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Biology 411 - Developmental Biology
Winter Quarter 2013

Midterm 2 KEY Version A

100 Total Points
Open Book

Read the Following Instructions:

Answer 20 questions out of the available 25 questions - (5 pts each)

Cross out answered questions that you do not want graded. We will grade the first 20 answered questions that are not marked out.

Provide answers using **full sentences**, unless instructed otherwise.

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1. In the Essner *et al*. paper that you read for Discussion section, researchers imaged counterclockwise movement of fluid within Kupffer's Vesicle (KV). Consider the following experiment. Take ten zebrafish embryos, and inject a solution of RNAase into Kupffer's Vesicle of each embryo. Predict the phenotypes that will be seen in this population of embryos as a result of this manipulation. Explain your reasoning. (For your information, injecting a control saline solution into Kupffer's Vesicle, with no RNAase, has no effect on the embryos).

The embryos would all have normal right-left asymmetry. RNAs are not secreted as signaling molecules between cells, and thus do not serve as morphogens in extracellular fluids. RNAase injected into the lumen of Kupffer's vesicle would not cross cell membranes, and thus would not degrade RNAs within the epithelial cells that line Kupffer's vesicle.

2. (pp. 220-225) **Draw** what you believe the phenotype of a *eve*; *ftz* double mutant (i.e. two mutations) *Drosophila* embryo would look like. **Accurately label** the parts of the double mutant embryo and explain your reasoning.

The embryo would have only an acron and a telson. No segments would form. *Fushi tarazu (ftz)* is a odd pair-rule gene. Odd parasegments would be missing. *Even-skipped (eve)* is an even pair-rule gene. Even parasegments would be missing.

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3. (p. 216) Draw the subdivision of tissues (cross-sectional view) in the *Drosophila* embryo if *dorsal* was mutated to a null phenotype. Remember to consider what the loss of snail activity would have on dorsoventral patterning.

Without Dorsal activity, dorsal tissues, like the aminoserosa and dorsal ectoderm, would be specified around the circumference of the embryo. Dorsal is a ventralizing gene product.

4. (p. 170) What would happen to micromeres in a sea urchin if Notch receptors were expressed in these cells? Explain your reasoning.

The micromeres would co-express skeleton forming genes and non-skeletogenic mesenchyme genes.

5. (pp. 258, 260-261) Lithium ion inhibits the actions of GSK3. Draw the frog larvae that would result if Li^+ was injected into the D4 blastomere during early development.

A conjoined twin would result.

6. (p. 232) Draw several segment of a *Drosophila* embryo. Label where parasegment boundaries are located.

Both the anterior and posterior boundaries of parasegments are shifted more anterior than segment boundaries.

7. (p. 210) Explain how *bicoid* and *oskar* mRNA get localized to opposite ends of the of the *Drosophlia* oocyte.

***bicoid* and *oskar* mRNA are carried by different motor proteins that transport cargo along microtubules.**

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8. (pp. 219-223) What would happen if you injected a morpholino for *gurken* into a fertilized *Drosophila* embryo? Explain why this phenotype would result.

***gurken* mRNA is already translated in the oocyte. The morpholino would bind to *gurken* mRNA, and not block the function of the Gurken protein. A normal embryo should be formed.**

9. (p. 269) In the first Harry Potter novel/movie, a large three-headed dog named "Fluffy" guarded a hatchway to a secret chamber. Fluffy has the same phenotype as Cerberus, the three-headed dog that guarded the gateway to Hades (Hell) in Greek mythology. Using your knowledge of embryology, how could you suppress the three-headed dog phenotype in a breed of dogs with the Cerberus phenotypes? **Use molecular manipulations** and explain your reasoning.

Increase the expression of BMP and Wnt signals in the anterior blastoderm (e.g. increase the amount of Cerberus in the anterior blastoderm). Too much expression of BMP and Wnt signals and no heads will form. With the right amount of BMP and Wnt signals, a single head should form instead of three.

10. (p. 181) Inject a small amount of cytoplasm from a fertilized egg of a *dd* snail into the cytoplasm of a fertilized egg of a *DD* snail. **Draw** the resulting cleave pattern that would result. Diagram the cleavage pattern at the 8-cell stage, looking from the animal pole. Explain your reasoning.

The spiral cleavage pattern is determined by maternal determinants, which are lacking in the egg produced by the *dd* female. Injection of dd cytoplasm into the DD fertilized egg will have no effect, because the maternal determinant for right-hand coiling is already in the *DD* fertilized egg. The cleavage pattern is clockwise looking from the animal pole at the 8-cell stage.

11. (pp. 213-214) If the active fragment of Spätzle was injected into the perivitelline space, Toll receptors would be activated everywhere in the developing embryo? Predict the resulting phenotype of the embryo, and explain your reasoning.

Dorsal would be released from Cactus in each cell, and would translocate into the nucleus to activate ventralizing genes. The embryo would be ventralized.

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12. (p. 249) What morphogenetic process does radial intercalation drive? What morphogenetic process does mediolateral cell intercalation drive?

Radial cell intercalation drives epiboly in amphibian gastrulation.
Mediolateral cell intercalation drives convergence and extension of the forming notochord.

13. What is the difference between involution and ingression? Provide an example of each in vertebrate embryogenesis.

Involution is the rolling inward of cells. Ingression is the internalization of cells one at a time. It often involves an epithelial-to-mesenchymal transition. Involution occurs at the dorsal lip of the amphibian embryo during gastrulation. Ingression occurs at the primitive streak during chick gastrulation.

14. What is the purpose of using F2 individuals for breeding pairs in colony of zebrafish?

Crosses between these individuals are used to generate homozygous phenotypes that are of interest.

15. (pp. 280, 296) Explain why an embryonic shield, transplanted from a zebrafish embryo into a chick blastoderm, would generate a second body axis in the chick embryo?

The embryonic shield is the organizer region for the zebrafish embryos. It secretes inducer molecules that are similar to the molecules secreted by Hensen's node, the organizer region in chick embryos.

16. (Essner *et al*. paper from Discussion) What pathway(s) show to have an upstream influence of *lrdr1* in zebrafish? Draw or write the Essner et al. proposed pathway from DFCs to asymmetric morphogenesis.

Nodal signaling pathway and *ntl* pathway.

a. Factors, such as *cas*, are required for proper DFC formation
b. DFCs require the *ntl* and Nodal pathways (*oep;sur)* to control *lrdr1* expression
c. DFCs organize to form Kupffer's Vesicle, requiring *ntl, oep,* and *spt* for KV organogenesis
d. Ciliogenesis begins inside of KV
e. Cilia becomes motile, regulated by *lrdr1*, and generate directional flow inside of KV
f. Asymmetry of Nodal, Lefty, Pitx2
g. Asymmetric morphogenesis of heart, brain, and gut

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17. What is the major difference between a blastopore and a primitive streak?

The blastopore is an actual opening. Blastopores are formed by invagination or by involution. A primitive streak is a location in the epiblast where ingression takes place.

18. King Tut of Egypt married his half-sister, who had the same father (Akhenaten) as King Tut. Their two daughters had major birth defects, and died shortly before, or after birth. What is the probability that the daughters inherited identical X chromosomes from King Tut and his half-sister? In a family with consanguinity, could the daughters have died from inheriting identical recessive alleles carried on the same X chromosome? Write an answer, and explain it.

a. 0%
b. 25%
c. 50%
d. 75%
e. 100%

In this case King Tut inherited a X chromosome from his mother, who is a different woman that the mother of his half-sister. However, in consanguineous families, it is theoretically possible for lethal recessive mutations to be inherited on the X chromosome.

19. What does "definite" endoderm mean in chick development?

"Definite endoderm" means that this endoderm will be incorporated into endodermal organs of the body.

20. (p. 269; Figure 7.30a) Using a gene product diagram, explain how you could prevent pharyngeal endoderm from being specified in the head of a frog embryo in a populations of cells already secreting Wnt inhibitors. What different fate would the cells have?

Add BMP ligands to the cells. The cells that would normally become pharyngeal endoderm will instead become specified to become more posterior tissues (i.e. non-head).

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21. (p. 180) Consider how the direction of shell coiling is determined in snails. Is this an example of maternal effect? Explain why.

Yes, the maternal genotype determines the phenotype of offspring (i.e. direction of shell coiling) regardless of the genotype of the offspring.

22. (p. 302) What would happen if *Oct4* was overexpressed in the early mouse embryo?

The morula would only form inner cell mass cells. No trophoblast would form.

23. (pp. 290) Figure 8.3. Draw a midsagittal view of tissues in the chick embryo, if ingression failed to occur in the primitive streak during gastrulation. Label the resulting tissues. Would a primary hypoplast form? Explain why.

The mesendoderm would remain in the epiblast. A primary hypoblast would form from hypoblast islands. The cells occupy the hypoblast before primitive streak formation.

24. (pp. 316-317) How does an increase in retinoic acid alter the number of neck vertebrate in a developing mouse embryo? What is this process called, when one body part is transformed into a different body part?

Increased RA changes the specification of body segments through the activation of Hox genes in the anterior portion of the embryonic axis. This change in segment identity is known as homeosis.

25. (p. 228-233) All known gap genes and pair-rule genes all encode transcription factors. In contrast, segment polarity genes encode a variety of signaling proteins (e.g. ligands, receptors, transcription factors, etc). What is a plausible explanation for this variety of signaling proteins only seen in segment polarity genes?

Ligands and receptors are particularly important for cell-cell interactions. Gap genes and pair-rule genes are expressed in a syncytial embryo. Segment polarity genes are expressed in a multicellular embryo.

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