

Course: M.Sc/M.Tech in different disciplines – MMST/ Biotechnology/ Biosciences etc.

Subject Title: Stem Cell Biology and Therapy

Subject Structure and Credit: L-T-P: 4-0-0

Credits: 4

Status of Subject: Elective

Pre-requisite of the subject: None

Objectives:

1. To understand the fundamentals of stem cell biology.
2. To orient students with the latest developments in stem cell research and their potential application in clinics.
3. To understand the molecular regulation of stem cells.
4. To provide students with information on the experimental methods and tools in use in stem cell research.
5. To appreciate the ethical concerns and regulatory issues related to stem cell research.

Details:

Introduction to different types of stem cells; their importance, sources, availability and present status in clinics and research

What does a stem cell mean? History of stem cell research. Explanation of totipotency, pluripotency and multipotency. Introduction to the different types of stem cells. What is the difference between embryonic and adult stem cell. Importance of stem cells.

Embryonic Stem (ES) Cells, Adult Stem (AS) Cells, Induced Pluripotent Stem Cells (iPSCs)

Differences between embryonic and adult stem cells. Fate of early embryonic cells. Ethical concerns with ES cells. Adult stem cells: Mesenchymal and hematopoietic stem cells. Sources and biology of different types of adult stem cells. Availability of adult stem cells and their current clinical use. What are iPSCs? Possible techniques of inducing pluripotency, nuclear transfer, cell-culture-induced reprogramming etc.

Cell signaling pathways: Introduction, cellular communications, different types of involved in MSC proliferation and differentiation

Introduction to cell signaling pathways. Communication between cells – electrical and chemical mechanisms. Basic concepts of cell signaling mechanisms - concepts of cell stimuli, receptors, transducers, amplifiers, messengers, sensors and effectors, cellular responses. Examples of the various components of signaling pathways. Cell signaling pathways involved in paracrine secretions of MSCs. Major cell signaling pathways involved in proliferation and differentiation of MSCs (example: TGF-beta/BMP, Wnt, FGF, Notch, Hedgehog etc.)

Small RNAs and stem cells

What are small RNAs? Biogenesis of microRNAs. miRNAs and their mechanism of action. Target predictions and analysis. Role of miRNAs in regulation of ES cells. Role of miRNAs in regulation of MSCs. miRNAs and their role in certain pathological conditions

Immunomodulatory properties of mesenchymal stem cells

Characteristics of MSCs. Mechanisms of immunomodulation by MSCs. Interaction of MSCs with T cells, B cells and NK cells. Induction of immune tolerance in host. MSCs and Induce Immune Tolerance in the Host Applications of immunomodulatory properties of MSCs: Graft vs. Host Disease (GVH), autoimmune diseases, organ transplantation. Future directions.

Homing of mesenchymal stem cells to injured tissues

Homing capacity of MSCs. Therapeutic effects of the ability to home. Mechanisms of Leukocyte Trafficking to sites of inflammation. Potential ligand/ receptors for MSC homing. Chemokines.

Cancer and stem cells

Introduction. Relationship between normal and cancer stem cells, Prospective isolation of cancer stem cells. Origin of cancer stem cells. Solid tumor stem cells – tumor stem cells in CNS and other organ systems. Signaling pathways in cancer stem cells. Signaling pathways in cancer stem cells. Clinical implications.

Experimental tools for stem cell research

In vitro differentiation of MSCs to different cell types. Basics of cell sorting. Flow cytometry. Polymerase Chain Reactions (PCR), Western Blotting, Transformation, Transfection. Molecular Cloning.

Introduction to Biomicrofluidics

Adult Stem Cells and their niches

The niche concept. Components of stem cell niches. Molecular pathways associated with functions of niche. Extracellular matrix and inter-cellular interactions. Stem cell niche dynamism and aging, malignancy stem cell niches.

Application of biomaterials in modulation of stem cells

Physicochemical effects on MSC fate. Physicomechanical control of MSC fate. Micro- and Nano-Structural Control of MSCs Fate.

Stem Cell Therapy: Applications, current status and future prospects

MSCs in cardiovascular diseases. MSCs in Graft vs. Host diseases, MSCs for liver diseases, bone repair, diabetes. Reprogramming of somatic cells to pluripotency. Generation of iPSCs. Directed reprogramming of cells. Future prospects.

Ethical considerations and regulatory affairs governing present day stem cell therapy

Regulatory challenges. Regulations and guidelines. Perspectives in different countries (US, EU, China, India). Harmonization.

Recent advances and trends in stem cell research

Understanding emerging trends in stem cell research. Newer experimental tools coming into practice. Stem cell therapeutics and market trends. Looking into the future.

Case studies and discussions

Discussions on clinical cases, trials and evidences in practice.

Suggested Textbooks:

1. The Cell Biology of Stem Cells. Edited by Eran Meshorer and Kathrin Plath. In Advances in Experimental Medicine and Biology, Volume 695. Year - 2010
2. Essentials of Mesenchymal Stem Cell Biology and Its Clinical Translation. (Ed) Robert Chunhua Zhao. Publisher: Springer Science+Business Media. Year – 2013

Suggested Literature:

1. Lobo, N.A., et al., The biology of cancer stem cells. Annu Rev Cell Dev Biol, 2007. 23: p. 675-99.
2. Other relevant research publications.