## Study Questions for 2nd hourly exam

1. Explain what is meant by the terms "autonomous specification" versus "conditional specification" in development. How are these terms related to "mosaic" and "regulative" development? Give examples of observations and experiments that demonstrate these two modes of development. Describe a specific example in which the molecular basis of autonomous specification is known (e.g., *C. elegans* early development using genes such as *skn-1, pie-1, mex-1* specifying early blastomere fate).

2. Describe the inductive process that leads to vulval formation in *C. elegans* and some of the experiments that demonstrated these cell-cell interactions. What kinds of proteins are involved in the signaling and reception between the cells involved? How does the control of vulval development in *C. elegans* parallel the control of mammalian epidermal cell proliferation (EGF / RTK signaling)? What role does Wnt signaling play?

3. Explain how Sander, Kalthoff and their colleagues' classical embryological experiments with leafhopper and midge foreshadowed Nüsslein-Volhard and Wieschaus' experiments identifying mutations that affected *Drosophila* early development. (For example, their ligature and other experiments suggested that anterior and posterior "organizing centers" were interacting to form the anterior-posterior axis of insects. What is the probable molecular basis for the anterior organizing center based on these experiments and then later from molecular genetic experiments with *Drosophila*?)

4. Describe in general terms the functions of each class of maternal (anterior, posterior and terminal) and zygotic genes (gap, pair-rule, segment polarity, homeotic selector) in the development of *Drosophila*. Describe the phenotypes of mutants and the normal pattern of expression in each class of genes to illustrate their functions. Select a specific gene in each class and describe its function, expression pattern of mRNA and protein (if they differ), mutant phenotype, and interactions with other genes (at higher, lower, and the same functional level).

5. A conserved molecular mechanism patterns the anterior-posterior axis of all multicellular animals, from nematodes to flies to vertebrates. Describe the organization and pattern of expression of the homeotic gene complex (HOM-C) genes in a typical animal. Describe how homeotic gene complexes evolved from an original single primordial homeobox gene (gene duplication, loss, acquisition of new functions, etc.). What additional changes in the HOM-C occurred in evolution in the line leading to the vertebrates?

6. Describe the experiments that have lead to our current understanding of the mechanism(s) of pattern formation in the anterior-posterior axis of the vertebrate forelimb (mainly done in chick embryo). What is the nature of the interaction between ectoderm and mesoderm in the growing limb bud?

7. Determining that a particular substance can affect the fate of a cell or tissue (e.g., induce the tissue) does not prove that the substance actually performs this function *in vivo*. What other evidence should be found to suggest the substance is the actual inducing agent? (For example, retinoic acid was for some time believed to be the morphogen of the ZPA (zone of polarizing activity). What do we believe currently is its role in limb pattern formation? What inconsistencies suggested it was unlikely to be the actual morphogen?)

8. What is the connection between the grey crescent and the varying results Spemann got when he separated two-cell embryos? What other experiments by Spemann suggested something important was happening during gastrulation?

9. When Hans Spemann and Hilde Mangold performed their famous "organizer" experiment, they transplanted tissue from a darkly pigmented newt into a lightly pigmented host newt. Describe

their experiment, its results, and why the use of the differently-colored tissues was critical to the interpretation of these results.

10. Cortical rotation is critical for dorsal-ventral axis formation in the amphibian embryo. Explain the current ideas about how this event creates the dorsal-ventral axis and experiments that support this hypothesis. Dorsal endoderm (the 'Nieuwkoop center') induces the formation of the organizer -- how is this linked to cortical rotation? Explain some of the experiments that led to the development of the concept of the Nieuwkoop center. Describe parallels in the Wnt signaling pathway in *Drosophila* segment polarity genes and amphibian axis formation.

11. What are some of the properties of the organizer, and what are the molecular bases of these properties? How is the "induction" of the neural ectoderm paradoxical (opposite in mechanism from what was expected)?