Course Title: Cell Biology

Course Instructor: Aprotim Mazumder

Duration of course: >36 hrs

This course will explore biological function at the level of the cell (as opposed to the level of the full multicellular organism as in Developmental Biology or Genetics, the level of individual biomolecules as in Biochemistry, or full ecosystems as in Ecological Biology or Population Genetics). A lot of interesting biological phenomena is observed at this intermediate scale, and affects function across the different levels. Of particular interest are processes of mechanical or biochemical regulation of cellular function, which have been generating a lot of excitement in recent times. We will study these through a mix of lectures and discussions of both classic and recent papers. Topics to be covered are presented below.

- Basic processes of transcriptional, translational and post-translational regulation:
    - Endocytosis, exocytosis and protein export
    - RNA production, splicing and export
    - Regulatory roles of non-coding RNA
    - Biochemical processes in specific cellular organelles like the endoplasmic reticulum, golgi, mitochondria, nucleus and nucleolus and the plasma membrane
    - Protein sorting in the cell - discovery of the Sec and SNARE proteins and their roles in regulating subcellular trafficking.

- Physical and chemical processes regulating cellular function:
    - The cell cycle and its regulation
    - Maintenance of pluripotency in stem cells; mechanobiology, effects of substrate stiffness and mechanical forces on cell fate and development
    - Chemical modifications of DNA and histone proteins regulating gene expression (Epigenetics)
    - Phosphorylation cascades that regulate chromatin function and DNA repair
    - Nuclear architecture and its regulatory role in controlling gene expression
    - Roles of membrane heterogeneity in regulating endocytosis and signaling
    - Sources and use for noise in gene expression

- Roles of the cytoskeleton and associated motor proteins:

    - Structure of actin, microtubules, cytoskeletal intermediate filaments, nuclear intermediate filaments (lamins)
    - Discovery and function of molecular motor proteins like myosin, kinesin and dynein.

Books: Molecular Biology of the Cell by Bruce Alberts et al, Genes by Benjamin Lewin.

Representative papers to be discussed:

The following papers, most of which are not reviews, are chosen for their lasting impact on the field of Cell Biology. These are some of the works that will be discussed in the course. The students are expected to learn the methods and the process that goes into the making of a seminal study:

1. Engler, A.J., et al., *Matrix elasticity directs stem cell lineage specification.* Cell, 2006. **126**(4): p. 677-89.
2. Lee, M.C., et al., *Sar1p N-terminal helix initiates membrane curvature and completes the fission of a COPII vesicle.* Cell, 2005. **122**(4): p. 605-17.
3. Mammoto, A. and D.E. Ingber, *Cytoskeletal control of growth and cell fate switching.* Curr Opin Cell Biol, 2009. **21**(6): p. 864-70.
4. Mehta, A.D., et al., *Myosin-V is a processive actin-based motor.* Nature, 1999. **400**(6744): p. 590-3.
5. Nakayama, J., et al., *Role of histone H3 lysine 9 methylation in epigenetic control of heterochromatin assembly.* Science, 2001. **292**(5514): p. 110-3.
6. Vale, R.D., T.S. Reese, and M.P. Sheetz, *Identification of a novel force-generating protein, kinesin, involved in microtubule-based motility.* Cell, 1985. **42**(1): p. 39-50.
7. Zhou, B.B. and S.J. Elledge, *The DNA damage response: putting checkpoints in perspective.* Nature, 2000. **408**(6811): p. 433-9.
8. Zhou, M. and R. Schekman, *The engagement of Sec61p in the ER dislocation process.* Mol Cell, 1999. **4**(6): p. 925-34.

Course Evaluation: There will be papers assigned every week after a lecture. The students will be expected to provide written reports of what they understand from the papers and also

discuss them in class. They are expected to convey not just the philosophical content of what is claimed, but the actual methods that led to the conclusions. In addition to these written assignments, the final examination will constitute of seminar presentations on specific topics chosen by the students. A student will be expected to perform extensive literature survey on the topic of their choice, write a comprehensive report and make a cogent presentation critically evaluating the current state of knowledge on the topic. A three-member committee convened by the course instructor will grade the presentations. A major aim that this course hopes to achieve is to inculcate students with the ability to critically evaluate studies in Cellular Biology and Biochemistry, in addition to conveying knowledge of the current state of the fields.

Weightage of marks - 65% from written assignments, 35% from presentations.