

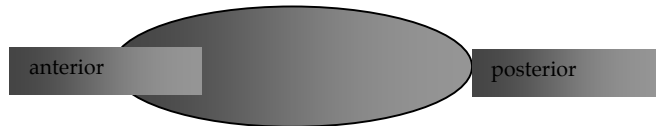
Solution key - 7.012 Section 15 - 2010

Questions

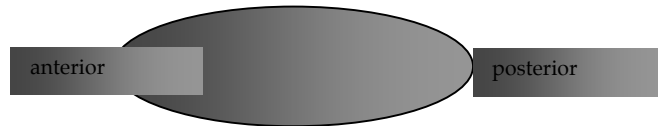
1. The first step in the developmental gene cascade is the uneven distribution of maternal mRNA in the egg cells. In *Drosophila*, the *bicoid* mRNA is localized to the anterior end of the egg, whereas *nanos* mRNA is localized to the posterior end of the egg. The *bicoid* mRNA is then translated into Bicoid protein, that diffuses to create a concentration gradient. In regions where Bicoid protein concentration is sufficient, Bicoid acts as a transcription factor for a different gene, the *hunchback* gene. The Nanos protein blocks the translation of hunchback mRNA.

On the figure roughly indicate the concentration of Bicoid, **Hunchback**, and Nanos protein.

b) On the figure roughly indicate the concentration of Bicoid, **Hunchback**, and Nanos protein.



Bicoid: Concentration gradient will be highest at the anterior end and will progressively decrease as we move to the posterior end.

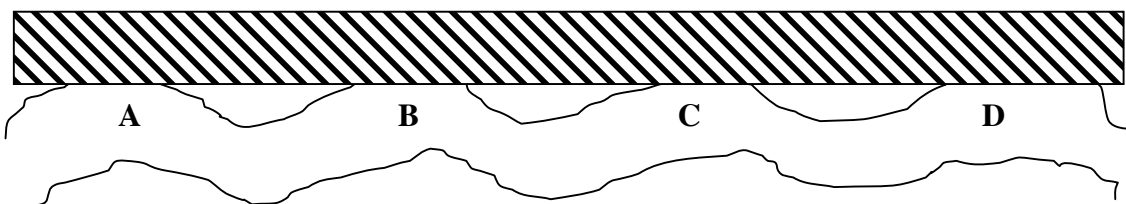
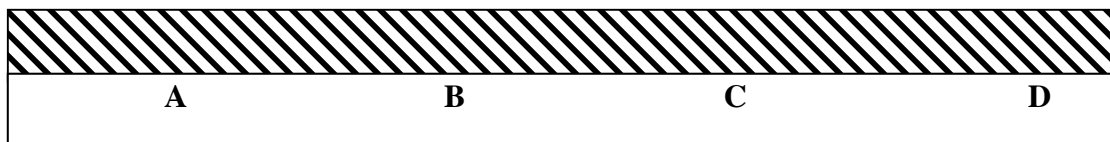


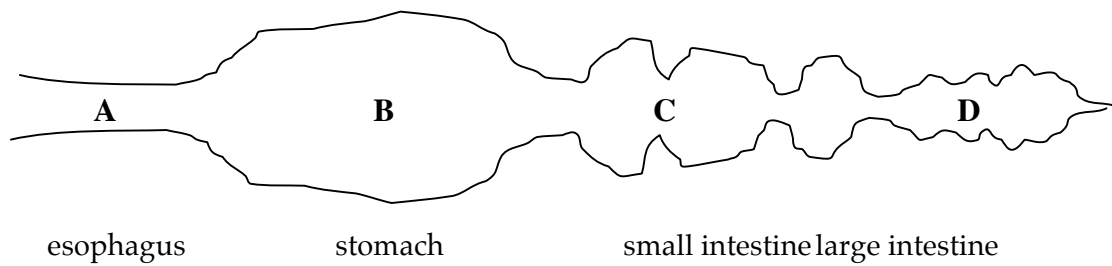
Hunchback: Since its expression is dependent on Bicoid protein its concentration gradient will be highest at the anterior end and will progressively decrease as we move to the posterior end.



Nanos: Concentration gradient will be highest at the posterior end and will progressively decrease as we move to the anterior end.

2. This question is about development of the alimentary canal (the “gut”) from the “endodermal” cell layer of the mouse embryo. This process requires contact between the endoderm (unshaded, labeled A, B, C, D in the diagrams below) and adjacent “mesodermal” cell layer (striped). Initially, a tube develops in the endoderm of the embryo. A few days later, the tube becomes kinked, and three days after that, four obvious morphological divisions (A, B, C, D) can be seen along the antero-posterior length of the tube, as diagrammed below. A, B, C, and D correspond the same regions at all stages (that will give rise to the esophagus, stomach, small intestine, large intestine, respectively). Differentiation occurs only at the latest stage, 1 week after the straight tube stage.





In order to analyze the timing of stomach determination, you do the following transplant experiment within the whole embryo in which you invert the endoderm of regions A and B (the future esophagus and stomach) at either straight or kinked tube stage, as indicated below. The mesoderm is left intact and is not inverted. After the gut regions have differentiated, you observe that in the straight tube transplant, a normal gut develops, whereas in the kinked tube stage transplant, the position of the esophagus and stomach are inverted.

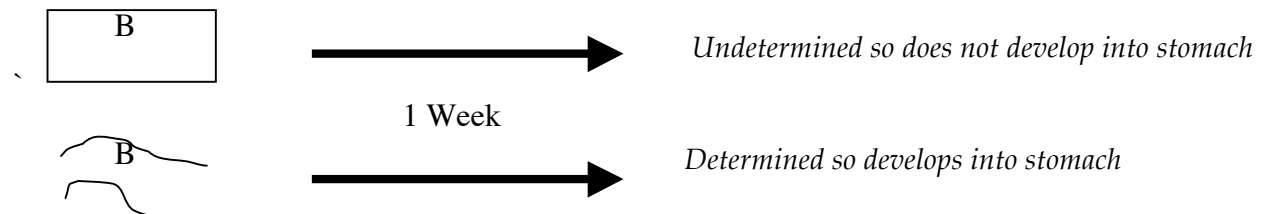
a) Distinguish between “determination” and “differentiation.”

Determination refers to the decision to become a certain cell type., whereas differentiation refers to formation of the final functional cell.

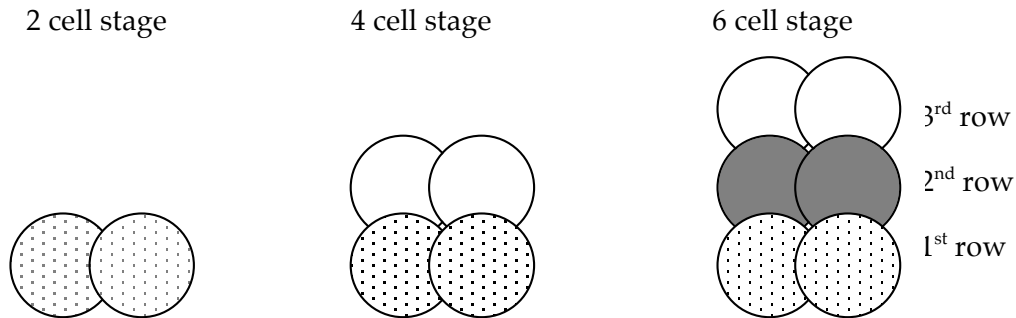
b) When does stomach determination occur? Explain.

At or just before the kinked tube stage, since at this time, the fate of the endoderm is fixed and cannot be altered by adjacent mesoderm. The first result, at the straight tube stage implies that the mesoderm is responsible for instructing (inducing) specific regions of the gut to develop. By the kinked tube stage, the identity of the stomach is fixed.

c) In a second set of experiments, you isolate (explant) the endoderm of region B at the straight or kinked tube stage, and then culture it for one week. No mesoderm is removed. Based on the results of the transplant assay above, what would you predict the outcome would be?



3. Leeches are medically important animals as they produce hirudin, a very effective anti-clotting agent. As embryos, they undergo interesting cell division, where a new row of cells is added at every division, so 1st row cells are the oldest cells, 2nd row cells are produced from division of 1st row cells, and 3rd row cells are produced from division of 2nd row cells. Based on patterns of gene expression, the following different “territories” (each a precursor to specific cell fates) are observed at each division.



a) Formulate a hypothesis, based on segregation of cell autonomous regulatory factors to account for the change in number of territories from the 2 cell to the 4 cell stage. What is the term for this type of regulatory factors?

The 1st row cells retain a determinant that regulates their specific fate. The 2nd row cells do not receive this and therefore are different from 1st row cells. Conversely, you could hypothesize that the 2nd row cells inherit a determinant at cell division that is not retained in the 1st row cells, and therefore their fates are different. Thus depending upon the receipt of the determinant different cells can end up having different fates.

b) Formulate a hypothesis, based on cell-cell signaling to account for the change in number of territories from the 4 cell to the 6 cell stage. Comment on when this signaling is likely to occur. What is the term for this type of signaling?

2nd row cells secrete a ligand that acts on 3rd row cells to change their fate. The 3rd row cells contain the receptor and downstream signaling components for this ligand. This is called induction.