TCIS, Hyderabad

Course: Cell physiology and Cell signaling

Start Date: 9th August 2017

Coordinates (Preferred): Monday and Wednesday between 11.30 am and 01.00 pm

Instructor(s): Dr. G. V. Velmurugan (Velu)

Syllabus:

Physiology is the science of life. Cell physiology is the functional side of biology and this course will discuss the basic physiological, biophysical and signaling properties of the cell. In this course, membrane biophysics and electrophysiology will be discussed in detail. Electrolyte and ion channel mediated action potential integrates different biological systems such as nervous, muscular (including cardiac cells) and endocrine system which are usually excitable in nature. Importantly, this course will also discuss about the endoplasmic/sarcoplasmic reticulum and mitochondria mediated Ca^{2+} signaling, mitochondrial ATP production and signal transduction of cell survival and death pathways in detail. Any alteration in physiology leads to pathological condition. Different pathological/medical conditions will be discussed wherever it is necessary. In a big picture student will learn how the basic structural and functional unit of the organism in a collection works as an intact system and functions in an integrated fashion.

Diffusion, osmosis and cell volumes: Understand how electrolytes and non-electrolytes change the cell volume in closed and open system under different experimental conditions. Provide examples for each experimental condition, how intra-cellular and extracellular permeants and impermeants change the flow-volume and ultimately the cell-volume. Know the similarities and differences between diffusion and osmosis. Provide examples to calculate the cell volume and osmotic pressure under different experimental conditions. Understand the difference between, molarity, osmolarity, equivalence and milli-equivalence. Explain why body fluids are measured in Osmolarity or milli-equivalence.

Body fluid volume: Learn the composition of body fluids; Intra-cellular Fluid (ICF), Extra-cellular Fluid (ECF), Interstitial Fluid (IS), Plasma volume (PV). Discuss how fluid loss changes the body fluid composition and the cell volume (ex: vomition, diarrhoea, sweating, etc.). Explain how body fluid volume could change the normal homeostasis and cell signaling.

Membrane Transport system: Know the similarities and differences between diffusion, facilitated diffusion, primary and secondary active transport, co-transport and counter transport. Provide examples of each type of transport. Understand the energy source which drives each type of transport. Understand the difference between pores, channels and pumps.

Ionic equilibrium, current voltage diagrams and membrane potential: Explain how chemical and electrical potential is getting developed in the cell and why cell maintains negative membrane

potential? Explain and derive Nernst potential equation. Understand the importance of Na^{2+}, K^{+}, Cl^{-} and Ca^{2+} ions and Na^{2+}/K^{+} pump in the context of membrane potential. Provide examples to calculate membrane potential from Nernst potential. Explain ionic current, conductance and permeability to understand the current-voltage (I-V) relationship and membrane potential. Give introduction to patch-clamp technique to measure the membrane potential and channel activity. Summarize Nernst potential, membrane potential, chord conductance equation and the resting membrane potential. Classify different types of ion channels.

Generation and transmission of Action potential: Explain the resting membrane potential, subthreshold potential, threshold potential and refractory period. Understand the sequence of events in the action potential, ion channels involved and transmission of action of potential. Explain the cable theory in comparison with neuronal signal transmission. Explain how depolarization and repolarization in cardiac myocytes measure as electro cardiogram (ECG).

Neuromuscular junction (NMJ) and central synapses: Learn the structure of a neuromuscular junction and the sequence of events that lead to neurotransmission. Understand end plate potential, miniature end plate potentials and spontaneous end plate potentials. Understand the properties of acetylcholine receptor and their importance in depolarization. Differentiate NMJ and central synapses.

Neurotransmitters in cell signaling: Learn different neurotransmitters involved in central and peripheral nervous system. Understand the signaling mechanism how it modulated ion channel and membrane proteins as a signaling molecules. Know different ion channel blockers and its toxicological effect and pharmaceutical usage by in modulating cell signaling.

Mitochondrial electron transport system and ATP production: Learn the structure and mitochondrial membrane potential. Understand the electron transport process and the respiratory enzyme complexes. Understand the mechanism of ATP synthesis using proton gradient and mitochondrial energy metabolism. Understand the importance of mitochondrial Ca^{2+} signaling. Learn about mitochondrial uncoupling protein (UCP) and mitochondrial calcium uniporter (MCU). Learn how UCP involved in hibernation. Learn how to image mitochondria using fluorescent dye.

Ca^{2+} signaling: Understand the important roles of calcium as a secondary messenger. Learn about Ca^{2+} channels (voltage gated Ca^{2+} channel, Store operated Ca^{2+} channel (SOC), etc.) and pumps (SERCA and PMCA). Know more about endoplasmic reticulum, intracellular and extracellular Ca^{2+} signaling. Learn Ca^{2+} imaging techniques using Fluo-4 and Fura-2.

Reactive oxygen species (ROS) signaling: Learn the mechanism of ROS generation in mitochondria and plasma membrane. Understand the physiological and pathological significance of ROS signaling.

Cell signaling pathways (cell survival and cell death signaling):
Learn the basic principles and classification of cell signaling pathways. Know about various types of receptor and cell stimuli involved in cell signaling. Understand different cell signaling pathways and proteins involved; PIP pathway, Akt/PI3K, MAP kinase, GPCRs, cAMP, cGMP, PKA, PKC, PLC etc.

Learn apoptotic and anti-apoptotic proteins and the signaling mechanism. Differentiate apoptosis, necrosis and autophagy. Understand different caspase proteins and their roles. Explain the relationship between Ca^{2+} signaling in apoptosis.

Primary Text / Reference Books:

Cell Physiology Source Book by Nicholas Sperelakis
Medical Physiology by Guyton
Principles of Physiology by Berne and Levy
Hand book of Cell Signaling by John T. Hancock

Evaluation Method (Weightage for Internal Assessment, Mid Term / Term End exams, Presentations etc.):

Midterm: 20 marks
Final Examination: 50 marks
Scientific paper presentation: 20 marks
Assignment: 10 marks

Course Evaluation: Midterm and final examinations for 20 and 50 marks respectively. Scientific paper presentation and assignment carries 20 and 10 marks respectively. Select the scientific paper related to the course content and relatively recent one. Student has to prepare power point slides to present and critic the paper. Choose the best answer questions will have more mathematical problems and physiological situation.

Midterm examination:
10 marks for choose the best answer type question (20 question)
10 marks for essay type question (5 questions)

Final examination
30 marks for choose the best answer type question (60 questions)
20 marks for essay type question (10 questions)