Name _____KEY_____

Biology 411 - Developmental Biology
Winter Quarter 2009

Midterm 2 KEY

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.

1. (p. 178, p.352) Individuals with Kartagener Triad Syndrome lack ciliated cells. Individuals have a 50% chance of having the heart on the right side of the body. Explain why a defect in ciliated cells would result in a developmental defect in the location of the heart.

In mammals, ciliated cells located in the Node region establish a counterclockwise flow of extracellular fluid. This flow of fluid translocates the morphogen, Nodal, to one side of the side of the Node, which in turn establishes a left-right asymmetry in gene expression in the paraxial mesoderm. Without functional cilia in the Node, the left-right asymmetry of gene expression, and the future chirality of body organs, will become randomized. This is why individuals with Kartagener Triad Syndrome have a 50% chance of having the heart on the right side of the body.

2. (p. 177) What type of modified organelle is the acrosome?

Book: The acrosome is a derivative of the Golgi Apparatus.
Dr. Cooper: The acrosome is a derivative of the Lysosome.

either answer was accepted

3. (p. 189) What would happen if sea urchin eggs were fertilized in seawater containing high levels of K^+? Explain your answer.

High levels of extracellular K^+ will depolarize a sea urchin egg membrane. If sperm is added to a depolarized sea urchin egg, polyspermy will probably occur. However, one could argue that no fertilization would be possible in the depolarized state. I accepted all answers to this ambiguous question. (It was interesting to read the range of your answers, as well as the reasoning behind your answers).

4. Turkeys can reproduce parthenogenetically, whereas mammals cannot. However, when methylation pathways in mice are disrupted, strains of mouse have been created that can reproduce parthenogenetically. From this information, formulate a hypothesis to explain why turkeys can reproduce parthenogenetically.

One may hypothesize that gene methylation is reduced, or absent, during gametogenesis. Without gene methylation, a turkey oocyte might be able to resorb a polar body after meiosis I, and initiate parthenogenesis.

5. (p. 185-186) In sea urchins, why are there species-specific bindin proteins on the surface of sperm heads?

Sea urchin sperm have species-specific bindin proteins on their sperm heads in order to prevent cross-fertilization with other species. Cross-fertilization between different sea urchin species must be reduced because sea urchins utilize external fertilization, which increases the probability that sperm and eggs from different sea urchin species come into contact.

6. (pp. 219-221) What would happen to *delta* and *hrf6* expression in large micromeres in a sea urchin embryo treated with Li^+? Explain why this would occur.

Two answers are acceptable. First answer: the expression of *delta* and *hrf6* in large micromeres are unchanged in a sea urchin embryo treated with Li^+. This is because large micromeres already have high levels of beta-catenin in them. Second answer: the expression of *delta* increases, and *hrf6* decreases, in large micromeres increases in a sea urchin embryo treated with Li^+. This would occur if the levels of beta-catenin increase in large micromeres after Li^+ treatment.

7. (pp. 215, 226-228) Describe how the elongation of the sea urchin archenteron is accomplished, using terms which define specific cell movements.

The archenteron in sea urchin is initially formed by an invagination of the vegetal plate. Subsequently, cells in the archenteron intercalate and undergo convergence and extension. This accounts for 2/3 of the elongation of the archenteron. The final 1/3 of archenteron elongation is produced by secondary mesenchyme cells pulling on the tip of the archenteron. Secondary mesenchyme cell are also attached to the anterior inner wall of the blastula.

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8. (p. 214) Using specific terminology for yolk distribution and cleavage patterns, describe the relationship between eggs type and cleavage pattern.

Points were awarded for completeness, as well as writing clarity.

9. (p. 215) Name three types of cell movements in early embryogenesis and, using an example of a particular species during gastrulation, describe the cellular or tissue dynamic that corresponds to each term. You may include drawings.

examples:

epiboly
invagination
involution
convergence and extension

Points were awarded for completeness, as well as writing clarity.

10. (p. 231) Start with two snail embryo at the 4-cell stage. One embryo is from a *DD* mother. The other embryo is from a *dd* mother. Replace the D blastomere in the embryo from the *dd* mother with the D blastomere from the *DD* mother. Predict the outcome on the coiling pattern of the adult, and explain why this would occur (i.e., what do we call this type of gene action?).

The transplated D blastomere rescues the wild-type phenotype in the *dd* embryo. A right-handed coiling pattern in produced in the adult.

11. What is a modern molecular definition of a gene? Draw a schematic and name all of the relevant "parts" of the gene. Now pretend that this is the *Ultrabithorax* gene. Show 2 ways the *Ultrabithorax* gene could be mutated to produce the bithorax phenotype.

The schematic diagram should include: promoter, coding region, introns, exons, enhancers.

Mutation of the *Ultrabithorax* gene could occur in the coding region, the promoter, or in enhancer regions of the gene to produce the bithorax phenotype.

12. (p. 282) Redraw the pattern of *Eve*, as well as the pattern of cell specification, shown in Figure 9.33A for a *fushi tarazu (ftz)* mutant.

The expression pattern of *Eve* increases. *wingless* and *engrailed* are still expressed in single adjacent cells are presumptive segment boundaries.

13. (p. 287) Draw the phenotype of a *Drosophila* embryo that would result if amino acid 9 on the recognition helix of the Bicoid protein was mutated from a lysine to a glycine residue. If you were to zygotically rescue this maternal-effect phenotype, what would you do?

Draw the *bicoid* mutation phenotype: two abdomens that are mirror-symmetric about the median plane of the AP axis. One could zygotically rescue the embryo by injected *bicoid* mRNA into the anterior end of the oocyte.

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14. (p. 262) What would happen if a mutation in *cactus* prevented a Dorsal protein from phosphorylating Cactus protein? Predict the phenotype of the embryo.

Dorsal protein would not detach from Cactus. Dorsal would not translocate into the nucleus. Ventral cell phenotypes would not be produced. A dorsalized embryo would result.

15. (p. 262) Which method is used to visualize what product of the gene for *fushi tarazu* in Fig. 9.32E? Name a strength and a weakness of this method.

***In situ* hybridization is the technique that was used for Fig. 9.32E. A strength of this technique is its ability to identify sites of gene expression. A weakness of this technique is that is does not show the location of the proteins that are translated from the mRNA messages.**

16. (pp. 282, 320) *Wingless* in *Drosophila* and *Wnt* in *Xenopus* are homologous on a molecular level. What is the major difference in the way these genes are used for the establishment of the body axis?

***Wingless* is used as an extracellular ligand in the establishment of segmental polarity in *Drosophila* whereas the Wnt ligands are used to establish anterior-posterior and dorsal-ventral polarity in *Xenopus*.**

17. (p. 308) Describe the outcome if a frog oocyte was treated with a drug that resulted in microtubule disassembly, then fertilized. What is the special name for this outcome?

Without microtubules, translocation of GBP and Disheveled to a specific side of the fertilized egg would not occur. β-catenin would not be stabilized in a specific location. As a consequence, a Nieuwkoop Center would not be established, nor would the Spemann-Mangold Organizer. A ventralized embryo would result. The term for this embryo is a "belly piece", or "bauchstuck."

18. (p. 309) How is β-catenin visualized in Fig. 10.23? What is a strength and a weakness of this technique?

β-catenin is visualized using immunohistochemistry. A strength of this technique is that it allows the location of a specific protein to be visualized in the embryo. A weakness of this technique is that it requires the isolation of an antibody that is specific for the protein of interest. This can be a time-consuming effort.

19. (p.323) At the time of its discovery in 1998, *Pitx2* seemed to be the master regulatory gene (i.e., furthest upstream) for determining chirality in *Xenopus*. How do the findings by Essner *et al*. (2005) change this view?

Nodal was found to be upstream of *Pitx2* activation.

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20. (p. 319-322) Draw the resulting frog larvae that would result if BMPs expression were inhibited throughout the embryo.

No ventral structures will be produced. The embryo will be hyper-dorsalized. Embryos that were "all head" were accepted as correct answers as well.

21. (pp. 356-357) Under which amnion & chorion conditions did the famous Siamese twins, Eng and Chang, likely become formed? You can draw this if you choose. When during development does this condition happen?

Eng and Chang were likely formed after day 9 within a single amnion and chorion.

22. (p. 350) What would happen to the early mouse blastocyst if *Stat3* expression was knocked down with morpholinos?

Self-renewal of the Inner Cell Mass (ICM) would be loss. The embryo would not be able to generate an adequate number of cells to form the hypoblast and epiblast.

23. (p. 344) Compare Waddington's "cut and paste" experiment from duck to chick with Spemann and Mangold's experiments in amphibians. Which structure in birds corresponds to the Spemann-Mangold Organizer? Why is Waddington's experiment significant?

Hensen's Node in avian embryos corresponds to the Spemann-Mangold Organizer in amphibians. Waddington's experiment shows that an interspecies transplant can induce a secondary body axis, whereas the Spemann-Mangold experiments show that homochronic transplantations in the same species of amphibian is able to induce a secondary body axis. Waddington's experiments suggest that the signals produced in the Organizer are common to all vertebrates.

24. (pp. 362-363) Most mammals have 7 cervical vertebrae. Why does extra Retinoic Acid (RA) result is an extra thoracic vertebra at the base of the neck, rather an extra cervical vertebra at the base of the neck? Hint: although retinoic acid is a morphogen, it can also be a teratogen when added in high concentration.

Retinoic Acid (RA) suppresses anterior fate specification in vertebrates. With high levels of RA induce a homeotic transformation of vertebrae. The most posterior cervical vertebra is transformed into a thoracic vertebra, which is a more posterior fate.

25. What does homeosis refer to? Give an example of a homeotic mutation, describing the phenotype.

Homeosis refers the substitution of one body part for another. Antennapedia and bithroax mutants are examples of homeotic mutations.