

<b>Course title:</b> Molecular Microbiology and Immunology				
<b>Course code:</b> BBP 131	<b>No. of credits:</b> 2	<b>L-T-P:</b> 30-0-0	<b>Learning hours:</b> 30	
<b>Pre-requisite course code and title (if any):</b> BBP161 Principles of Biochemistry and Biophysics (semester 1)				
<b>Department:</b> Department of Biotechnology				
<b>Course coordinator:</b> Dr. Chaithanya Madhurantakam		<b>Course instructor:</b> Dr. Chaithanya Madhurantakam		
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<b>Course type:</b> Core		<b>Course offered in:</b> Semester 2		
<b>Course description:</b> The course is designed to provide students with basic concepts, principles and applications of molecular microbiology and immunology. The course aims to introduce microbial systems to the students and molecular basis of microbial pathogenicity and resistance. Various mechanisms employed by microbes against host immune responses will be covered at a molecular level. The course will provide information on microbial growth patterns and pathogens. Further, basic concepts in immunological responses including adaptive T cell and B cell responses will be described including T cell receptor/MHC interactions and antigen-antibody interactions. The section on molecular assays and techniques will comprehensively provide concepts and principles of major microbiological and immunological methods employed regularly in research laboratories. Finally, through this course, actual concepts and insights within cancer biology and potential anti-cancer therapies are provided.				
<b>Course objectives:</b> 1. To introduce students to pathogens and microbial systems that have commercial applications. 2. Providing students with fundamentals of microbial growth and kinetics. 3. Familiarizing students with concepts of microbial drug resistance and the underlying molecular basis. 4. Acquainting students with basic concepts of immunology, with a focus on the molecular bases underlying TCR/pMHC and antibody/antigen interactions 5. Familiarizing students with various molecular techniques employed in microbiology and immunology. 6. Acquainting students with molecular mechanisms underlying cancer development and anti-cancer therapies.				
<b>Course contents</b>				
<b>Module</b>	<b>Topic</b>	<b>L</b>	<b>T</b>	<b>P</b>
<b>Module 1: Microbes and Microbial applications</b>				
	Pathogens (classification/structure and function), Infection life cycles of viruses and bacteria, Pathogen host interactions, Viral vectors in gene and cancer therapy, Molecular compounds of microbial origin for agriculture, industry, and pharmaceuticals	2	0	0
<b>Module 2: Microbial Kinetics</b>				
	Microbial growth and kinetics, batch, and continuous process, Microbial strain improvement for pharmacologically active agents	3	0	0
<b>Module 3: Microbial Pathogenicity and Resistance</b>				
	Molecular basis of pathogenicity and resistance of bacteria against host immune responses, Drug resistance: <i>Mycobacterium tuberculosis</i> (MDR-TB and XDR-TB) and <i>Streptococcus pneumoniae</i> , Mechanisms employed by bacterial toxins (cholera, diphtheria, and tetanus), Microbial transformation of antibiotics	4	0	0

<b>Module 4: Antibodies and Antigens</b>			
Immunoglobulins- structure and function, Antigenic Determinants (isotype, allotype, idiotype), Antigens (types of antigens, characteristics of an antigen), Adjuvants, Cellular and Humoral immunity, Antigen presentation, TCR, pMHC, Monoclonal antibodies (mAbs), Hybridoma technology, characterization of mAbs through epitope mapping, Immune evasion mechanisms of virulent pathogens, raising antibodies in an animal system, Antibody and Vaccine engineering, Complement system.	4	0	0
<b>Module 5: Molecular Assays and Techniques</b>			
5.1: Antibody Titration Techniques: Immuno assay systems, Immuno precipitin reactions, ELISA, RIA, RID,	3	0	0
5.2: Immunotechniques: Yeast one hybrid, Yeast two hybrid, TAP- TAG Technology, Synthetic lethal screens, Pull down assays, expression library screening, AFM	2		
5.3: Fluorescent antibody techniques: Bimolecular fluorescence complementation (BiFC), Fluorescence resonance energy transfer (FRET) and Fluorescence correlation spectroscopy, Label transfer, Quantitative immunoprecipitation combined with knock-down (QUICK),	3		
5.4: Protein-Protein Interaction studies: PPI maps, Protein Chips for diagnostics, SPR, MST, ITC and nanoDSF, Static Light Scattering (SLS)	3		
5.5: Immunocytochemistry (cryo-sectioning, resin embedding, freeze-shattering and freeze fracture), Negative Staining, Immunogold labelling, Electron Microscopy	2		
<b>Module 6: Cancer Biology</b>			
Tumorigenesis, Invasion and Metastasis, Immunosuppressive mechanisms, Anti-cancer agents and Therapies	4		
<b>Total</b>	<b>30</b>	<b>0</b>	<b>0</b>
<b>Evaluation criteria:</b>			
1. Minor test 1	30%		
2. Minor test 2	30%		
3. Major test (end semester)	40%		
<b>Learning outcomes:</b>			
1. Acquaintance of basic microbial structure and microbial diversity. Grasp of various microbial systems and applications of microbial compounds of commercial interest (Minor test 1, Minor test 2 and Major test)			
1. An insight into the growth patterns of microbes (Minor test 1, Minor test 2).			
2. An understanding of mechanisms behind microbial pathogenicity and resistance. Students will be able to outline key aspects of immune reactions and host responses against pathogens. (Minor test 2).			
3. Grasp of basic concepts of immunology: a. Able to define molecular machinations of cellular and humoral immune responses, roles played by diverse immune cells. b. Understanding of molecular basis of immunological tolerance and autoimmunity. (Minor test 2).			

4. Knowledge of principles underlying the assays and techniques employed in immunology and microbiology (Major test).
5. A detailed understanding of mechanistics of cancer biology (Major test).

**Pedagogical Approach:**

1. Classroom lectures.
2. Providing case studies to support the concepts.
3. Peer-reviewed research articles to discuss various modules in the course.
4. Peer-review reading

**Skill Set:**

1. Analytical skills based on case studies provided.
2. Knowledge of immunological and microbiological applications in various sectors.
3. Knowledge of techniques employed.

**Employability:**

The course will provide skillsets and knowledge that may play key role to get employed in Universities, R & D industry, Medical centres/Colleges, Research Institutes and Diagnostic centres apart from specialized units like pharma, breweries, dairy and agri sectors.

**Materials:****Suggested Readings**

1. Schroeder HW Jr, Cavacini L. Structure and function of immunoglobulins. *J Allergy Clin Immunol.* 2010;125(2 Suppl 2):S41-S52. doi:10.1016/j.jaci.2009.09.046
2. Peleg AY, Hogan DA, Mylonakis E. Medically important bacterial-fungal interactions. *Nat Rev Microbiol.* 2010 May;8(5):340-9. doi: 10.1038/nrmicro2313. Epub 2010 Mar 29. PMID: 20348933.
3. Vermelho AB, Supuran CT, Guisan JM. Microbial enzyme: applications in industry and in bioremediation. *Enzyme Res.* 2012;2012:980681. doi:10.1155/2012/980681
4. Pham JV, Yilma MA, Feliz A, Majid MT, Maffetone N, Walker JR, Kim E, Cho HJ, Reynolds JM, Song MC, Park SR, Yoon YJ. A Review of the Microbial Production of Bioactive Natural Products and Biologics. *Front Microbiol.* 2019 Jun 20;10:1404. doi: 10.3389/fmicb.2019.01404. PMID: 31281299; PMCID: PMC6596283.
5. Singh S, Kumar NK, Dwiwedi P, Charan J, Kaur R, Sidhu P, Chugh VK. Monoclonal Antibodies: A Review. *Curr Clin Pharmacol.* 2018;13(2):85-99. doi: 10.2174/1574884712666170809124728. PMID: 28799485.
6. Lu RM, Hwang YC, Liu IJ, Lee CC, Tsai HZ, Li HJ, Wu HC. Development of therapeutic antibodies for the treatment of diseases. *J Biomed Sci.* 2020 Jan 2;27(1):1. doi: 10.1186/s12929-019-0592-z. PMID: 31894001; PMCID: PMC6939334.
7. Madhurantakam C, Rajakumara E, Mazumdar PA, Saha B, Mitra D, Wiker HG, Sankaranarayanan R, Das AK. Crystal structure of low-molecular-weight protein tyrosine phosphatase from *Mycobacterium tuberculosis* at 1.9-Å resolution. *J Bacteriol.* 2005 Mar;187(6):2175-81. doi: 10.1128/JB.187.6.2175-2181.2005. PMID: 15743966; PMCID: PMC1064030.
8. Madhurantakam C, Chavali VR, Das AK. Analyzing the catalytic mechanism of MPTpA: a low molecular weight protein tyrosine phosphatase from *Mycobacterium tuberculosis* through site-directed mutagenesis. *Proteins.* 2008 May 1;71(2):706-14. doi: 10.1002/prot.21816. PMID: 17975835.
9. Madhurantakam C, Duru AD, Sandalova T, Webb JR, Achour A. Inflammation-associated nitrotyrosination affects TCR recognition through reduced stability and alteration of the molecular surface of the MHC complex. *PLoS One.* 2012;7(3):e32805. doi: 10.1371/journal.pone.0032805. Epub 2012 Mar 14. PMID: 22431983; PMCID: PMC3303804.
10. Neiers F, Madhurantakam C, Fälker S, Manzano C, Dessen A, Normark S, Henriques-Normark B, Achour A. Two crystal structures of pneumococcal pilus sortase C provide novel insights into catalysis and substrate specificity. *J Mol Biol.* 2009 Oct 30;393(3):704-16. doi: 10.1016/j.jmb.2009.08.058. Epub 2009 Aug 31. PMID: 19729023.

11. Duru AD, Sun R, Allerbring EB, Chadderton J, Kadri N, Han X, Peqini K, Uchtenhagen H, Madhurantakam C, Pellegrino S, Sandalova T, Nygren PÅ, Turner SJ, Achour A. Tuning antiviral CD8 T-cell response via proline-altered peptide ligand vaccination. *PLoS Pathog.* 2020 May 4;16(5):e1008244. doi: 10.1371/journal.ppat.1008244. PMID: 32365082; PMCID: PMC7224568.
12. Borek F. The fluorescent antibody method in medical and biological research. *Bull World Health Organ.* 1961;24(2):249-256.
13. Slastnikova TA, Ulasov AV, Rosenkranz AA, Sobolev AS. Targeted Intracellular Delivery of Antibodies: The State of the Art. *Front Pharmacol.* 2018 Oct 24;9:1208. doi: 10.3389/fphar.2018.01208. PMID: 30405420; PMCID: PMC6207587.
14. Bertram JS. The molecular biology of cancer. *Mol Aspects Med.* 2000 Dec;21(6):167-223. doi: 10.1016/s0098-2997(00)00007-8. PMID: 11173079.
15. Liu L, Wannemuehler MJ, Narasimhan B. Biomaterial nanocarrier-driven mechanisms to modulate anti-tumor immunity. *Curr Opin Biomed Eng.* 2021 Dec;20:100322. doi: 10.1016/j.cobme.2021.100322. Epub 2021 Jul 30. PMID: 34423179; PMCID: PMC8372976.
16. Günther G. Multidrug-resistant and extensively drug-resistant tuberculosis: a review of current concepts and future challenges. *Clin Med (Lond).* 2014;14(3):279-285. doi:10.7861/clinmedicine.14-3-279

**Note:** Further updated reference and review articles will be provided during the lectures

**Additional information (if any): Not Applicable**

**Student responsibilities:**

1. Study of course material as specified by the instructor.
2. Proactive involvement in studying, reviewing and analysing the accessible scientific literature in online/offline modes.

**Course reviewers:**

**1. Prof. Adnane Achour**, Structural and Biophysical Immunology, Department of Medicine, Solna, Karolinska Institute, Stockholm, Sweden

**2. Dr. Rajakumara Eerappa**, Associate Professor, Department of Biotechnology, Indian Institute of Technology, Hyderabad, India