Course title: Synthetic and Systems Biology **credit: 2+1+0**

Part A: Synthetic Biology – 16 classes (each class is 1.5 h) = 24 h

Instructor: Dr. Varuna H P, PhD

1. Introduction, concepts and practice of synthetic Biology and its subfields (4 classes): (Bioengineering, synthetic genomics, protocell synthetic biology, unconventional molecular biology, and in silico techniques)
   Impact of synthetic biology of culture and life.

   Tutorial 1: 1 class

2. Basic research, Case studies and applications of synthetic biology tools (6 classes):
   a. Genetic code expansion and Protein engineering: A case study. Principles and applications of genetic code expansion, a powerful tool in synthetic biology and protein engineering.
   b. Self-assembled biomaterials: Applications in drug discovery, drug-delivery tools addressing the unmet clinical needs

   Tutorial 2: 1 class

3. Invited Lectures and workshop: (3 lectures and one day workshop)

Genetic Code Expansion and Protein Engineering: Significant aspects of the molecular and cellular mechanisms underlying genetic code expansion. In addition, learn about the various methods for incorporating non-natural amino acids into proteins. Explore the diverse applications of this technology in areas such as drug discovery, receptor-ligand interaction, and biotechnology.

Tutorial 3: 1 class

References:

1. "Piecing together a puzzle. An exposition of synthetic biology". EMBO Rep. 2009 May;10(5):428- 32. doi: 10.1038/embor.2009.76. PMID: 19415076; PMCID: PMC2680885.
2. "Intermittent scavenging of storage lesion from stored red blood cells by electrospun nanofibrous sheets enhances their quality and shelf-life." Nat Commun 13, 7394 (2022). https://doi.org/10.1038/s41467-022-35269-3
3. "Enhancement of the gut barrier integrity by a microbial metabolite through the Nrf2 pathway." *NatCommun* **10**, 89 (2019). https://doi.org/10.1038/s41467-018-07859-7
4. "Expanding and reprogramming the genetic code", Nature. 2017 Oct 4;550(7674):53-60. doi: 10.1038/nature24031.
5. "Expanding the genetic code", Annu Rev Biophys Biomol Struct. 2006:35:225-49.
6. "A chemical toolkit for proteins--an expanded genetic code", Nat Rev Mol Cell Biol. 2006Oct;7(10):775-82. doi: 10.1038/nrm2005.
7. "Expanding the genetic code for biological studies", Chem Biol. 2009 Mar 27;16(3):323-36.doi: 10.1016/j.chembiol.2009.03.001.

Textbook: "Genetic Code Expansion: Methods and Protocols" edited by Jason W. Chin

Part B: Systems Biology (24 h)
Instructor: Dr. Divyashri Baraniya

About the course: Systems Biology brings together Biology, Mathematics, Physics and computational approaches to get a detailed picture of Biological systems at cell, tissue and organism level. Approacheslike mathematical modelling and network analysis are often used to understand the manner in which components of a biological system interacts at different level.

1. **Introduction and basic principles** (3 classes)
    - Introduction to systems biology
    - Fundamentals of mathematical modelling, properties of models.
    - Biological systems and models. Some example models.
    - Understanding Systems Biology Graphical notation (SBGN).
    - Introduction and types of biological networks.

    Tutorial: 1 class

2. **Network Biology** (5 classes)
    - Principles of Biological networks, Network representation and statistics, networkperturbations.
    - Optimality and robustness of biological networks.
    - Reconstruction of Gene regulation networks - Negative and positive regulation in transcription networks with example.

    Tutorial: 2 classes

3. **Metabolic fluxes** (4 classes)
    - Properties and control of metabolic flux.
    - Metabolic flux analysis: Flux Balance Analysis (FBA), Flux Variability Analysis, Flux Map.
    - Applications of metabolic flux analysis.
    - Lab

    Tutorial: 2 classes

4. **Guest lectures** (2 Lectures): **TBD**

References

Books
1. **Systems Biology in Practice: Concepts, Implementation and Application** by Edda Klipp, RalfHerwig, Axel Kowald, Christoph Wierling and Hans Lehrach.
2 **Introduction to systems biology (Springer)**, edited by Sangdun Choi.

Published articles
1. Fang X, Lloyd CJ, Palsson BO. Reconstructing organisms in silico: genome-scale models and theiremerging applications. Nat Rev Microbiol. 2020;18(12):731-43.
2. Ohno S, Uematsu S, Kuroda S. Quantitative metabolic fluxes regulated by trans-omic networks.Biochem J. 2022;479(6):787-804.