MCB 141 Midterm I  Feb. 19, 2009

Circle the name of your TA

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Question #1  _____________ / 30 pts
Question #2  _____________ / 30 pts
Question #3  _____________ / 25 pts
Question #4  _____________ / 15 pts
TOTAL  _____________ / 100 pts

Exam is closed book, closed notebook
NO CELL PHONES or other electronic devices
Exams must be turned in by 12:30 PM
All answers must be written in ink.
If you need extra space, write on the back of the page, but clearly indicate this on
the front page of the question
Regrade policy: Turn in your entire exam to your TA and include a written
explanation as to why you think you deserve additional credit.
Question #1

We have discussed the pathway that establishes the initial dorsal/ventral polarity of the fly embryo (see below).

It turns out that the eggshell, which is made by the follicle cells, also shows dorsal/ventral patterning. The dorsal side of the eggshell has projections, called dorsal organs, while the ventral side is smooth. You examine the eggs laid by mothers homozygous for null (complete lack-of-function) alleles of gurken, torpedo, snake, easter, Toll, cactus, and dorsal and find the following:

<table>
<thead>
<tr>
<th>Female genotype</th>
<th>Eggshell phenotype</th>
<th>Embryo phenotype</th>
</tr>
</thead>
<tbody>
<tr>
<td>gurken−/gurken−</td>
<td>ventralized</td>
<td>ventralized</td>
</tr>
<tr>
<td>torpedo−/torpedo−</td>
<td>ventralized</td>
<td>ventralized</td>
</tr>
<tr>
<td>snake−/snake−</td>
<td>normal</td>
<td>dorsalized</td>
</tr>
<tr>
<td>Toll−/Toll−</td>
<td>normal</td>
<td>dorsalized</td>
</tr>
<tr>
<td>cactus−/cactus−</td>
<td>normal</td>
<td>ventralized</td>
</tr>
<tr>
<td>dorsal−/dorsal−</td>
<td>normal</td>
<td>dorsalized</td>
</tr>
</tbody>
</table>

(ventralized egg shells lack dorsal organs and are smooth all around)
1A (9 pts). Explain why some of these genes are required for both eggshell and embryo patterning, while others only affect the embryo.

1B (9 pts). Predict both the eggshell and embryo phenotypes that are produced by females homozygous for:

1) a null mutation of easter

2) a dominant allele of Toll that produces a Toll protein that acts as though it is always bound to Spätzle protein

3) a dominant allele of torpedo that produces a Torpedo protein that acts as though it is always bound by Gurken protein
1C (12 pts). You find a new gene x, where female flies homozygous for a null mutation of x produce eggs where the eggshell is dorsalized (has dorsal organs all around the egg shell circumference), but the embryo inside is normal. You suspect that gene x is expressed in (and functions in) the follicle cells and not in the oocyte/nurse cells. Design pole cell transplant experiments to test your hypothesis. Describe (use drawings if necessary) how you will carry out your experiments and interpret your results. Assume that you already have available wild-type embryos as well as embryos that are homozygous mutant for a null allele of x that were produced by a heterozygous mother (so no need to tell us how you produced these starting embryos).
Question #2

In a new mutant screen for maternal effect mutations, you discover five new genes (which you name n, o, p, q, and r). Female flies that are homozygous for null alleles of any one of these genes produce embryos that have no head and thorax, but have an enlarged abdomen instead. You also find that bicoid mRNA is not localized at the anterior of the oocytes produced by these females, but rather the bicoid mRNA is found uniformly (diffusely) spread out through the oocyte. Given that all your alleles produce the same phenotype, you realize that you cannot carry out a standard epistasis test by making double mutants. However, you have antibodies directed against the protein products produced by each gene n through r. You use these antibodies to look at the corresponding protein distribution of proteins N through R. You find that all five proteins are localized to the anterior end of the developing oocytes in wild-type females. You decide to use your antibodies to look at the distribution of proteins N through R in oocytes produced by females that are homozygous mutant for each of your genes n-r.

You obtain the following results:

- "wt" means the same pattern as seen in oocytes in wild-type females (localized at the anterior end)
- "diff" means the protein (or mRNA in the case of bicoid) is diffuse throughout the oocytes
- "–" means that you see no protein (or mRNA in the case of bicoid)

<table>
<thead>
<tr>
<th>Female genotype</th>
<th>Prot N</th>
<th>Prot O</th>
<th>Prot P</th>
<th>Prot Q</th>
<th>Prot R</th>
<th>bicd mRNA</th>
</tr>
</thead>
<tbody>
<tr>
<td>n−/n−</td>
<td>–</td>
<td>diff</td>
<td>diff</td>
<td>wt</td>
<td>diff</td>
<td>diff</td>
</tr>
<tr>
<td>o−/o−</td>
<td>wt</td>
<td>–</td>
<td>diff</td>
<td>wt</td>
<td>wt</td>
<td>diff</td>
</tr>
<tr>
<td>p−/p−</td>
<td>wt</td>
<td>wt</td>
<td>–</td>
<td>wt</td>
<td>wt</td>
<td>diff</td>
</tr>
<tr>
<td>q−/q−</td>
<td>diff</td>
<td>diff</td>
<td>diff</td>
<td>–</td>
<td>diff</td>
<td>diff</td>
</tr>
<tr>
<td>r−/r−</td>
<td>wt</td>
<td>wt</td>
<td>diff</td>
<td>wt</td>
<td>–</td>
<td>diff</td>
</tr>
<tr>
<td>bcd−/bcd−</td>
<td>wt</td>
<td>wt</td>
<td>wt</td>
<td>wt</td>
<td>wt</td>
<td>–</td>
</tr>
</tbody>
</table>
2A (15 pts). While you cannot carry out a standard genetic epistasis analysis, you can use the protein localization data to determine the order in which the proteins act to eventually localize bicoid mRNA. Draw out the order of this relationship for N, O, P, Q, and R (with bicoid mRNA at the end of your series). Briefly explain the reasoning for your answer.
2B (15 pts). In snails, the shell can coil to the left (called sinistral), or coil to the right (called dextral). The direction of coiling is controlled by a single gene, called F. There are two alleles of F, which are called $F^{\text{DEXTRAL}}$ ($F^D$) and $F^{\text{SINISTRAL}}$ ($F^S$). Below is a diagram showing a series of crosses (matings), and the shell phenotype and the genotype of each animal.

Is F acting maternally or zygotically (explain your answer)? How would you describe the interaction between the alleles $F^D$ and $F^S$? [Hint: think of one as $F^+$ and the other as $F^-$]
Question #3

You discover a fascinating insect, Dihaltere, that is closely related to flies, but it has no wings but has two pairs of halteres. In Dihaltere, T1 has legs only, T2 has halteres and legs, and T3 has halteres and legs. As in flies, the abdominal segments of Dihaltere have no legs. You expect that the pattern of Ubx expression is different in Dihaltere than in Drosophila, and you find that this is true.

3A (10 pts). What pattern do you think you would see for Ubx expression in early stage embryos (beforeDll expression begins), in late stage embryos (after Dll has become autoregulatory), and in the imaginal disks of Dihaltere animals. How does this differ from what is seen in Drosophila?
3B (15 pts). Describe an experiment that would help you tell if these differences in Ubx expression between Dihaltere and Drosophila were cis changes in Ubx or were trans changes (changes in other genes). Use diagrams as needed.
Question #4 (15 pts).

As described in class, eve stripe 2 is activated by bicoid and hunchback and repressed by giant and Krüppel.

You discover the following:

Bicoid protein binds to the sequence CGCGGGGG
Hunchback protein binds to the sequence ATATTTTT
Giant protein binds to the sequence GGGGACACAC
Krüppel protein binds to the sequence TTTTCAGCAG

You create a synthetic enhancer SynEveA with the sequence:

CGCGGGGAAGGGGACACACTTATATTTTTCTTTTTCAGCAG

You put this in front of a lacZ reporter gene and introduce it into flies via P-element transposition. You expect the lacZ pattern to mimic eve stripe 2, but instead you get a stripe that is much broader (spread both anteriorly and posteriorly from the normal boundaries for eve stripe 2).

You create a second synthetic enhancer called SynEveB with the sequence:

CGCGGGGACACACTTATATTTTTTCAGCAG

You put this in front of a lacZ reporter gene and introduce it into flies via P-element transposition. You find that the lacZ pattern now perfectly mimics the pattern of eve stripe 2.
Give an explanation for your results. Why the difference in results for SynEveA and SynEveB? Give a possible explanation for how Giant and Krüppel proteins act as repressors and prevent activation by Bicoid and Hunchback proteins.