Syllabus template

Semester: 7	
Course : MAJOR 2	
Paper Title: Protein Trafficking & Cell Signaling	
Paper code:	**Credits: 4**
Hours/week: 4	
Category: Core/MDC/SEC/VAC: Core	
Theory / Practical / Composite: Theory	
No of Modules: 2	

Course Overview: From this course, students will gain knowledge on how cells interact with its local, as well as global environments, including interaction with their neighbouring cells. Protein trafficking deals with import and export of cargoes by cells while signaling involves adjustment of cells with changing environments, both intracellular and extracellular. Any error in these two interrelated disciplines can lead to pathological states. A thorough understanding of mechanisms of protein trafficking and cell signaling will help students to understand the modes of action of various marketed drugs that specifically target these processes when they malfunction.

Course Outcome:

Module A

1. **Recall** structure and function of cells including intracellular organelles, with special emphasis on the ER-Golgi network and plasma membrane.
2. **Explain** the basic mechanisms of protein trafficking and cell signaling pathways.
3. **Apply** knowledge of different biophysical, biochemical and genetic techniques to understand the experiments that were conducted in the past to decipher protein trafficking and signaling pathways.
4. **Analyse** in depth molecular mechanisms of these processes.
5. **Evaluate** physiological significances of protein trafficking and cell signaling and realise the adverse effects on the normal functioning of cells in case of any dysregulation.
6. **Design** experimental approaches to understand in depth, the intricacies of these processes, which are yet to be unfolded.

Module B

1. **Recall** different types of non-covalent interactions, membrane properties, protein modifications and catalytic turnovers which are all part and parcel of cell signaling pathways be it at the level of ligand-receptor interaction, interaction between downstream molecule, amplification of signal or functions served by effector molecules.
2. **Explain** the general principles of cell signaling taking examples of the major signaling pathways that are downstream of mostly all signal-receptor interaction.
3. **Apply** the knowledge gained from in depth study of major signaling pathways, to understand why signal network of a cell is called a ‘bow tie’ or an ‘hour glass’ network .
4. **Analyse** the different experimental techniques routinely used in deciphering signaling pathways and develop the expertise to choose the right technique to address a specific question.
5. **Evaluate** the physiological significances of the different signaling pathways covered in the syllabus and develop a sense of how and where, under pathophysical states, these pathways can be targeted by drugs.

6. **Design** a signaling pathway by assimilating observations collected from multiple experiments or design proper experiments to decipher a signaling pathway starting from ligand-receptor interaction to generation of effector molecules. Gaining capability of judicious designing of agonists, antagonists, or biased ligands for targeting malfunctioning signaling pathways is the ultimate application of this module.

Prerequisites: Basic knowledge of cell including intracellular organelles, components and structure of membrane and cytoskeleton.

SYLLABUS

Module A: Protein Trafficking

UNIT I: Protein localization based on fluorescence-based techniques.
UNIT II: Intracellular Compartments and Protein Sorting: The Transport of Molecules Between the Nucleus and the Cytosol; Transport of Proteins into Mitochondria; Peroxisomes; Endoplasmic Reticulum
UNIT III: Vesicular trafficking:
Transport from the ER Through the Golgi Apparatus; Transport from the *Trans* Golgi Network to Lysosomes; Secretory protein trafficking; Endocytosis and Exocytosis

Module B: Cell Signaling

Unit IV: General principles of cell signaling – ligand, receptor, intracellular signaling molecules including domains involved in protein-protein interactions, second messengers, and effector molecules;
Unit V: General techniques frequently used in cell signaling studies – co-immunoprecipitation, western, ELISA, wound-healing assay, Boyden chamber, immunofluorescence, flow-cytometry: analysis and sorting;
Unit VI: Some major signaling pathways involving cell surface receptors – G-protein coupled receptor (GPCR) signaling including sensory signaling, and receptor tyrosine kinase (RTK) signaling with a special mention of insulin signaling, brief discussion on cardiovascular drugs targeting specific GPCRs and cancer drugs targeting specific RTKs, receptors associated with serine/threonine kinase activity with special reference to cytokine signaling;
Unit VII: Steroid hormone signaling involving cytoplasmic and nuclear receptors;
Unit VIII: Receptor-independent signaling by nitric oxide (NO);
Unit IX: Concept of 'Bow Tie' or 'Hour Glass' signaling network – a few common pathways like mitogen-activated protein kinase (MAPK), phosphatidylinositol 3' kinase (PI3K), phospholipase C (PLC) including Ca^{2+}-signaling, and JAK-STAT pathways, upstream and downstream of which are a diverse range of signals and effectors, respectively.

UNIT/Module	CONTENT	HOURS or NUMBER OF CLASSES	CO Mapping	COGNITIVE LEVEL
Module A	**Protein Trafficking** **UNIT I:** Protein localization based on fluorescence-based techniques **UNIT II:** Intracellular Compartments and Protein Sorting: The Transport of Molecules Between the	**24**	**CO 1-6**	**K 1-6**

	Nucleus and the Cytosol; Transport of Proteins into Mitochondria; Peroxisomes; Endoplasmic Reticulum **UNIT III:** Intracellular Membrane Traffic: Molecular Mechanisms of Membrane Transport; Transport from the ER Through the Golgi Apparatus; Transport from the *Trans* Golgi Network to Lysosomes; Endocytosis and Exocytosis			
Module B	**Cell Signaling** **Unit IV:** General principles of cell signaling – ligand, receptor, intracellular signaling molecules including domains involved in protein-protein interactions, second messengers, and effector molecules; **Unit V:** General techniques frequently used in cell signaling studies – co-immunoprecipitation, western, ELISA, wound-healing assay, Boyden chamber, immunofluorescence, flow-cytometry, FACS; **Unit VI:** Some major signaling pathways involving cell surface receptors – G-protein coupled receptor (GPCR) including sensory receptors, and receptor tyrosine kinase (RTK) with a special mention of insulin signaling, brief discussion on cardiovascular drugs targeting specific GPCRs and cancer drugs targeting specific RTKs, receptors associated with serine/threonine kinase activity with special reference to cytokine signaling; **Unit VII:** Steroid hormone signaling involving cytoplasmic and nuclear receptors;	**24**	**CO 1-6**	**K 1-6**

	Unit VIII: Receptor-independent signaling by nitric oxide (NO); **Unit IX:** Concept of 'Bow Tie' or 'Hour Glass' signaling network – a few common pathways like mitogen-activated protein kinase (MAPK), phosphatidylinositol 3' kinase (PI3K), phospholipase C (PLC) including Ca^{2+}-signaling, and JAK-STAT pathways, upstream and downstream of which are a diverse range of signals and effectors, respectively.			

Text Books for Modules A & B

1. **Molecular Biology of the Cell - Alberts, Johnson, Lewis, Raff, Roberts & Walter (4thed)**
2. **Molecular Cell Biology Lodish and Darnell et. al (5th edition)**
3. **Leininger Principles of Biochemistry - Nelson & Cox (5th Ed)**

Suggested readings

1. **Signal Transduction – Principles, Pathways & Processes – Cantley, Hunter, Sever & Thorner**

Evaluation

Paper Structure for Theory Semester Exam Module :

Theory (100)
CIA- 20
Assignment – 05
Attendance - 05
Semester Exam- 70

Module A (35 marks):

1 compulsory question of 10 marks, comprising objective problems
5 questions of 5 marks (with choice, subparts not less than 1 mark)

Module B (35 marks):

1 compulsory question of 10 marks
2 out of 3 questions of 12.5 marks each
(no sub-part will be less than 1 or more than 5 marks)

Course outcomes (COs) and Cognitive Level Mapping

COs	CO Description	Cognitive levels
Module A		

CO 1	Recall the principles of fluorescence-based protein localization techniques and list the major intracellular compartments involved in protein sorting and membrane trafficking	**K 1**
CO 2	Explain mechanisms of protein sorting and intracellular membrane transport pathways.	**K 2**
CO 3	Apply fluorescence-based techniques to determine protein localization and infer intracellular targeting pathways.	**K 3**
CO 4	Analyse molecular mechanisms of vesicular transport and protein sorting.	**K 4**
CO 5	Evaluate experimental data related to protein localization and trafficking.	**K 5**
CO 6	Design experimental approaches to study intracellular protein transport.	**K 6**
Module B		
CO 1	Recall different types of non-covalent interactions, membrane properties, protein modifications and catalytic turnovers which are all part and parcel of cell signaling pathways be it at the level of ligand-receptor interaction, interaction between downstream molecule, amplification of signal or functions served by effector molecules.	**K 1**
CO 2	Explain the general principles of cell signaling taking examples of the major signaling pathways that are downstream of mostly all signal-receptor interaction.	**K 2**
CO 3	Apply the knowledge gained from in depth study of major signaling pathways, to understand why signal network of a cell is called a 'bow tie' or an 'hour glass' network .	**K 3**
CO 4	Analyse the different experimental techniques routinely used in deciphering signaling pathways and develop the expertise to choose the right technique to address a specific question.	**K 4**
CO 5	Evaluate the physiological significances of the different signaling pathways covered in the syllabus and develop a sense of how and where, under pathophysical states, these pathways can be targeted by drugs.	**K 5**
CO 6	Design a signaling pathway by assimilating observations collected from multiple experiments or design proper experiments to decipher a signaling pathway starting from ligand-receptor interaction to generation of effector molecules. Gaining capability of judicious designing of agonists, antagonists, or biased ligands for targeting malfunctioning signaling pathways is the ultimate application of this module.	**K 6**