells; genomic equivalence and the cytoplasmic determinants; imprinting; mutants and transgenics in analysis of development

Unit IV. Gametogenesis, fertilization and early development (15 hrs)

Production of gametes, cell surface molecules in sperm-egg recognition in animals; zygote formation, cleavage, blastula formation, embryonic fields, gastrulation and formation of germ layers in animals.

Books for study and references:

1. Lodish, H. F. (2021). *Molecular Cell Biology,* (9th Edition). New York: W.H. Freeman.
2. Alberts, B., Johnson, A., Lewis, J., Raff, M., Roberts, K., & Walter, P. (2022). *Molecular Biology of the Cell,* (7th Edition). New York: Garland Science.
3. Gilbert SF., Barresi MJF. (2020) D*evelopmental Biology*; (12thEdition).;Sinauer Associates Inc.
4. Wolper L., Tickle C; (2019); *Principles of Development*(6thEdition); Oxford University Press, UK

(Paper 2) SCRM.1.1.2 Cell Biology and Developmental Biology (60 hrs)

Unit I. Work of Cells (15 hrs)

Membrane structure and function: Lipid bilayer and membrane protein diffusion, osmosis, ion channels, active transport, membrane pumps; Structural organization and function of intracellular organelles: Cell wall, nucleus, mitochondria, Golgi bodies, lysosomes, endoplasmic reticulum, peroxisomes; structure & function of cytoskeleton and its role in motility; Cell division and cell cycle: Mitosis and meiosis, their regulation, steps in cell cycle, regulation and control of cell cycle.

Unit II. Cell communication and Cell Signalling (15 hrs)

Hormones and their receptors, cell surface receptors, signaling through G-protein coupled receptors, Signal transduction pathways, second messengers, regulation of signaling pathways; General principles of cell communication, cell adhesion and roles of different adhesion molecules, gap junctions, extracellular matrix, and integrin.

Unit III. Basic concepts of development (15 hrs)

Potency, commitment, specification, induction, competence, determination and differentiation; morphogenetic gradients; cell fate and cell lineages; stem cells; genomic equivalence and the cytoplasmic determinants; imprinting; mutants and transgenics in analysis of development.

Unit IV. Gametogenesis, fertilization and early development (15 hrs)

Production of gametes, cell surface molecules in sperm-egg recognition in animals; zygote formation, cleavage, blastula formation, embryonic fields, gastrulation and formation of germ layers in animals.

Books for study and references:

1. Lodish, H. F. (2021). *Molecular Cell Biology,* (9th Edition). New York: W.H. Freeman.
2. Alberts, B., Johnson, A., Lewis, J., Raff, M., Roberts, K., & Walter, P. (2022). *Molecular Biology of the Cell,* (7th Edition). New York: Garland Science.
3. Gilbert SF., Barresi MJF. (2020) D*evelopmental Biology*; (12thEdition).; Sinauer Associates Inc.
4. Wolper L., Tickle C; (2019); *Principles of Development*(6thEdition); Oxford University Press, UK

(Paper 3) SCRM 1.1.3 Genetics and Molecular Biology (60 hrs)

Unit I. Principles of Genetics (15 hrs)

Classical genetics: Mendelian laws of Inheritance, Chromosomal basis of inheritance, principles, Gene interaction, Genetic linkage and gene mapping, Yeast genetics and Tetrad analysis, Sex chromosomes and sex determination. General features of chromosomes. General features of Genetic code, Cytogenetics: Human karyotype, Chromosome banding, ploidy, chromosome aberrations and position effect. Population genetics: Calculation of allelic frequencies, Hardy-Weinberg law. Contributions of Thomas Hunt Morgan.

Unit II. Nucleic Acids and Replication (15 hrs)

Molecular structure of DNA and RNA. Identification of DNA as a genetic material. Hershey and Chase experiments on T_2 phage. Chargaff s experiments. Central Dogma of molecular biology. DNA Replication. A structural Overview. Three different models on DNA replication. Semi-conservative model. Bacterial DNA replication. *In vitro* DNA replication. Eukaryotic DNA replication, Steps and enzymes involved.

Unit III. Gene transcription and Translation (15 hrs)

Transcription in prokaryotes and eukaryotes.RNA modification. Types of RNA. Transcriptional regulation in prokaryotes and eukaryotes. Translation of mRNA. The genetic basis of protein synthesis. The structure and function of t RNA. Ribosome structure and assembly. Translation in prokaryotes and eukaryotes. Gene regulation in prokaryotes and eukaryotes. Chromatin remodeling. Histone modification. DNA methylation. Regulation of RNA processing, Gene silencing, siRNA, micro RNA, Gene editing Crispr-Cas system.

Unit IV. Gene mutations and human genetic disorders (15 hrs)

Consequences of mutation. Causes and occurrences of mutations. Repair of DNA: various mechanisms. Genetic recombination: Homologous recombination. Site specific recombination, Transposons, Discovery and molecular identification of transposons in various life forms. Introduction to Human Genetic Diseases: Cystic Fibrosis, Duchene muscular dystrophy, Thalassemia, sickle cell anaemia , SCID, Downs syndrome.

Books for study and references:

1. Robert J Brooker , Genetics : Analysis and Principles. Mc Graw Hill Publications .New York, USA. International student's edition. 2012.
2. Jocelyn E.Krebs, Elliot S.Goldstein and Stephen T.Kilpatrick . Lewin s: Genes XI .Jones & Bartlett student edition. 2014
3. Mathew R.Walker with Ralph Rapley: Route Maps in Gene Technology. Blackwell Science.Mass.USA.1997.
4. Robert F.Weaver : Molecular Biology Fifth edition. McGRAW Hill International Edition. 2008.
5. Brown TA: Gene Cloning and DNA Analysis. Willey Blackwell.2010.West Sussex.UK

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(Paper 4) MBT.1.1.4 Immunology and Virology (60 hrs)

UnitI. Introduction to immune system(15 hrs)

Introduction and history; Primary and secondary organs of the immune system, Cells of the immune system. Innate immune response & inflammation, complement system. 3. Hapten/antigen; antibody, structure & function, Immunoglobulin classes. Antigen & antibody interaction, Antibody diversity.

Unit II Generation and regulation of immune responses (15 hrs)

Major histocompatibility complex, Polymorphism, Human leukocyte antigen association with disease, Ontogeny, Positive and negative selection. Antigen processing and presentation, Co-stimulation, T and B cell stimulation, Cytokines & Chemokines.

Unit III. Transplantation Immunology (15 hrs)

Immunologic basis of graft rejection, clinical manifestation of graft rejection, immunosuppressive therapy; applications of monoclonal antibodies, single chain and humanised antibodies.

Unit IV. Virology (15 hrs)

Immune response to infectious diseases Concept of immunotherapy; Vaccines (Recombinant, DNA, live and attenuated, subunit); Herd immunity; Success stories in vaccinology e.g. small pox, polio, Hepatitis, DPT.

Books for study and references:

1. Kuby, RA Goldsby, Thomas J. Kindt, Barbara, A. Osborne, (2002), *Immunology*, 6th Edition, Freeman
2. Brostoff J, Seaddin JK, Male D, Roitt IM., (2002), *Clinical Immunology*, 6th Edition, Gower Medical Publishing
3. Janeway *et al*., *Immunobiology*, (1999), 4th Edition, Current Biology publications
4. Peakman, M and Vergani D, (2009), *Basic and Clinical Immunology*, 2nd Edition.
5. Maclachlan, NJ and Dubovi, EJ. (2011). *Fenner's Veterinary Virology*, 4th edition. Elsevier Inc.
6. Murphy, FA (2015). The Foundations of Medical and Veterinary Virology:
7. Discoverers and Discoveries, Inventors and Inventions, Developers and Technologies.
8. Mahy BWJ & Kangaro HO. (1996). *Virology Methods Manual*. Academic Press.
9. Reference: Meeting Educational Needs with “Course” Remodelled Biotech Curricula Cellular and Molecular Immunology, 10th Ed, South Asia Edition Paperback – 1 January 2021

Practicals

(Practical 1) SCRM.1.1.P.1 Biochemistry (15 h)

1. Paper chromatography technique for amino acid separation.
2. Estimation of Protein by Lowry's method and Bradford's method.
3. Determination of isoelectric pH of Casein.
4. Estimation of DNA by DPA Method.
5. Estimation of RNA by Orcinol method.
6. Estimation of Free Fatty acids.
7. Determination of saponification value of fatty acids.

(Practical 2) SCRM.1.1.P.2 Cell Biology & Developmental Biology(15h)

1. Preparation of temporary stained mount of human cheek cells.
2. Preparation of temporary mount of onion peel to observe and study epidermal cells.
3. Demonstration of osmosis by potato osmometer.
4. Lysosome Isolation in Isotonic Sucrose from Rat liver cells.
5. Isolation of Mitochondria from Rat liver cells.

(Practical 3) SCRM.1.1.P.3 Genetics and Molecular Biology (15h)

1. Isolation of total DNA from bacteria.
2. Preparation of plasmid from bacteria.
3. Separation of DNA by Agarose gel electrophoresis
4. Purification of DNA from agarose gel.
5. Restriction Digestion of DNA.
6. DNA / RNA quantification by UV spectrophotometer.

(Practical 4) SCRM.1.1.P.4 Immunology and Virology (15h)

1. Double Diffusion immuno precipitation assay
2. Sodium Dodecyl Sulphate Polyacryamide gel electrophoresis of Protein
3. Detection of serum antibodies by WIDAL test.
4. RNA extraction of given biological sample
5. Detection of Viral disease by RTPCR

(Practical 5) SCRM.1.1.P.5 Industry visit and report

Semester II

(Paper 5) SCRM.1.2.1 Metabolism and Clinical Biochemistry (60 h)

Unit I. Carbohydrate Metabolism (15 h)

Brief account of Glycogen Metabolism, Fructose Metabolism, Galactose Metabolism and Uronic acid pathway. Inborn errors associated with carbohydrate metabolism – Glycogen storage diseases, Fructosuria, Fructose intolerance, Pentosuria, Galactosuria. Blood glucose regulation (fasting/pp/random)–hormones influencing carbohydrate utilization, Insulin, glucagon, glucocorticoids, epinephrine, growth hormone. Hyperglycaemia, Diabetes Mellitus, Hypoglycaemia.

Unit II. Lipid Metabolism (15 h)

Digestion of Lipids, Biosynthesis of cholesterol, Regulation of Cholesterol synthesis, Fate of Cholesterol, Cholesterol transport, Atherosclerosis, Hyper cholesterolemia. Hyper- and Hypoproteinemia, Fatty Liver, Brief account of Ketone body metabolism, Ketosis. Complete Lipid profile.

Unit III. Amino acid, Protein, Nucleic acid Metabolism (15 h)

Body amino acid pool, Aminoacidopathies, Amino Acid Analysis, Proteins – Catabolism and Nitrogen Balance, Dynamic state of body proteins; Plasma proteins – Prealbumin (Transthyretin), Albumin, Globulins; Total Protein abnormalities– Hypoproteinaemia, Hyperproteinaemia; Methods of analysis– Total nitrogen, Total proteins, Fractionation, Identification and Quantification of specific proteins,

Brief account of Metabolism of Glycine, Phenyl alanine, Tyrosine and Sulphur containing amino acids. Glutathione, Formation of Taurene, Hyperglycinaemia's, Homocystinuria, Cystinuria and Cystinosis, Phenyl ketonuria and Alkaptonuria, Albinism, Tyrosinemia,

Brief account of Purine and Pyrimidine metabolism including Purine Salvage Pathways. Disorders of Purine Pyrimidine Metabolism such as Gout, LeschNyhan Syndrome and Orotic aciduria.

Unit IV. Clinical Enzymology, Plasma Proteins and NPN compounds (15 h)

Part A: Enzymes of clinical significance – Creatine Kinase, Lactate Dehydrogenase, Aspartate Aminotransferase, Alanine Aminotransferase, Alkaline Phosphatase, Acid Phosphatase, Glutamyl transferase, Amylase, Lipase, Glucose-6-Phosphate Dehydrogenase, Drug – Metabolizing Enzymes, Tumour markers, Bone markers, Cardiac markers, liver markers. Clinical Isoenzymology.

Part B: Serum protein electrophoresis, High-resolution protein electrophoresis, Immunochemical methods; Proteins in other body fluids – Urinary proteins and Cerebrospinal fluid proteins; Non – protein nitrogen compounds (Physiology, clinical application, methods, and pathophysiology) – Urea, Uric acid, Creatine, Creatinine, Ammonia,

Synthesis of thyroid hormones, Synthesis and catabolism of catecholamines.

Books for study and references:

1. Michael L. Bishop, Edward P. Fody and Larry E. Schoeff; (2013). *Basic Principlesand Practice of Clinical Chemistry*, (7th Ed). Lippincott Williams and Wilkins.
2. Stryer, L. (2002). *Biochemistry*, (8th Ed). Freeman.
3. D.M. Vasudevan and Sreekumari, S, (2010). *Textbook of Biochemistry forMedical Students*, (6th Ed). Jaypee Brothers Medical Publishers, New Delhi.
4. Sucheta Dandekar; (2010). *Concise Medical Biochemistry*, (3rd ed), Elsevier Health.
5. Satyanarayana and Chakrapani, (2013), *Biochemistry*; (4th Ed). Elsevier.
6. Meeting Educational Needs with "Course" Remodelled Biotech Curricula
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(Paper 6) SCRM.1.2.2. Biostatistics and Bioinformatics (60 h)

Unit I. Basics of Biostatistics

Definition – Biostatistics, Variable: Quantitative and Qualitative Variable, Applications of statistics in Biology with Examples.

Sampling: Definitions, Population Sample, Advantages of Sample Studies. Types of Samples. Methods of Sampling- Simple random sampling, stratified random sampling, systematic sampling, cluster sampling, multistage sampling, multiphase sampling, Sampling error.

Descriptive statistics: Types of data - Qualitative, Quantitative, Categorical, Raw and grouped data.

Graphical Presentation of data - Pie chart, Bar diagram, Histogram, Frequency polygon, Frequency Curve.

Averages - Arithmetic mean, Median, Mode (Calculations, merits, demerits and uses).

Measures of dispersion - Range, standard deviation, Coefficient of Variation (Computation, merits, demerits and application).

Correlation and Regression: Dependent Variable, Independent variable, Definition and properties of simple Pearsons correlation co-efficient, concept of simple linear regression, scatter graph with regression line.

Unit II. Probability distributions, Testing of significance (15 h)

Definition of probability - Classical relative frequency. Conditional probability. Addition theorem, Multiplication theorem (only statements)

Discrete probability Distributions-Binomial and Poisson (concept and list of applications).Continuous probability Distribution-Normal distribution concept, properties and applications.

Tests of significance: Null hypothesis, Alternate hypothesis, Type I error, Type II error, Level of significance, p-value, Power of the test, Concept of test of significance. Chi-Square test, Normal test, Student's t-test (paired and unpaired). One-way analysis of variance (only introduction), Test of significance of correlation co-efficient.

Unit III. Bioinformatics basics (15h)

Bioinformatics basics: Computers in biology and medicine; Database concepts; Protein and nucleic acid databases. Primary and secondary data bases, Structural databases; Databases and search tools. Biological background for sequence analysis; Identification of protein sequence from DNA sequence. Searching of databases for similar sequences. NCBI; Entrez, publicly available tools; resources at EBI; resources on web; database mining tools.

Unit IV. Bioinformatics analysis (15h)

DNA sequence analysis: gene bank sequence database. Submitting DNA sequences to databases and database searching. Sequence alignment. Pairwise alignment techniques. Multiple sequence alignment. Motif discovery and gene prediction. Genomics, Whole genome sequencing. Human genome sequencing. *Saccharomyces* genome data base. Assembly of data from genome sequencing

.Protein database, Proteomics. Sequence alignment programs, BLAST Searches, Gene expression analysis using microarray, RNA sequencing, Transcriptomics. Biochemical pathway database (KEGG).

Books for study and references:

1. Wayne W. Daniel, Chad L. Cross- Biostatistics: A foundation for analysis in the health science, 10th edition (2013), John Wiley & sons
2. Richard J. Sundar P. S. Rao S. Introduction to Biostatistics and Research Methods, 4th edition (2006), Prentice-Hall of India Pvt. Ltd. publication
3. Armitage P and Berry G - Statistical methods in medical Research, 4th edition (2008), Oxford Blackwell scientific publication 4. Sokal P R and Rohlf F. R.-Biometry: The principles and practice of statistics in Biological, 3rd edition (1981), Freeman and company Sanfranscisco
4. Lesk, A. M. (2002). *Introduction to Bioinformatics*. Oxford: Oxford University Press.
5. Mount, D. W. (2001). *Bioinformatics: Sequence and Genome Analysis.* Cold Spring Harbor, NY: Cold Spring Harbor Laboratory Press.
6. Baxevanis, A. D., & Ouellette, B. F. (2001). *Bioinformatics: a Practical Guide to the Analysis of Genes and Proteins*. New York: Wiley-Interscience.
7. Pevsner, J. (2015). *Bioinformatics and Functional Genomics*. Hoboken, NJ.: Wiley-Blackwell.
8. Bourne, P. E., & Gu, J. (2009). *Structural Bioinformatics*. Hoboken, NJ: Wiley-Liss.
9. Lesk, A. M. (2004). *Introduction to Protein Science: Architecture, Function, and Genomics.* Oxford: Oxford University Press.

11. 11.Jaype Brothers, (2011), Methods in Biostatistics for Medical Students and Research Workers (English), 7th Edition. Edited Dr. Suman Govil, Adviser, DBT Dr. Purnima Sharma, MD, BCIL

(Paper 7) SCRM.1.2.3 Biomedical instrumentation and Nanobiotechnology (60 h)

Unit I. Biomedical Instrumentation I (15 h)

Chromatography: Paper, TLC, Gel filtration, Ion exchange chromatography, Gas Chromatography, HPLC, HPTLC, affinity chromatography, UV-Visible Spectroscopy, Mass Spectrometry, Nuclear Magnetic resonance, Infrared spectroscopy, Circular Dichroism

Unit II. Biomedical Instrumentation -II (15 h)

Electrophoresis: Principle and types, Agarose gel Electrophoresis, pulse field gel electrophoresis, SDS-PAGE, 2D Gel Electrophoresis, Iso-Electric Focusing, Capillary electrophoresis, PCR, RTPCR, Flow Cytometry, Microscopy- SEM, TEM, Confocal, X-ray crystallography, ECG, MRI, PET, EEG and CT

Unit III. Principles of Nanobiotechnology (15 h)

Biological Nanostructures and natural biological assemblies at nanoscale: Bacterial S layers, phospholipid membranes, viruses, Nucleic acids, Oligosaccharides, polysaccharides, biological polymers, Proteins. Biological nanomotors, protein assemblies: Kinesin and dynein, cilia. Bacterial flagella: structure and function; nanomotor. Ion channels: nanopores of high specificity. Bioinspired nanomaterials: DNA and peptide based. Interaction between biomolecules and nanoparticle surfaces. Self-Assembly, Self-Organization, Molecular Recognition.

Unit IV. Biomedical applications of Nanobiotechnology (15 h)

Diagnosis: Bio MEMS, Nanochips-Gene chip and Protein chip, Ultrasensitive biobarcode, Nanobiosensors. Therapeutics: Nanobiotechnology in imaging, Woundcare products, Implantable materials and bionics for medical application, Implantable materials for orthopedics and dentistry. Nanorobotics, Nanotechnology based chemotherapy.

Books for study and references:

1. David Friefelder, (1983), *Physical Biochemistry*, 2nd edition, W.H. Freeman and Co., USA.
2. G.H. Jeffery, J. Bassett. J. Mendham, R.C. Denney, (1991), *Vogel's Textbook of Quantitative Chemical Analysis*, 5th Edition, ELBS, England.
3. P.W. Atkins, (1996), *The Elements of Physical Chemistry,* Oxford University Press.
4. Jack A. Tuszynski Michal Kurzynski, *Introduction to Molecular Biophysics*, CRC Press. 370 | Remodelled Biotech Curricula
5. R.A. Day, A.L. Underwood*, Quantitative Analysis*, 1999, 6th Edition; Prentice-Hall of India Pvt. Ltd., New Delhi.
6. Plummer, 2002. *An Introduction to Practical Biochemistry,* 3rd edition, Tata Mc Graw Hill.
7. K Wilson and J Walker (eds.), 1999. *Principles and Techniques of Practical Biochemistry*, 4th edition, Cambridge Univ.Press.

8. GeroDecher, Joseph B. Schlenoff, (2003); *Multilayer Thin Films: Sequential Assembly of Nanocomposite Materials,* Wiley-VCH Verlag GmbH & Co. KGaA
9. David S. Goodsell, (2004); *Bionanotechnology: Lessons from Nature*, Wiley-Liss
10. Neelina H. Malsch, *Biomedical Nanotechnology,* CRC Press Greg T. Hermanson, (2013); *Bioconjugate Techniques*, (3rd Edition); Elsevier Recent review papers in the area of Nanomedicine.
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(Paper 8) SCRM.1.2.4 Stem Cell Biology(60 h)

Unit I. Introduction and basic biology of stem cells (15 h)

History of stem cell research, Stemness, Type of stem cells, Stem cell markers, Types of adult stem cells: Bone marrow, adipose tissue, cord blood, placenta etc, Differentiation and trans-differentiation of stem cells, Stem cell niches and regulation of stem cell niche in different adult tissues.

Unit II. Pluripotent stem cell and molecular mechanism of Self renewal and differentiation (15h)

Pluripotent stem cells, Isolation and maintenance of embryonic stem cell isolated from: Mouse, Human, Extracellular signaling involved in embryonic vs adult stem cells, induced Pluripotent stem cells (iPSCs) and their characterization, Telomerase and its regulation, Symmetric and asymmetric division.

Unit III. Hematopoeitic stem cells and their differentiation (15h)

Bone marrow microenvironment, Hematopoietic stem cell mobilization, Isolation of Hematopoietic stem cells, Ex vivo expansion, Characterization of Hematopoietic stem cells, Transcriptional regulation of Hematopoietic stem cells, Side population phenotypes, endothelial progenitor cells, Multipotent adult progenitor cells, Differentiation of stem cells *in-vivo* and *ex-vivo*, Differentiation of hematopoietic stem cell lineages.

Unit IV. Cancer stem cells and their regulation (15h)

Introduction to cancer, Stem cell origin of cancer, Cancer stem cells, Isolation and characterization of Cancer stem cells, Pathways involved in cancer stem cells and their tumor progression, Pericytes and tumor angiogenesis.

Books for study and references:

1. Khawaja H. Haider (2021)Stem Cells: Latest Advances(1st Edition), Springer, Cham
2. Khalid Al-Anazi (2020)Update on Mesenchymal and Induced Pluripotent Stem Cells.

IntechOpen

3. Jonathan M. W. Slack (2017)The Science of Stem Cells, John Wiley & Sons, Inc.
4. RoberLanza (2014) Hand book of Stem Cells" (3rd Edition), Elsevier, Academic Press
5. Stewart Sell, (2013)Stem Cells Handbook(2nd Edition),, Human Press

Practicals

(Practical 6) SCRM. 1.2.P.1 Clinical Biochemistry and Disease Metabolism (15 h)

1. Estimation of Sugar in given sample of blood.
2. Blood Cell counting.
3. Kidney function test.
4. Liver function test.
5. Cholesterol estimation / lipid profile of blood.

(Practical 7) SCRM. 1.2.P.2 Biostatistics and Bioinformatics(15 h)

1. Use of Statistical methods for data analysis.
2. PCR Primer designing by suing primer designing tools.
3. Similarity search of DNA sequence using BLAST and interpretation of results.
4. Similarity search of protein sequence using BLAST and interpretation of results.
5. Multiple sequence alignment using ClustalW.
6. Homology modeling of proteins.

(Practical 8) SCRM. 1.2.P.3 Biomedical instrumentation and Nanotechnology (15 h)

1. Synthesis of Nanoparticles by chemical method.
2. Synthesis of Nanoparticles by biological method.
3. Characterization of Nanoparticles.
4. Preparation of Alginate nanobeads for drug delivery.
5. Separation of Protein by Column chromatography.

(Practical 9) SCRM. 1.2.P.4 Stem Cell Biology(15 h)

Isolation of stem cells from cord blood.

2. Isolation of stem cells from bone marrow.
3. Isolation of stem cells from cord tissue.
4. Isolation of stem cells from Placenta.
5. Stem cell counting and viability checking.
6. Cell proliferation assay.
7. Characterization of Stem cells by immune histochemistry.

(Practical 10) SCRM. 1.2.P.5 Industry Visit and Report

Semester III

(Paper 9) SCRM.2.3.2 Regenerative Medicine and its applications in Diseases(60 h)

Unit I. Source of stem cells for neuronal repair (15 h)

Application of stem cell Therapy (SCT) for degenerative neuronal diseases (Parkinson disease, Motor neuron disease) and demyelinating diseases (Multiple sclerosis). Stem Cell Therapy in stroke, Stem Cell Therapy in spinal cord regeneration.

Unit II. Stem cell for Myocardial regeneration and Diabetes (15h)

Pathology of acute myocardial infarction and chronic ischemic heart disease, Role of stem cells in acute myocardial infarction and dilated cardiomyopathy, Types of diabetes and stem cell applications.

Unit III. Stem cell in Genetic diseases and Immunological diseases (15h)

Genetic basis of hereditary hemolytic anemias: Thalessemia, sickle cell anemia and hereditary spherocytosis. Role of stem cells in treatment of hereditary hemolytic anemias. Severe combined immunodeficiency disease (SCID), Wiskott-Aldrich syndrome, Stem Cell Therapy for muscular dystrophies.

Unit IV. Stem cell and Tumors/Malignancy(15h)

CART cell therapy, NK & dendritic cell therapy for solid tumors, Hematopoietic stem cell transplantation for malignancies, lymphoma, leukemia and myeloma

Books for study and references:

1. "Stem cell basics and application" Ed. By K. D. Deb and S. M. Totey, Tata McGraw Hill Pvt. Ltd, 2011. 2.
2. "Hand book of Stem Cells" Edited by Rober Lanza, Elsevier, Academic Press, 2011.
3. "Stem Cells Handbook", Edited by Stewart Sell, Human Press, 2010.
4. Handbook of stem cells, Edited by Robert Lanza. Elsevier academic press.
5. Human embryonic stem cells, Edited by Arlene Y. Chiu, Mahendra Rao. Humana press. 6. "Stem cell therapy for organ failures", Edited by S. Indumathi, Springer Verlag, 2015.

Paper 10. SCRM.2.3.3. Biomaterials, Tissue engineering and 3 D bioprinting(60 h)

Unit I. Properties of Materials, Classes of materials used in medicine(15 h)

Metals, Polymers, Hydrogels, Bioresorbable and Biodegradable Materials, Ceramics, Natural materials, Composites, Thin films, grafts, Coatings, Medical fibers and Biological functional materials

Unit II. Host reactions to biomaterial and testing of biomaterials (15h)

Inflammation, Wound healing and the Foreign bodyresponse. Systemic toxicity and Hypersensitivity, Blood coagulation and Blood-materials interactions, Tumorigenesis, Testing biomaterials: In Vitro and In Vivo assessment of tissue compatibility. Testing of blood-material interactions,

Unit III. Tissue Engineering And Its Clinical Application (15h)

Reconstruction of the skeleton, bone, cartilage, teeth, Reconstruction of skeletal and cardiac muscle, urinary bladder, liver, cornea. Tissue engineering transplants: Trachea, Bladder, arteries.

Unit IV. 3D Printing technology (15h)

3D printing design, its types and advantages, use of CT/MRI images for 3D printing, 3D printing and its clinical applications, Bio ink for 3D printing of Bone, cartilage, skin, arteries and heart

Books for study and references:

1. Biomaterial Science: An Introduction to Material in Medicine, Buddy D. Ratener, Allan S. Hoffman- 3rd edition (2012), Elsevier
2. Translational Approaches In Tissue Engineering & Regenerative Medicine, J.J. Mao, G. Vunjak-Novakovic- 1st edition (2008), Artech House, INC Publications.
3. 3D Bioprinting and Nanotechnology in Tissue Engineering and Regenerative MedicineLijie Zhang, Kam Leong, John Fisher 2nd Edition - February 18, 2022 Elsevier
4. Biomaterials for Tissue Engineering: Methods and Protocols (Methods in Molecular Biology) Kanika Chawla17 April 2018, Springer protocols
5. 3D Bioprinting: Modeling In Vitro Tissues and Organs Using Tissue-Specific BioinkDong-Woo Cho, Byoung Soo Kim, et al. | 16 December 2020 Springer
6. Medical 3D BioPrinting – The Revolution in Medicine Technologies for Patient-centered Medicine: From R&D in Biologics to New Medical Devices (Series E: Patient-Centered Medicine Book 4) Larry H. Bernstein, Irina Robu, et al. 30 December 2017 Kindle Edition

(Paper 11) SCRM .2.3.3 Elective I (Choose any one of the following)

Paper 11 (A) Clinical Research, Bioethics and Regulatory affairs (60h)

Unit I. Clinical Research (15 h)

Introduction to Clinical Research, Historical Perspectives : Nuremberg Code Study, The Belmont Report, Origin and Principles of International Conference on Harmonization, Types of Clinical Research, Good Clinical Practice (ICH-GCP) guidelines, Drug development process, Clinical drug development phases, Safety Monitoring in Clinical Trials, Analysis and reporting in clinical trials , Clinical Research regulations in India, Career in Clinical Research.

Unit II. Bioethics **(15 h)**

Introduction to bioethics, Social and ethical issues in biotechnology. Principles of bioethics. Ethical issues clinical research, Ethics committees, constitution and practices, Declaration of Helsinki and Informed consent process, Misconduct and Fraud in clinical research, Ethics and clinical trials in special population.

Unit III. Biosafety **(15 h)**

Biosafety: Definition of bio-safety, Biotechnology and bio-safety concerns at the level of individuals, institutions, society, region, country and world with special emphasis on Indian concerns. Bio safety regulation: handling of recombinant DNA products and processes in industry and in institutions (Indian context).

Unit IV. Intellectual Property Rights (IPR) **(15 h)**

Introduction to IPR, Types of IP: Patents, Trademarks, Copyright & Related Rights, Industrial Design, Traditional Knowledge, Geographical Indications, Protection of New GMOs; International framework for the protection of IP. IPs of relevance to Biotechnology and few Case Studies; Introduction to History of GATT, WTO, WIPO and TRIPS.

Indian Patent Act 1970 and Recent Amendments.

Patent application- forms and guidelines, fee structure, time frames; Types of patent applications: provisional and complete specifications; PCT and convention patent applications.

Books for study and 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. Recent Central Drugs Standard Control Organization. Good Clinical Practices-Guidelines for Clinical Trials on Pharmaceutical Products in India. New Delhi: Ministry of Health; 2013,2017.
4. International Conference on Harmonization of Technical requirements for registration of Pharmaceuticals for human use. ICH Harmonized Tripartite Guideline. Guideline for Good Clinical Practice.E6; May 1996.
5. Ethical Guidelines for Biomedical Research on Human Subjects 2000,2014, 2017. Indian Council of Medical Research, New Delhi.
6. Textbook of Clinical Trials edited by David Machin, Simon Day and Sylvan Green, March 2005, John Wiley and Sons.
7. Biotechnology - A comprehensive treatise (Vol. 12). Legal economic and ethical dimensions VCH. (2nd ed) ISBN-10 3527304320.
8. 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. Textbook of Clinical Trials edited by David Machin, Simon Day and Sylvan Green, March 2005, John Wiley and Sons.
10. Clinical Data Management edited by R K Rondels, S A Varley, C F Webbs. Second Edition, Jan 2000, Wiley Publications
11. Singh B.D. Biotechnology expanding horizons. Kalyani Publishers**,** Year: 2019
12. Law and Strategy of biotechnological patents by Sibley. Butterworth publication. (2007) ISBN: 075069440, 9780750694445.
13. Intellectual property rights- Ganguli-Tat McGrawhill. (2001) ISBN-10: 0074638602,
14. Intellectual Property Right- Wattal- Oxford Publication House. (1997) ISBN:0195905024.
15. Kuhse, H. (2010). Bioethics: an Anthology. Malden, MA: Blackwell.

Paper 11 (B) Nanobiotechnology (60 h)

UnitI. Introduction to nanobiotechnology (15 h)

Introduction to Nanobiotechnology; Concepts, historical perspective; Different formats of nanomaterials and applications with example for specific cases; Cellular Nanostructures; Nanopores; Biomolecular motors; Bio-inspired Nanostructures, Synthesis and characterization of different nanomaterials.

Unit II. Nano Particles and Nano Films (15 h)

Nanoparticles for drug delivery, concepts, optimization of nanoparticle properties for suitability of administration through various routes of delivery, advantages, strategies for cellular internalization and long circulation, strategies for enhanced permeation through various anatomical barriers. Thin films; Colloidal nanostructures; Self Assembly, Nanovesicles; Nanospheres; Nanocapsules and their characterisation.

Unit III. Applications of Nanoparticles (15 h)

Nanoparticles for diagnostics and imaging (theranostics); concepts of smart stimuli responsive nanoparticles, implications in cancer therapy, nanodevices for biosensor development. Nanomaterials for catalysis, development and characterization of nanobiocatalysts, application of nanoscaffolds in sythesis, applications of nanobiocatalysis in the production of drugs and drug intermediates.

Unit IV. Nanotoxicity (15 h)

Introduction to Safety of nanomaterials, Basics of nanotoxicity, Models and assays for Nanotoxicity assessment; Fate of nanomaterials in different stratas of environment; Ecotoxicity models and assays; Life cycle assessment, containment.

Books for study and references:

1. GeroDecher, Joseph B. Schlenoff, (2003); *Multilayer Thin Films: Sequential Assembly of Nanocomposite Materials,* Wiley-VCH Verlag GmbH & Co. KGaA
2. David S. Goodsell, (2004); *Bionanotechnology: Lessons from Nature*, Wiley-Liss
3. Neelina H. Malsch, *Biomedical Nanotechnology,* CRC Press
4. Greg T. Hermanson, (2013); *Bioconjugate Techniques*, (3rd Edition); Elsevier
5. Recent review papers in the area of Nanomedicine.
6. Meeting Educational Needs with "Course" Remodelled Biotech Curricula May, 2017 Copyright © Deptt. of Biotechnology Ministry of Science & Technology Government of India Compiled and Coordinated Ms. Shreya Malik, DM, BCIL Edited Dr. Suman Govil, Adviser, DBT Dr. Purnima Sharma, MD, BCIL

(Paper 12) SCRM .2.3.4 Elective II

Elective Papers (Choose any one of the following)

Paper 12 (A) Cell & Tissue Banking and Cryopreservation(60 h)

Unit I. Basics of tissue banking(15 h)

What is Cell and Tissue Banking? Definition. Scope and need of Cell and Tissue Banking and Cryopreservation, Processing of different organ tissues, Tissue preservation procedure, Validation and checking/quality control, Sterilization, disinfection and decontamination.

Unit II. Cord blood banking(15 h)

Advantage and disadvantages of cord blood banking, Regulation of cord blood banks, Donor Recruitment, Cord blood collection, processing and testing, Registration of cord blood units, Search, issue and release for transplantation, HLA typing and other related issues.

Unit III. Tissue banking (15 h)

Tissue banking of Skin, musculo-skeletal, Ocular, Cardiovascular tissue and sperm Structure of skin, Wound healing, Use of allograft, Long bone formation, growth and endochondral ossification, Bone characteristics and functions, Bone and tendons, processing storage and issue, Bone remodeling, Structure and function of the cornea, Ocular tissue transplantation, Corneal storage, processing and tissue, Eye banking, tissue processing, storage and issue of heart valves, Pericardium, Blood vessels and tissue transplantation, sperm banking indications, Culture Media, Protocols, Instrumentation, Applications.

Unit IV. Cryopreservation(15 h)

Introduction and Historical Background of Cryopreservation, Review of Basic, Thermodynamics, Properties of Cryogenic fluids, first and Second Law, approaches to the study of thermodynamic cycles, Isothermal, Adiabatic and Isenthalpic processes. Production of Low Temperatures: Liquefaction systems, ideal, Cascade, Linde Hampson and Claude cycles and their derivatives; Refrigerators: Stirling, Gifford-McMahon cycles and their derivatives. Cryogenic Insulations: Foam, Fibre, powder and Multilayer. Principles of Cryopreservation, Effects of Freezing on Cells, Thawing & amp; Post Thaw Handling, Cryoprotectants.

Books for study and references:

1. "An Introduction to cell and Tissue Transplantation Science" published by British Blood Tranfusion Society, Manchester, 2007.
2. "Hand book of Stem Cells" Edited by Rober Lanza, Elsevier, Academic Press, 2011.
3. "Stem Cells Handbook", Edited by Stewart Sell, Human Press, 2010.
4. "Human embryonic stem cells", Edited by Arlene Y. Chiu, Mahendra Rao, Human Press, 2011.
5. Translational Approaches: In Tissue Engineering &Regenerative Medicine", Artech House, INC Publications 2008 J. J. Mao, G. Vunjak Novakovic et al (Eds).
6. Stem Cell Repair and Regeneration, Naggy, 2007, Imperial College Press N. Habib, M.Y. Levicar, L. G. Jiao, and N. Fisk.

Paper 12 (B)Environmental Sciences and Biodiversity (60 h)

Unit I. Environmental Pollution (15h)

types of pollution methods for management of the pollution, Environmental management, waste water treatment, Solid waste management, degradation of xenobiotics in Environment, Bioremediation of xenobiotics and heavy metals, Ozone depletion, greenhouse effect and acid rains and their impact and biotechnological approaches of management. Use of microbes: Mineral beneficiation and oil recovery.

Unit II Ecosystem (15h)

Definition, Principles and scope of ecology, Human ecology and Human settlement, Evolution, Origin of life and speciation. Ecosystem : Structure and functions, Abiotic and Biotic components, energy flows, Food Chains, Food web, Ecological pyramids. Ecological Succession, Population, Community ecology and Parasitism, Preypredator relationships. Common flora and fauna in India Aquatic : Phytoplankton, Zooplankton and Macrophytes.

Unit III Biodiversity **(15h)**

Terrestrial : Forests Endangered and Threatened Species Biodiversity and its conservation : Definition, 'Hotspots' of Biodiversity, Strategies for Biodiversity conservation. National Parks and Sanctuaries. Gene pool. Microflora of Atmosphere : Air Sampling techniques, Identification of aeroallergens. Air-borne diseases and allergies. Environmental Biotechnology: Fermentation Technology, Vermiculture technology, Biofertilizer technology.

Unit IV Biodiversity Conservation **(15h)**

Biodiversity conservation Act 2002, Wildlife parks, wildlife reserves, privately owned wildlife reserves & Biosphere reserves , Single species / single habitat based conservation programmes (e.g. Project tiger, Valley of flowers), International conventions on conservation, Important International conventions &treaties on nature & conservation India's role & contribution (including VISION 2040) Ex- situ & in-situ conservation, Conservation Breeding (e.g. Vulture, Pygmy hog, Gharial etc.)

Books for study and references:

1. The primary readings will be from Fundamentals of Conservation Biology. Hunter M.L. and Gibbs J.P. Third Edition.
2. A Text Book of Environmental ScienceVidya Thakur (2016) – 307.
3. Biodiversity: Law, Policy and Governance Usha Tandon, Mohan Parasaran, Sidharth 2017 · Luthra.

(Practical 11) SCRM .2.3.P.2. Regenerative Medicine and its applications in Diseases (60h)

1. Isolation of $CD34^+$/ $EPCAM^+$cells from cord blood using magnetic cell sorting.
2. Isolation of MSCs from Placenta using magnetic cell sorting.
3. Potency Analysis of Hematopoietic Stem Cells Obtained from Umbilical Cord Blood using Colony Forming Units (CFU) Assay.
4. Potency Analysis of Hematopoietic Stem Cells Obtained from Umbilical Cord Blood using Aldehyde Dehydrogenase Enzyme Histochemistry.
5. Differentiation of Stem Cells in to various lineages.
6. Isolation of Cancer stem cells using magnetic cell sorting.
7. Case studies of stem cell therapy for various diseases.

(Practical 12) SCRM .2.3.P.2. Biomaterials and Tissue engineering and 3D Printing

1. Preparation of tissue engineered Alginate Capsules.
2. Tissue engineered composites Hydrogel.
3. Preparation and decellularization of porcine/ bovine tracheal scaffold.
4. Preparation of thin films by dip coating method.
5. CAM assay for biocompatibility of scaffolds.
6. 3D Printing of Scaffolds.

Practicals of Electives

(Practical 13) SCRM 2.3.P.3. Elective I (Choose any one)

Practical 13 (A) Clinical research, bioethics and regulatory affairs

1. Preparation of Informed Consent Process (ICF) for the following population.
   - Geriatric Patients
   - Pediatric patients
   - Psychiatric patients
   - Unconscious patients
2. Preparation of the standard operating procedures (SOP) for procurement and storage filing of Investigational product (IP).
3. Preparation of e-CRF(Electronic Case Report Form) for dummy clinical data.
4. Preparation of protocols for handling and disposal of laboratory Biohazard material and waste.
5. Preparation of Patent application Draft.
6. Preparation of Case study report of Karyotype and Pedigree analysis.

Practical 13 (B) Nanobiotechnology

1. Synthesis of Iron oxide nanoparticles by wet chemical method.
2. Synthesis of Gold Nanoparticles by biogenic methods.
3. Synthesis of Silver Nanoparticles by biogenic methods.
4. Isolation of enzymes involved in biosynthesis of nanomaterials.
5. To identify andanalyze the given nanomaterial by FTIR spectroscopy.

(Practical 14) SCRM.2.3.P.4. Elective II(Choose any one)

Practical 14 (A)Cryopreservation and tissue banking.

1. Introduction of different Cryopreservation Solutions and Formulation.
2. Protocol for Pre-freeze Processing and Post-freeze Processing of whole Blood Lymphocytes.
3. Liquid Nitrogen Safety and Quality Control Protocols.
4. Preparation of Umbilical Cord Blood Mono Nuclear Cells (UCMNCs) for cryopreservation.
5. Preparation of Umbilical Cord derived Mesenchymal Stem Cells (UCMSCs) for cryopreservation.
6. Chemically Defined and Xeno-Free Cryopreservation of Cord Blood Mono Nuclear Cells (UCMNCs).
7. Storage and Shipping of Frozen Cells in different Liquid Nitrogen (LN_2)Phases.
8. Thawing and Post-Thaw Processing using Trypan Blue Exclusion method.

Practical 14 (B) Environmental Sciences and Biodiversity

1. Determination of total organic matter in soil.
2. Determination of pH value of different types of soil.
3. Determination of water holding capacity of soil.
4. Prepare a map of India, showing bio-geographical zones and expanse of territorial waters.
5. Identification and description of plant species.
6. To plot biosphere reserve on a map of India.
7. Prepare a document of endemic and exotic species of plants and animals for a selected PAN.

(Practical 15) SCRM.2.3.P.5. ResearchProject Synopsis.

SEMESTER-IV

	University Exam marks	Internal marks	Total marks	Credits
(Practical 16) SCRM.2.4.P.1 Research Project				
Oral / Poster Presentation in conference/ workshop/ any other relevant program	-	100	100	4
Dissertation	200	-	200	8
Viva	200	-	200	8
Industry Visit and Report	100	-	100	4
Total	**500**	**100**	**600**	**24**

Standard of Passing

1. All external examinations will be held at the end of year and will be conducted by the University as per the existing norms.
2. Internal assessment- IA (20%) and University examination (80%) - shall have separate heads of passing (i.e. 8 Marks out of 20 for passing internal assessment and 32 out of 80 Marks for passing in University examination).
3. To pass, a student has to obtain minimum grade point E, and above separately in the IA and external examinations.
4. The candidate shall prepare and submit for the practical examination a certified journal based on the practical course carried out under the guidance of a faculty.
5. The candidate shall prepare the dissertation based on the Research Project for the fulfillment of degree.
6. As per ordinances and regulations prescribed by the University grading system.
7. The candidate shall have attendance record of not has than 75 % in theory class and not less than 80 % in practical work.
8. Standard point scale for grading:

Marks Grade Points and Class:

Grade	Marks	Class
O	70 and above	First class with Distinction
A	60 -69.99	First class
B	55-59.99	Second class
C	50 -54.99	Pass class
D	45-49.99	Pass class
E	40-44.99	Pass class
F	Fail 39.99 and below	Fail

Cumulative Grade Point Average (GPA) calculation:

The Final remark of class will be decided on the basis of Cumulative Grade Point Average (CGPA) which is weighted average of the grade point obtained in all the exams including repeat exams.

$$SGPA = \frac{\sum_{i=1} C_i p_i}{\sum_{i=1} C_i}$$

C_i = The number of credits earned in the ith course of a semester.

p_i = Grade point earned in the ith course

i = 1,2,....n represents number of courses for which the student is registered.

M. Sc. Sem.-…… - Examination, 202__
(Stem Cells & Regenerative Medicine)

Paper No-_____ Paper Name:_____

Total Duration: Section A+B = 3 Hours Total Marks (A+B): 80
Time: - 30 Minutes Date:-

SECTION – A
(MCQ)

Instructions:

1. *Darken the appropriate circle against the question number once only.*
2. *Use Blue/Black ball point pen only.*
3. *Each questions carries one mark.*
4. *A student will not be allotted any marks if he/she overwrites, strikes out or puts white ink on the circle once marked.*
5. *Do not write anything on the **blank portion of question paper.** If written anything, such type of act will be considered as an attempt to resort to unfair means.*

Q.1) Multiple Choice Questions **16×1=16**

1.
a. **b.**
c. **d.**

2.
a. **b.**
c. **d.**

3.
a. **b.**
c. **d.**

4.
a. **b.**
c. **d.**

5.
a. **b.**
c. **d.**

8.
a. **b.**
c. **d.**

9.

a. **b.**
c. **d.**

10.

a. **b.**
c. **d.**

11.

a. **b.**
c. **d.**

12.

a. **b.**
c. **d.**

13.

a. **b.**
c. **d.**

14.

a. **b.**
c. **d.**

15.

a. **b.**
c. **d.**

16.

a. **b.**
c. **d.**

SET-___

M. Sc. Sem……. - Examination, 202 _
(Stem Cells & Regenerative Medicine)

Paper No-_____ Paper Name:_____
Total Duration: Section A+B = 3 Hours

SECTION – B

Time: - 2 ½ hours **Date:-** **Total Marks: 64**

Instructions:

1. *Q. No. 2 is compulsory.*
2. *Attempt any three Questions from Q3 to Q7*
3. *The number to the right indicates full marks.*
4. *Draw diagrams wherever necessary.*
5. *Do not write anything on the blank portion of question paper. If written anything, such type of act will be considered as an attempt to resort to unfair means.*

Q 2	Write a short note on (**any 4**)		**16**
	a)		(4x4)
	b)		
	c)		
	d)		
	e)		
Q 3	a)	Long	**12**
	b)	Short	**04**
Q 4	a)	Long	**12**
	b)	Short	**04**
Q 5	a)	Long	**12**
	b)	Short	**04**
Q 6	a)	Long	**12**
	b)	Short	**04**
Q 7	a)	Long	**12**
	b)	Short	**04**

M. Sc. Sem.-…… - Examination, 2022
(Stem Cells & Regenerative Medicine / Medical Biotechnology)

Paper No-_____ Paper Name: Biostatistics and Bioinformatics

Total Duration: Section A+B = 3 Hours Total Marks (A+B): 80
Time: - 30 Minutes Date:-

SECTION – A
(MCQ)

Instructions:

1. *Darken the appropriate circle against the question number once only.*
2. *Use Blue/Black ball point pen only.*
3. *Each question carries one mark.*
4. *A student will not be allotted any marks if he/she overwrites, strikes out or puts white ink on the circle once marked.*
5. *Do not write anything on the **blank portion of question paper.** If written anything, such type of act will be considered as an attempt to resort to unfair means.*

Q.1) Multiple Choice Questions 16×1=16

Biostatistics

1. **a.** **b.**
c. **d.**

2.
a. **b.**
c. **d.**

3.
a. **b.**
c. **d.**

4.
a. **b.**
c. **d.**

5.
a. **b.**
c. **d.**

8.
a. **b.**
c. **d.**

Bioinformatics

9. a. b.
c. d.

10.
a. b.
c. d.

11.
a. b.
c. d.

12.
a. b.
c. d.

13.
a. b.
c. d.

14.
a. b.
c. d.

15.
a. b.
c. d.

16.
a. b.
c. d.

M. Sc. Sem……. - Examination, 202 _
(Stem Cells & Regenerative Medicine/ Medical Biotechnology)

Paper No-_____ Paper Name: Biostatistics and Bioinformatics
Total Duration: Section A+B = 3 Hours

SECTION – B

Time: - 2 ½ hours Date:- Total Marks: 64

Instructions:

1. *Q. No. 2 is compulsory.*
2. *Attempt any three Questions from Q3 to Q7*
3. *The number to the right indicates full marks.*
4. *Draw diagrams wherever necessary.*
5. *Do not write anything on the blank portion of question paper. If written anything, such type of act will be considered as an attempt to resort to unfair means.*

Q 2		**2.1 Write a short note on (From Bioinformatics) (Any 2)**	**16**
	a)		(4x4)
	b)		
	c)		
		2.2 Write a short note on (From Biostatistics) (Any 2)	
	a)		
	b)		
	c)		
Q 3	c)	Long answer question from bioinformatics	**08**
	d)	Long answer question from Biostatistics	**08**
Q 4	e)	Long answer question from bioinformatics	**08**
	c)	Long answer question from Biostatistics	**08**
Q 5	f)	Long answer question from bioinformatics	**08**
	c)	Long answer question from Biostatistics	**08**
Q 6	g)	Long answer question from bioinformatics	**08**
	c)	Long answer question from Biostatistics	**08**
Q 7	h)	Long answer question from bioinformatics	**08**
	c)	Long answer question from Biostatistics	**08**

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