Developmental Biology MCDB 4650 – Course Learning Goals

Topics we expect you to be familiar with when you begin (at the level covered in Alberts et al., *Molecular Biology of the Cell* or equivalent):

1. Eukaryotic gene expression and its control; chromatin structure; classes of transcription factors.
2. Eukaryotic protein synthesis, protein targeting, and protein degradation.
3. Transmembrane signaling; molecular strategies of different signaling pathways.
4. Structures and functions of cellular organelles, the cell cytoskeleton, and extracellular matrix.
5. The characteristics and roles of epithelial and mesenchymal cells.
6. Cell biology of mitosis and meiosis.
7. Mendelian genetics.
8. DNA markers and their uses in gene mapping and cloning.
9. Standard techniques of modern molecular biology [restriction digests, gel electrophoresis, Southern, "Northern" and "Western" blots, hybridization with nucleic acid probes, autoradiography, footprinting analysis, gel shift (EMSA) analysis, co-immunoprecipitation, making genomic and cDNA libraries, DNA sequencing, polymerase chain reaction (PCR), RNA interference].

What we expect you to be able to do when you finish:

Content goals

1. Discuss the relationships between genome information content, genome organization, genome size, and gene number.
2. From the known molecular biology of eukaryotic gene expression, predict the steps likely to be regulated in controlling the output of active proteins during development.
3. Explain the mechanisms by which transmembrane signaling pathways can influence gene expression and cell behavior in development.
4. Explain the concept of combinatorial control (CC) in cell signaling and transcription, and defend the proposition that CC can explain in general how development works.
5. Design experiments to demonstrate the phenomena of cell fate, cell commitment (determination), and differentiation.
6. Justify the importance of using "model organisms" for the study of development, and compare the advantageous biological features of *C. elegans*, Drosophila, Xenopus, chick, and mouse.
7. Compare the mechanisms by which embryonic axes (anterior-posterior, dorsal-ventral, and left-right) are established in different embryos.
8. Explain the general developmental objectives that are accomplished by fertilization and the cleavage stage of animal embryonic development.
9. Explain the general developmental objectives that are accomplished during gastrulation in a typical animal embryo, and list the major tissues and organs that arise from each of the three germ layers.
10. Explain the general steps in formation and patterning of the nervous system following gastrulation.
11. Define the phenomenon of lateral inhibition and explain how it can result in spatial patterning of specific cell types within a tissue.
12. Compare the developmental research applications of finding and studying new mutations ("forward" genetics) with manipulation of molecularly defined genes ("reverse") genetics
13. Compare the segmentation mechanisms by which Drosophila and vertebrates develop repeating structural and functional units along the anterior-posterior body axis.

14. Describe the general structure of the universally conserved Hox gene clusters, and explain how Hox genes control patterning along the anterior-posterior axis and in many developing organs.
15. Explain the mechanisms of sex determination, dosage compensation, and imprinting in vertebrates.
16. Describe how transgenic animals, genomics, proteomics, and cultured stem cells can be used to study development, and be able to design experiments using these techniques.
17. Formulate some of the still unanswered major questions in development.

Non-content goals

18. Explain where the information in textbooks comes from and judge how reliable it is. Describe how research is supported, done, communicated, evaluated, and validated or invalidated.
19. Obtain information you need from other sources beyond the textbook and lectures.
20. Critically read research papers in the current developmental biology literature and judge validity of the conclusions.
21. Gauge how much new understanding you have gained through this course.
22. Verbalize how you learn best, and apply your preferences in learning new material.

Throughout the course we stress experimental approaches. *We expect you to understand the evidence for what is known and the available methods for approaching what is unknown in modern developmental biology.* We also expect you to be able to read developmental biology papers in current journals and understand the methods and the evidence presented well enough to judge the validity of the conclusions.