

NAME: \_\_\_\_\_

**MCB 141 – First Midterm Feb. 21, 2008**

**Only answer 4 of these 5 problems. You MUST put an “X” below on this page to indicate the question that you are NOT answering. Only 4 out of the 5 questions will be graded.**

**Write your name on each page of the exam. Write your answers with a pen. If you need extra space, continue on the back of the exam pages, but clearly indicate this on the front page of the question.**

**Problem 1 (25 points)      \_\_\_\_\_/25**

**Problem 2 (25 points)      \_\_\_\_\_/25**

**Problem 3 (25 points)      \_\_\_\_\_/25**

**Problem 4 (25 points)      \_\_\_\_\_/25**

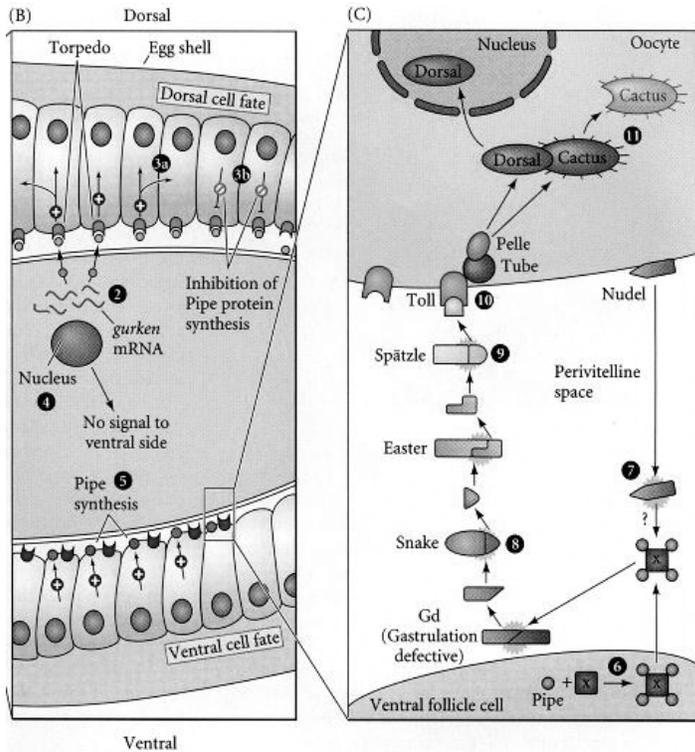
**Problem 5 (25 points)      \_\_\_\_\_/25**

**TOTAL (100 points)      \_\_\_\_\_/100**

Name: \_\_\_\_\_

### Problem 1)

Here is a schematic of the dorsal-ventral patterning pathway in *Drosophila*:



Describe the phenotype (normal, dorsalized, or ventralized) of the following embryos that come from mothers with the following genotypes:

a. 1 point) Homozygous mutant for complete lack of function for Toll.

b. 1 point) Homozygous mutant for complete lack of function for cactus.

c. 1 point) Homozygous mutant for complete lack of function for easter.

d. 1 point) Homozygous mutant for complete lack of function for torpedo.

Name: \_\_\_\_\_

e, 2 points) Homozygous mutant for complete lack of function for torpedo AND easter.  
Explain in 1-3 sentences.

f, 2 points) Homozygous mutant for complete lack of function for Toll AND easter.  
Explain in 1-3 sentences.

g, 2 points) Homozygous mutant for complete lack of function for cactus AND easter.  
Explain in 1-3 sentences.

h, 1 point) You obtain some embryos that have just been laid by a female homozygous for a complete lack of function mutation in the snake gene. What is the phenotype you expect for these embryos?

Name: \_\_\_\_\_

i, 3 points) You inject these same eggs described in (h) above (within the first few minutes of egg laying) with some synthetic full-length snake protein. Your injection is into the perivitelline space that completely surrounds the embryo. What is the phenotype you expect for these embryos? Explain your answer in 1-3 sentences.

j, 3 points) You inject these same eggs described in (h) above (within the first few minutes of egg laying) with some synthetic snake protein that you have pre-cleaved to yield the active form of the snake protein. Your injection is into the perivitelline space that completely surrounds the embryo. What is the phenotype you expect for these embryos? Explain your answer in 1-3 sentences.

Name: \_\_\_\_\_

k, 4 points) You inject these same eggs described in (h) above (within the first few minutes of egg laying) with some synthetic easter protein that you have pre-cleaved to yield the active form of the easter protein. Your injection is into the perivitelline space that completely surrounds the embryo. What is the phenotype you expect for these embryos? Explain your answer in 1-3 sentences.

l, 4 points) You inject these same eggs described in (h) above (within the first few minutes of egg laying) with some synthetic Gd (gastrulation defective) protein that you have pre-cleaved to yield the active form of the Gd protein. Your injection is into the perivitelline space that completely surrounds the embryo. What is the phenotype you expect for these embryos? Explain your answer in 1-3 sentences.

Name: \_\_\_\_\_

**Problem 2)**

You isolate embryos laid by a female *Drosophila* that lacks both copies of the bicoid gene.

a. 6 points) Describe (in 1-3 sentences or with a clearly labeled diagram) the spatial distribution of caudal protein at the syncytial blastoderm stage that is made from the corresponding maternal caudal mRNA in these mutant embryos (laid by female homozygous mutant for bicoid lack of function mutation). Explain in an additional 1-3 sentences how and why this distribution is different from that seen in normal embryos.

Name: \_\_\_\_\_

Into some freshly laid mutant embryos (laid by females homozygous mutant for a bicoid lack of function mutation) you inject synthetic bicoid mRNA into the middle of the egg. b, 9 points Describe (in 1-3 sentences or with a clearly labeled diagram), the spatial distribution of caudal protein at the syncytial blastoderm stage that is made from the corresponding maternal caudal mRNA in these embryos. Explain how this distribution is achieved in an additional 1-3 sentences.

Name: \_\_\_\_\_

c. 10 points) Describe in 3-6 sentences (plus any diagrams you wish to use) the mechanisms that cause bicoid and nanos mRNAs to be localized during *Drosophila* oogenesis [note: its okay if you don't specifically remember which end is (+) versus (-)].

Name: \_\_\_\_\_

**Problem 3)**

a, 7 points) Describe in 3-6 sentences how the cuticle patterns of mutant embryos can be used to distinguish between gap, pair-rule, segment polarity, and homeotic mutants.

Name: \_\_\_\_\_

b, 10 points) Describe how the information provided by Krüppel, giant, bicoid, and hunchback is used to create the expression pattern seen for eve stripe 2. Use diagrams as needed.

Name: \_\_\_\_\_

c, 8 points) Both wingless and engrailed are segment polarity genes and in a wild-type embryo they are expressed in adjacent cells within each segment. In an embryo homozygous for the complete loss of the wingless gene, engrailed mRNA and protein expression begins normally (end of the blastoderm stage through the onset of gastrulation), but then fades away. Explain in 3-6 sentences why engrailed expression starts out normally in these wingless mutants, but then fades away.

Name: \_\_\_\_\_

**Problem 4)**

a, 7 points) In *Drosophila*, Ubx expression inhibits the formation of appendages in the first abdominal segment, but Ubx expression also makes the appendages of the third thoracic segment different from the appendages of the second thoracic segment. At first these two functions seem contradictory. Explain in 5-8 sentences how it is that Ubx can play both roles.

Name: \_\_\_\_\_

You discover a new crustacean species in which there are 8 thoracic segments and 6 abdominal segments. All eight thoracic segments have identical large walking legs. Both Ubx and abd-A in this species are uniformly expressed (at the mRNA and protein levels) at all stages in all thoracic segments and all abdominal segments. All six abdominal segments are identical and have identical small feathery legs that are used to hold developing eggs. Abd-B is uniformly expressed at all stages in all six abdominal segments and is not expressed in the thoracic segments.

b, 4 points) Predict the phenotype, in terms of leg patterns, that you would expect if you had a mutant of your new crustacean species that lacked all Abd-B expression. Explain your answer in 1-3 sentences.

c, 4 points) Predict the phenotype, in terms of leg patterns, that you would expect if Abd-B were to be uniformly expressed at all stages throughout the entire thorax and abdomen of your new crustacean species. Explain your answer in 1-3 sentences.

Name: \_\_\_\_\_

d, 8 points) You isolate a new mutant allele of Ubx in *Drosophila*. It creates a dominant phenotype in which the wings of the adult fly are transformed into halteres (there are no embryonic defects). You find that this mutation does not alter Ubx expression (at either the mRNA or protein level) during embryogenesis, but during late larval and pupal development it causes Ubx mRNA and protein to be expressed more anteriorly than normal – that is to say that you observe Ubx expression in what should be the wing disks of T2. Explain in 1-3 sentences how this mutation might be acting to change Ubx expression. In an additional 1-3 sentences, explain why this is a dominant instead of a recessive allele of Ubx.

Name: \_\_\_\_\_

e, 2 points) You examine the mRNA expression pattern of the pair-rule gene even-skipped in a blastoderm stage embryo that is homozygous mutant for a complete loss of function allele of Ubx. In 1-2 sentences, describe the pattern that you would see.

Name: \_\_\_\_\_

**Problem 5)**

While exploring in the Amazon, you discover two new species of beetles that you name species A and species B. Both species have 8 abdominal segments. In species A, the first two abdominal segments are blue, and the remaining six are red. In species B, the first four abdominal segments are blue, and the remaining four are red.

You carry out a genetic screen in species A, and discover a mutant with all blue abdominal segments. Further analysis of the mutant leads you to discover gene Q, which is normally expressed (both mRNA and protein) in the last six abdominal segments of species A. If gene Q is eliminated, the abdomen of species A becomes completely blue. If you express gene Q in all the abdominal segments of species A, the animals now have abdomens in which all eight segments are red. You also discover that species B has a gene that encodes a protein identical to that encoded by gene Q in species A, but in species B, this gene Q is normally expressed (both mRNA and protein) in just the last four abdominal segments.

You isolate the regulatory region for gene Q from species A. When combined with a lacZ reporter gene, this regulatory region from species A gives the expression of lacZ in the last six abdominal segments when placed into species A. You also isolate the regulatory region for gene Q from species B. When combined with a lacZ reporter gene, this regulatory region from species B gives the expression of lacZ in the last four abdominal segments when placed into species B.

You hypothesize that the differences in expression of gene Q between species A and B are responsible for the coloration differences between the two species. You now wish to test whether the differences in expression are due to differences in the enhancers of gene Q between species A and B (cis regulatory changes), or if the differences are due to differences in genes that regulate gene Q transcription (trans regulatory changes).

Name: \_\_\_\_\_

a. 6 points) In 4-6 sentences, explain the experiment you would carry out to test the two possibilities (cis versus trans).

Name: \_\_\_\_\_

b, 6 points) Describe in 2-4 sentences the outcome of your experiment if the answer is that “cis” changes are responsible.

c, 6 points) Describe in 2-4 sentences the outcome of your experiment if the answer is that “trans” changes are responsible.

Name: \_\_\_\_\_

d, 7 points) Imagine that you find that “trans” changes are responsible for the difference between the two species. In species A, you discover genes X and Y. Gene X encodes a protein X that is expressed in all segments except the last six abdominal segments of species A. Gene Y encodes a protein Y that is found everywhere in the animal. You find that the X protein directly binds to the enhancer of gene Q and represses the transcription of gene Q, while the Y protein binds to the enhancer of gene Q and activates transcription. Predict the pattern you might expect to see for gene Q (**CORRECTION announced during the test - this should be gene X, not gene Q**) in species B and how this would account for the “trans” result you obtained.

**Problem 6) 0 POINTS**

Explain the sentence

“Time flies like an arrow, fruit flies like a banana”