Curriculum

Ph.D.

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Indian Institute of Technology Jodhpur

Ph.D. (Biology)

Cat.	*Course Number: Course Title*	*L-T-P*	*Credits*		*Cat.*	*Course Number: Course Title*	*L-T-P*	*Credits*
I Semester					**II Semester**			
E	*Electives*				E	*Electives*		
			Total					*Total*
III Semester					**IV Semester**			
H	**BL799 Ph.D. Thesis**				H	**BL799 Ph.D. Thesis**		
			Total					*Total*
V Semester					**VI Semester**			
H	**BL799 Ph.D. Thesis**				H	**BL799 Ph.D. Thesis**		
			Total					*Total*
VII Semester					**VIII Semester**			
H	**BL799 Ph.D. Thesis**				H	**BL799 Ph.D. Thesis**		
			Total					*Total*

Electives

Semester I				Semester II			
BL751	Physiology and Neuroscience	3-0-0	3	BL756	Biomacromolecules and Bioengineering	3-0-0	3
BL752	Computational and Systems Biology	3-0-0	3	BL757	Cellular and Molecular Neuroscience	3-0-0	3
BL758	Neuroengineering Systems	3-0-0	3				

S.No.	***Category***	***Category Title***	**Students with**	***Total Courses***	***Total Credits***
1	E	*ELECTIVES*	Master's Degree	4	12
			Bachelor's Degree	10	30
2	H	Thesis	-	-	-

Course Title	***Neuroscience and Physiology***	Course No.	**BL751**			
Department	Biology	Structure	3	0	0	3
Offered for	PhD students	Status	Core		*Elective*√	
Faculty Members Offering		Type	*New*		Old √	
Pre-requisite	*Consent of Teacher*	To take effect from				

Objectives

To produce students and future engineers who:

1. Have a basic understanding of neuroscience and physiology
2. Can design experiments and evaluate research papers
3. Have good oral and written communication skills
4. Are creative, independent and critical thinkers

Learning Outcomes

1. To understand basics of neuroscience and physiology;
2. To be able to integrate basics with research questions.

Course Content

1. Organization of tissues and basic physiology of organs
2. Fundamentals of Sensory Systems
3. Somatosensory System
4. Fundamentals of Motor Systems
5. Fundamentals of Vision System
6. Introduction of Neuroscience and basic plan of nervous system
7. Cellular and Molecular Neuroscience and Cellular component of Nervous Tissue
8. Microcirculation, Cerebral and Pulmonary circulation
9. Generation and survival of nerve cells, Generation and survival of glia
10. Regulation of innate immune responses in the human brain, Introduction to neuroimmunology
11. Introduction to cellular and molecular neuroscience, Microglia in neuroinflammation, Astrocytes in neuroinflammation
12. Introduction to Endocrinology, Key Hormones pathways, Neuroendocrine pathways
13. Breathing, Acid base balance, Neural control of respiration

Paper presentations

Students will present a scientific paper from the assigned reading section. This presentation will be graded on the critical analysis of the research as well as presentation skills

Reference Books

1. Kandel, E. R., Schwartz, J. and Jessell, T., *Principles of Neural Science*, 4th Edition, McGraw-Hill, 2000
2. Lodish, H. *et al*, *Molecular Cell Biology*, 6th Edition, W. H. freeman, 2007
3. Squire, L. R. *et al*, *Fundamental Neuroscience,* 3rd Edition, Academic Press, 2008
4. Reece, J. B. *et al,* Cambell Biology, 9th Edition, Benjamin Cummings, 2010

Course Title	***Computational and Systems Biology***	Course No.	**BL752**			
Department	Biology	Structure	3	0	0	3
Offered for	PhD students	Status	Core		*Elective*√	
Faculty Members Offering		Type	*New*		Old √	
Pre-requisite	*Basics understanding of biology and computation*	To take effect from	*July 2013*			

Objectives

1. To initiate the students into areas on the interface of biology and computation
2. To introduce and train in the aspects of systems biology and its applications

Learning Outcomes

1. Learning the fundamentals of computational and systems biology.
2. Getting detailed understanding of few of the computational methods used in modern biology.

Course Content

*Introduction to Biological Complex Systems: D*efinition and notion of system and complexity, Natural selection and evolution of biological systems, Adaptability; Differences in engineered vs. evolved systems

Biological Sequences and Alignment: Biological sequences: DNA, RNA, Protein, Sequence Alignment; phylogeny, Basics of Dynamic programming, Needleman and Wunsch Algorithm, Applications of alignment algorithms

Biological Macromolecules: Proteins- Introduction to proteins, Basic ingredients, Ramachandran Plot, Protein structure, function and folding, Protein structure organization, Protein folding models, First principle and Knowledge-based models

Homology Modeling and Clustering Methods: Basics of protein structure modelling, Homology modeling, Basics of clustering, K-means clustering

Microarray: Data and Analysis- Basics of microarray technique, Applications of microarrays, Data compilation and analysis, Construction of network models from microarray data

Introduction to Graph Theory and Systems Biology: Introduction to graph theory, Graph theoretical metrics, Application of graph theoretical analysis for biological systems modelling

Systems Biology: Applications- Gene regulatory networks, Protein-protein interactomes, Anatomical networks

Reference Books

1. Branden, C. and Tooze, J., *Introduction to protein structure*, 2nd Edition, Garland Science, 1999
2. Bar-Yam, Y., *Dynamics of Complex Systems*, Addison-Wesley, Reading (MA), USA, 1997

Course Title	**Biomacromolecules and Bioengineering**	Course No.	BL756
Focus Group	Biology	L-T-P[C]	3-0-0[4]
Offered for		Type	Elective
Pre-requisite	Introduction to Biology	To take effect from	July 20, 2014

Objectives:	**Learning Outcomes:**
1. To gain basic foundational knowledge on biomacromolecules, their structure and function 2. To have a greater understanding of wider applications of proteins in biotechnology including drug-design, protein engineering and novel biomaterials applications.	1. Understanding biological molecules from detailed molecular structure to macro molecular assemblies. 2. To use the concepts of the above foundational knowledge to understand bioengeering applications 3. To be able to build a connection between principles of biology and biotechnology applications.

Contents:

Definition and introduction to Biomacromolecules: Building blocks, Water, Elementary ideas of structure, Chemical bonding, Properties and optical activity; and hydration, biothermodynamics, amino acids, Secondary, tertiary and three-dimensional structures, complex structures, Nucleic acids and Polysaccharides.

Specific examples of Biomacromolecule: Globular proteins (Hemoglobin); Fibrous protein (Collagen); Membrane proteins (Calcium Channels); Receptors (Glyco-proteins); Hormones (Insulin).

Protein folding, misfolding, and aggregation: Concept and importance of protein folding/misfolding, Energetics, Biophysical techniques for biomacromolecules including chromatography, spectroscopy and calorimetry methods. Purification, characterization of properties.

Enzymes and Mechanism of Enzyme Action: Enzymes; Mechanism of enzyme action; Substrate specificity; Coenzymes; Regulation of enzymatic activity; Enzyme kinetics, inhibition; Effect of pH, temperature, and solvent; Arrehenius equation for activation energy.

Protein design and engineering: Strategies to alter catalytic efficiency; Drug-protein interactions and Therapeutic designs, Applications of rationally engineered proteins e. g. nanowires, tissue scaffolds, biomaterials, immoblized enzymes, Drug Delivery systems.

Reference Books:

1. Cox, M. M, Nelson, D. L. , Lehninger Principles of Biochemistry, W. H. Freeman & Co, 2009.
2. Stryer, L. , Berg, J. M. , Tymoczko, J. L. , Biochemistry, W. H. Freeman & Co Ltd 2012
3. Voet, D. , Voet, J. G. , Pratt, C. W. , Fundamentals of Biochemistry: Life at the Molecular Level, Wiley, 2012
4. Creighton, T. E. , Proteins: Structures and Molecular Properties, W H Freeman & Co; 3rd edition, 2013
5. Campbell, N. A, Reece, J. B. , Urry, L. A. , Cain, M. L. , Wasserman, S. A. , Minorsky, P. V. , Jackson, R. B. , Biology, 8th Edition, Pearson- Benjamin Cummings, 2009.

Course Title	***Cellular and Molecular Neuroscience***	Course No.	**BL757**			
Department	Biologically Inspired System Science	Structure (LTPC)	3	0	0	3
Offered for	PhD students	Status	Core		*Elective* √	
Faculty Members Offering		Type	*New* √		Old	
Pre-requisite	*None*	To take effect from	30Dec2013			

Objectives

1. The purpose of this course in Cellular and Molecular Neuroscience is to acquaint students with the experimental basis for our current concepts of nervous system function
2. This is NOT a survey course. It is a demanding discussion-based course that meets for 3hours each week with additional optional meetings outside of the class. The goals of the course are not so much to inform as to foster an understanding of how we accumulate our information; not to provide a complete textbook picture of the functioning nervous system as we know it but

Learning Outcomes

1. To provide mental tools to evaluate current and future hypotheses;
2. To define unanswered research questions.

Course Content

1. Universal features of cells in the nervous system, Chemical components, Cell Metabolism, Cell membrane composition and effects on function.

2. Proteins and Protein function , Creutzfeldt-Jakob disease, Control of gene expression, Membrane transport, Protein import and secretion, Protein sorting and endocytosis.

3. Alzheimer's disease, The cytoskeleton, Contractility, Excitability, Addiction, G proteins and hormones, Tyrosine kinases and signalling, Cell cycle regulation, Cell cycle dysregulation, Gliomas

4. Manipulating proteins, DNA and RNA, Cell culture and fractionation, Isolating, cloning and sequencing DNA, Analyzing protein structure and function, Visualizing cells under a microscope, Visualizing molecules in a living cell

5. Research paper presentations and discussions

Books

1. Principles of Neural Science, 4th Edition, Eric Kandel, James Schwartz, Thomas Jessell, Hard cover.
2. Molecular Cell Biology, 6th Edition, Lodish Berk , Kaiser Krieger, Hard cover.
3. Alberts B. et al, Molecular Biology of the Cell (4th Ed.) Garland Publications
4. Reference papers for paper presentations

Course Title	**Neuro Engineering Systems**	Course No.	**BL758**			
Department	Biology	Structure (L-T-P-C)	3	0	0	3
Offered for	Ph.D. Students	Status	*Elective*			
Pre-requisite	*Consent of Teacher*					

Objective

1. To help broadening students' understanding of applicability of engineering.
2. To emphasize the need of learning neuroengineering in order to confer health benefits to the mankind.

Learning Outcomes

1. The course will empower engineering students with biological basics, which would be helpful in technical solutions.
2. Students will be benefited through learning biological applications of their engineering skills.

Contents

*Preface - Most Complex Machine***:** Brain as designed by Evolution and comparison with complex machines, Turing test and computational limitations of *Homo Sapiens* and representative examples

Neuronal Tissue Engineering: Neuronal augmentation, Neuronal prostheses – sensory and motor prostheses and their general design, introduction to grafting methods – case studies and issues

Functional Aspects of Neuroengineering Systems: Elucidating motor, auditory and sensory tasks in terms of conceptual aspects of neuronal response, mirror neurons, neuronal Patch clamping in various function areas. General concepts and issues, principles of BMI and plasticity and neuronal column organization

Neural Signal Processing: Meaning of information, transmission of neuronal signal and processing, encoding and decoding of neuronal signals, spatiotemporal dynamics of neuronal signals

Neural Networks: Introduction to neural networks, artificial neural networks, single and multilayer neural networks, perceptron, applications and future perspectives

Neuronal Repair and Neuromodulation: Definitions of neuronal growth, regrowth and repair, Mechanisms of action for neuronal stimulation, Responsive neurostimulation, Pain management through deep stimulation of brain and spinal cord

Reference Books

1. DiLorenzo, D.J., and Bronzino, J.D., (2007), Neuroengineering, First Edition, Taylor and Francis, CRC Press
2. Akay, M., (Ed.) (2006), Handbook of Neural Engineering, Wiley Publishers, USA
3. Kandel, E.R., (2012), Principles of Neural Science, Fifth Edition, Elsevier, USA
4. Zigmond, M.J., (2012), Fundamental Neuroscience, Fourth Edition, Elsevier, USA