

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

Spring 2003

### Developmental Biology Exam #3

1. How would the embryos (or cells) indicated develop after each of the following experiments or manipulations? [3 pts each]

- Tunicate embryo: separate cells at the 8-cell stage. Culture the cells containing yellow crescent cytoplasm in isolation. How would the isolated cells develop?
- Tunicate embryo: inject anti-sense RNA with a sequence complementary to that of *macho-1* mRNA.
- Snail embryo: remove the polar lobe at the two-cell stage.
- *Drosophila*: inject *bicoid* mRNA into the posterior pole of the embryo just after fertilization.
- *Drosophila*: mate a female heterozygous for the bicoid gene (+/-) with a homozygous recessive (-/-) male.
- *Drosophila*: before fertilization, prick an egg at its posterior end and allow a small amount of cytoplasm to leak out. After the egg heals, allow it to be fertilized as usual.

- Frog embryo: combine gastrula stage dorsal mesoderm with early gastrula stage (uncommitted) ectoderm. How will the ectoderm develop?
- Frog embryo: treat embryos immediately after fertilization with nocodazole, an inhibitor of microtubules. (You then wash out the nocodazole so that cleavage occurs normally.)

2. To study lens induction, optic vesicles from mouse embryos can be combined with head ectoderm *in vitro*, and a lens will form in many cases. Recent studies suggest that the optic vesicle releases BMP-4. If BMP-4 is indeed necessary for lens development, how would the ectoderm develop in each of the following experiments? *Explain your answer.* [3 pts each]

- combine optic vesicle and competent ectoderm

*lenses would form in many cases*

- combine optic vesicle and ectoderm in the presence of a high concentration of chordin protein.

- culture ectoderm in the presence of a high concentration of *Drosophila* decapentaplegic (dpp) protein.

3. *VegT* and *Xbra* (*brachyury*) are both members of the T-box family of transcription factors. The two genes encode related, but not identical, proteins that are important in *Xenopus* development. What would be the effect on development of replacing the DNA-binding domain of *VegT* with the corresponding region of *Xbra*? (That is, the DNA binding domain of *VegT* would be exactly the same as the DNA-binding domain of *Xbra*.) Explain your answer. [4 pts]

4. Which of the following is true of the *Drosophila hunchback* gene/protein? (circle all that apply): [4 pts]

it is a maternal mRNA	its RNA is cytoplasmically localized
it is transcriptionally controlled	it is translationally controlled
it is a transcription factor	it is a translation factor
it is a homeotic selector gene	it is an inducer

5. If there were a mutation in both copies of the *fushi tarazu* (*ftz*) promoter that eliminated only stripe 4 of *ftz* expression, what would the resulting fly larva look like? [3 pts]

6. In frog embryos in which cortical rotation is inhibited, it is possible to inject mRNAs into a single vegetal cell at the 16- to 32-cell stage, and some RNAs (but not all) will rescue normal development. If mRNA encoding  $\beta$ -catenin is injected, for example, development is normal. If mRNA encoding Wnt is injected, development is *not* rescued, but if mRNAs encoding *both* Wnt and the Wnt receptor are injected, then development *is* rescued. How can you explain these results? [4 pts]

7. In *Xenopus* embryos, the so-called “animal cap assay” is often used to assess the possible roles of genes during development. In one version of this assay, mRNAs can be injected into the embryo, near the animal pole, at the 1-2 cell stage. Then, at the blastula stage, the animal cap is removed and cultured alone. Normally, the animal cap develops into epidermis. Into what germ layer of cell type would the animal cap develop after the embryo was injected with each of the following mRNAs?

- *noggin*
- *VegT*
- *Xnr-1* (*Xnr* = *Xenopus nodal-related*)
- *lefty*

8. **True or false:** (Please explain your answer): [3 pts each]

- Because *C. elegans* development is invariant from one wild-type individual to another (that is, all show precisely the same cell lineage), early developmental is mosaic (that is, decisions are controlled by localized cytoplasmic determinants).

- The first cleavage division in *Drosophila* is asymmetric

9. In early chicken embryos, the somites form from dorsal mesoderm near the notochord. The **medial cells** (that is, those closest to the notochord) **normally form the sclerotome**, and differentiate into bone. The **lateral cells** (that is, those that are furthest away from the notochord) **normally form the myotome**, and differentiate into muscle. To study what causes the cells in the different parts of the somite to form different cell types, you perform the following experiments:

- (1) You rotate the somite by 180° (that is, turn it around completely) at the early neural tube stage. The cells that were originally lateral (and are now medial) form bone. If you perform the same operation at the late neural tube stage (several hours later), the cells that were originally lateral (and are now medial) form muscle.
- (2) You remove cells from the somite-forming region of an early neural tube stage embryo and transplant them into the **lateral** portion of the somite of another embryo at the same stage. The cells form muscle.
- (3) You remove cells from the somite-forming region of an early neural tube stage embryo and transplant them into the **medial** portion of the somite of another embryo at the same stage. The cells form bone.
- (4) You remove cells from the lateral part of the somite of a **late** neural tube stage embryo and transplant them to the medial part of the somite of another embryo at the **early** neural tube stage. The cells form muscle.

Based on these results:

- When do the somite cells become determined? [2 pts]
  
- What do you think is causing the somite cells to become committed to different pathways of development? [3 pts]
  
- In experiment (4), why do the transplanted cells develop as muscle? [3 pts]

10. The *Drosophila* homeotic gene *Sex Combs Reduced (Scr)* is normally expressed in the first thoracic segment (segment T1), which forms neither wings nor halteres. The homeotic gene *Antennapedia (Antp)* is normally expressed in the second thoracic segment (T2), which forms wings. When the *Antp* gene is mutated so that no functional Antp protein is made, then *Scr* is expressed in the region of the embryo where *Antp* would normally have been expressed. Assuming it can develop into an adult, what will an adult *Antp*-minus fly look like? [2 pts]

11. In *Drosophila*, gap genes are involved in the specification of different parts of the body. For example, the gene *orthodenticle (otd)* specifies the formation of anterior head structures, the gene *empty spiracles (es)* specifies formation of more posterior parts of the head, and the gene *Krüppel* specifies formation of the anterior thorax. Analysis of all these genes that they encode transcription factors, and that **each one represses the transcription of the other two**.

**\*\*note\*\*** for this question, you may assume there are no other gap genes active in that portion of the embryo. (That is, don't worry about hunchback.)

At the syncytial blastoderm stage, the expression patterns look like this:

What would be the effect of a mutation of the *empty spiracles* gene on:

● the pattern of the larva? [3 pts]

● the expression of the other two genes? [3 pts]