DISCIPLINE SPECIFIC ELECTIVE COURSE-17 (BIOMED-DSE-17)

MODEL ORGANISMS IN BIOMEDICAL RESEARCH

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Model Organisms in Biomedical Research	**4**	**2**	**0**	**2**	**XII Passed**	**Basic knowledge of Biological Science**

Learning Objectives:

This course aims to give the students an introduction to different model organisms, fundamental discoveries made through these organisms, what they are used for, the techniques to modify their genome, and how the students may use these organisms employing modern technological approaches for research and understanding of biology.

Learning Outcomes:

After the completion of this course, students shall learn and appreciate:

1. The need to study model organisms ranging from unicellular to multicellular and complex higher order animals and their use in deciphering the mysteries of life.
2. Selection criteria of a model organism for any specific condition
3. Ethical issues related to studies on model organisms

SYLLABUS **(30 hours)**

Unit I: Introduction **(3 hours)**

Introduction to model organisms; need to study model organisms; criteria to choose appropriate model organisms for biomedical research; Ethical issues in using model organisms.

Unit II: Unicellular model organisms **(7 hours)**

Escherichia coli: Life cycle, Advantages and disadvantages as a model, It's use in understanding of the fundamental concepts of molecular biology such as replication, gene expression and protein synthesis through *E. coli*, Utilization in discovery of fundamental metabolic pathways and understanding of antibiotic resistance mechanisms.

Saccharomyces cerevisiae (Baker's yeast): Life cycle, Mating types and their inheritance, Culture conditions, Advantages and disadvantages as a model, Use of yeast in the discovery of cell cycle regulatory genes-*cdc* mutants, Yeast two hybrid systems for protein-protein interactions. Commonly used yeast assays, Overview of the Yeast Genome Deletion Collection.

Unit III: Invertebrate model organisms (8 hours)

Caenorhabditis elegans (Nematode worm)
Life cycle, Maintenance, Advantages and disadvantages as a model, Overview of fundamental discoveries in programmed cell death (role of proteases- *ced* genes), Cell-fate mapping, lineage studies, Discovery of RNAi. Nobel prizes won by *C. elegans*. Use in study of ageing process. Genetic screening
Drosophila melanogaster (Fruit fly)
Life cycle, Maintenance, Advantages and disadvantages as a model, Overview of fundamental discoveries in genetics using fruit fly- TLR genes, development regulators, Nobel prizes won by Drosophila, Insights into forms of cancer and neurodegenerative diseases using Drosophila. The Gene disruption project, transgenic flies.

Unit IV: Vertebrate and Alternative Model Organisms in Biomedical Research (12 hours)
(a): Vertebrates model organisms
Danio rerio (Zebrafish): Life cycle, Maintenance, Advantages and disadvantages as a model, Overview of historical discovery of genetic control of early embryonic development, Zebrafish as a model for neurodevelopmental disorders and ecotoxicological studies, Introduction to tools for standard mutagenesis and Genetic screening.
Mus musculus (Mouse) and *Rattus norvegicus* (Rat)
Mouse vs rat w.r.t. physical features, age, size, weight, gestation period, weaning time and maintenance in animal house. Advantages and disadvantages of inbred and outbred species. "Premier" model organism for studying complex physiological processes and complex disorders such as infectious diseases (malaria) and non-infectious diseases (RA, diabetes, CVD, neurodegenerative disorders). Generation and application of knockout and transgenic mice as disease models. Applications in immunization, drug development and toxicology. Overview of the Knockout database.
Overview of other vertebrates model organisms commonly used in biomedical research- rabbit and guinea pig
(b): Introduction to other model organisms
Dictyostelium discoideum (Social amoeba) as a model for induced multicellularity and differentiation.
Daphnia (Water flea), ciliate and fish as models for ecotoxicological studies.

Practical (60 hours)
(Wherever wet lab experiments are not possible the principles and concepts can be demonstrated through any other material or medium including videos/virtual labs etc.)

1. To induce artificial competence in *E.coli* and compare it with organisms having natural competence.
2. To explore Saccharomyces genome database (SGD)
3. To explore the Wormbase database to retrieve information for ced9 for understanding *C. elegans* as a model organism
4. To investigate Flybase and retrieve information of any homologous gene for a Cancer to evaluate fruit fly as a suitable model organism.
5. To study SCN2A gene involved in neurodegenerative disorders through the MGI database (Mouse Genome Informatics).

6. To study genes involved in neurodevelopment using the Zebrafish Information Network.
7. To observe different mutants of Yeast
8. To observe different mutants of Drosophila
9. To observe different mutants of *C. elegans*
10. To select a suitable model organism for any given disease and design experiments to investigate the given hypothesis like deciphering the mechanism of a particular protein in the pathogenesis of a disease or progress of a disease, etc.

Essential Readings:

- Walz K et al. (2019), 1st edition, Cellular and Animal Models in Human Genomics Research. Elsevier, ISBN: 9780128165737
- Lodish H et al. (2021), 9th edition, Molecular Cell Biology. W H Freeman & Co., ISBN: 1319208525
- Experiments with Drosophila for Biology Courses: An e-resource book for laboratory experiments at under- and post-graduate levels and for research projects in Biology courses. Editor-in-Chief: S. C. Lakhotia, Co-Editor: H. A. Ranganath. Indian Academy of Sciences, Bengaluru. March 2021, ISBN: 978-81-950664-2-1
- Tang, B., Wang, Y., Zhu, J., & Zhao, W. (2015). Web resources for model organism studies. *Genomics, proteomics & bioinformatics*, *13*(1), 64–68. https://doi.org/10.1016/j.gpb.2015.01.003
- Westerfield, M. (2000). The zebrafish book. A guide for the laboratory use of zebrafish (Danio rerio). 4th ed., Univ. of Oregon Press, Eugene.

Suggested Readings:

- Hedrich, H.,(2012) 2nd edition. The Laboratory Mouse, Elsevier, ISBN: 9780123820082.
- Wilson-Sanders, S.E. (2011), Invertebrate models for biomedical research, testing, and education).*ILAR J,* 52(2):126-52. doi: 10.1093/ilar.52.2.126.
- Yancheva et al. (2015), Fish in Ecotoxicological Studies, *Ecologia Balkanica,* Vol 7 (1), pp149
- Vilas-Boas, J.A., et al. (2020), Ciliates in ecotoxicological studies: A minireview, *Acta Limnol. Bras,* https://doi.org/10.1590/S2179-975X6719, Compendium of CCSEA
- Guide for the Care and Use of Laboratory Animals Paperback by National Research Council, National Academic Press; 8th edition (2010), ISBN-10: 0309154006, ISBN-13: 978-0309154000
- Eisenmann, D. M., Wnt signaling (June 25, 2005), *Worm Book*, ed. The *C. elegans* Research Community, WormBook, doi/10.1895/wormbook.1.7.1, http://www.wormbook.org.
- Handbook on Laboratory Animals by PV Desai and P Saravanan, Jaypee Brothers Medical Publishers (P) Ltd., 2nd edition (2015), ISBN 9789351529521
- Handbook of laboratory animal science: Essential principles and practices Hau, Jann; Schapiro, Steven Jay. 3rd edition (2011), CRC Press, ISBN:978-1-4200-8455-9