

**Zoology 470 - Exam #2 – 2008**

This exam has **5** pages and a total of **50 points**. You will have 90 minutes to complete it. Answer all short answer questions as briefly as possible. Make sure your name and ID number are on all pages. **You will receive 1 point for doing so.**

1. Provide concise definitions for each of the following (**5 points**)

a. Wolffian duct: *Tubular structure that is retained in male mammals. It becomes portions of the male reproductive tract, including the vas deferens.*

b. midblastula transition: *Transition that occurs at different times in different organisms, but is accompanied by randomization of cell division, and a large-scale transition from reliance on maternal transcripts to production of zygotic transcripts.*

c. ectoderm: *Most external of the three primary germ layers. Ectodermal fives rise to tissues such as epidermis and neural tissues.*

d. contractile ring: *Actomyosin-based structure that is responsible for pinching daughter cells off during cytokinesis. The CR is found at the cleavage furrow.*

e. invagination: *Inward bending of sheet of tissue.*

2. Complete the following table referring to cleavage patterns in early embryos of various animals (**4 points**)

<b>Animal</b>	<b>Yolk Distribution</b>	<b>Completeness of Cleavage</b>	<b>Orientation of cleavages</b>
Squid (cephalod mollusk)	<i>telolecithal</i>	meroblastic	<i>bilateral</i>
Chimpanzee (mammal)	<i>isolecithal</i>	<i>holoblastic</i>	rotational
Earthworm (annelid)	isolecithal	holoblastic	<i>spiral</i>
Salamander (amphibian)	<i>mesolecithal</i>	<i>holoblastic</i>	<i>radial</i>

3. Transcription factors can play a powerful role in the differentiation of tissues in embryos.

a. The *pax-6* family of proteins are important for the development of eye structures. Describe **one** experiment that demonstrates a *pax-6* family member is necessary for eye development (**2 points**):

*eyeless mutants in flies, small eye mutants in mice, and aniridia patients in humans all carry mutations in the pax-6 equivalent. [Note: overexpression does NOT prove necessity, but merely sufficiency]*

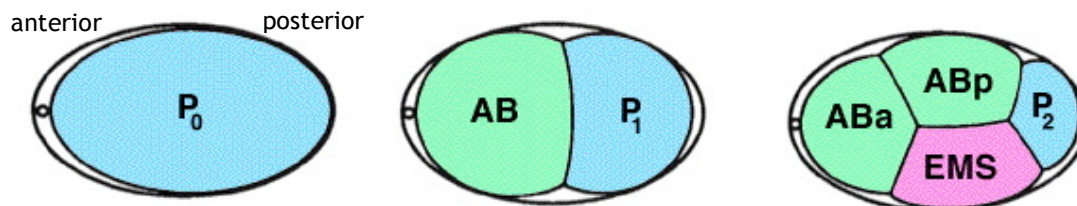
b. *Sry* is crucial for development of male mammals. Describe **one** experiment that demonstrates that *Sry* is sufficient to confer the male phenotype (**2 points**):

*Transgenic mice carrying an sry transgene who are XX display male characteristics; XX mice with a crossover that carries the sry locus onto the pseudoautosomal region of one X chromosome have the same phenotype.*

## 4. Circle true (T) or false (F) for each of the following (7 points)

T	RNA helicases are a conserved component of germ plasm in many animal embryos
T	Protein gradients as a patterning mechanism are possible in <i>Drosophila</i> because the early embryo is syncytial
F	<i>oskar</i> would be expected to be a zygotically acting gene, since it encodes a gene product required for germ cell formation in <i>Drosophila</i> embryos [maternally acting]
F	Genes can be transcriptionally regulated or translationally regulated, but not both [bad wording, since genes technically can't be translationally controlled, but even then the statement is false. If "gene products" was assumed, it's still false!]
F	Presumptive endodermal cells in <i>C. elegans</i> are internalized via convergent extension [ingression]
T	Transcription factors can increase or decrease the amount of transcripts produced from the genes they regulate
T	Testosterone is made in both male and female mammals
F	Normal zebrafish primordial germ cells placed into an embryo lacking the function of the chemokine, SDF-1, would be expected to migrate abnormally into the gonadal ridge (OOPS!) [with no SDF-1 around, PGCs can't chemotax]
T	MicroRNAs are short RNAs that can regulate the translation of mRNAs
F	Removing the RNA polymerase binding site from the <i>even-skipped</i> gene would not be expected to disrupt the transcription of <i>even-skipped</i> , since its transcription is tightly controlled. [RNA pol is generally needed for genes to be transcribed]
T	Removing the 3'-untranslated region from the <i>oskar</i> RNA would be expected to affect where it is localized in the oocyte
T	If a frog is discovered whose oocytes have 100 times the yolk found in a <i>Xenopus</i> oocyte, it would be less likely to undergo complete cleavage, and its blastocoel would be expected to be less centrally located than in <i>Xenopus</i>
F	The midblastula transition in <i>Xenopus</i> would be delayed in an embryo derived from an oocyte with a much less than the normal amount of cytoplasm [occur earlier, not later]
T	Treating a fertilized sea urchin egg immediately after sperm penetration with a microtubule poison would block pronuclear migration

5. Your friend is working in a laboratory that studies early blastomere specification in a nematode species closely related to *C. elegans*. Assume all cells in the early embryo have the same names as in *C. elegans*. Diagrams of the one-, two-, and four-cell embryo of the new species are shown for reference.



a. Your friend has developed a way to see where the sperm entered the oocyte at fertilization, and uses this technique in the new species. Assuming the same cues operate in the new species, at which end (left or right) of the oocyte did the sperm enter, if the zygote (P<sub>0</sub>) is shown in the same position as the oocyte? (1 point)

Location where sperm entered (left/right): \_\_\_\_\_ *Right* \_\_\_\_\_

5 (cont)

b. Your friend goes on to discover a new *mex* gene, which she has named *Tex mex*. In the absence of *Tex mex* function, SKINHEAD protein localization is abnormal. If *Tex mex* is similar to MEX proteins in *C. elegans* in function, in which cell(s) of the 2-cell embryo would you expect to find SKINHEAD if the embryo lacks TEX MEX protein? **State your reasoning (2 points)**

*MEX-5 in C. elegans represses translation of PIE-1 and SKN-1 in AB, and hence anterior cells. If the MEX-5 equivalent is lacking, PIE-1 and SKN-1 would be expected to be found in AB and P1.*

c. RNA-mediated interference (RNAi) works well in the new species, so your friend performs RNAi against the Wnt gene most similar to *mom-2* in *C. elegans*, which your friend names *Wntergreen* (your friend has a penchant for goofy names). What major organ/tissue do you expect to be absent when the function of *Wntergreen* is removed? **Clearly state your reasoning (2 points)**

*Gut cells; gut induction requires a Wnt signal between P2 and EMS. If the same signal is working here via Wntergreen, we'd expect the same thing.*

6. You are studying sex determination and dosage compensation in mammals.

a. In a female mouse embryo that is homozygous for a loss-of-function mutation in the *Xist* gene, what well-known structures observable under an ordinary microscope would be absent from the cells of the embryo (1 point)?

Structure predicted to be absent: Barr bodies

b. You develop a new tool that allows you to watch the localization of *Xist* transcripts in living cells of the very early mouse embryo. Using the diagram below, indicate where *Xist* transcripts would be found, if the indicated X chromosome becomes inactivated (1 point)



7. In an episode of the X-Files called "Postmodern Prometheus", an evil developmental biologist is experimenting with a human *Hox* gene most similar to the *Drosophila* homeotic gene *proboscipedia*. Mulder is unfamiliar with homeotic genes, and asks for an explanation from Scully, who does her best to remember her undergraduate biology classes. Name two key features of all homeotic genes that Scully should explain to Mulder (4 points):

Feature #1: *They all encode homeodomain transcription factors (the DNA contains the "homeobox")*

Feature #2: *The anterior/posterior domain whose identity they control correlates with their 3'/5' position within the Hox cluster*

Other answers: They specify identity of body parts, etc.

8. The following questions refer to the functioning of the segment polarity genes in *Drosophila*.

a. Segment polarity genes are thought to be regulated heavily by the products of the pair rule genes. What kinds of proteins are encoded by the pair rule genes? (1 point)

Kind of protein: transcription factor

b. *Armadillo*, the fly  $\beta$ -catenin, is a segment polarity gene. How would the levels of *armadillo* protein in the cytoplasm of cells making *engrailed* protein compare with levels of cytoplasmic *armadillo* in other cells? Explain your answer (3 points)

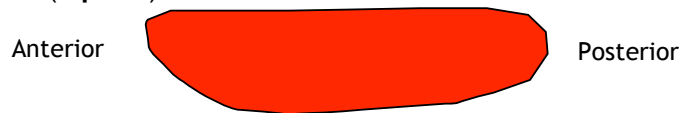
*Engrailed producing cells are the cells receiving a Wingless (Wnt) signal, which should cause elevation of cytoplasmic Arm protein as a result, since Wnt signals suppress the activity of the "destruction complex", which normally phosphorylates  $\beta$ -catenin, and hence destines it for destruction*

c. Eric Wieschaus and Christiane Nüsslein-Volhard used a convenient, easily visible feature of the *Drosophila* embryo to screen for segmentation mutants. What was this feature? (1 point)

Visible feature: denticle bands in cuticle

9. Maternal polarity gene products dramatically affect anterior and posterior development in *Drosophila*. Answer the following questions regarding how these proteins act. Use the provided diagrams to indicate the expected expression of the molecule in each case.

a. Indicate the expression pattern of *caudal* protein in an embryo derived from a *bicoid* loss-of-function mutant mother (1 point)



b. Indicate the expression pattern of maternal *hunchback* mRNA in an embryo derived from a *bicoid* loss-of-function mutant mother (1 point)



c. Indicate the expression pattern of *nanos* mRNA when the anterior end of the oocyte is pricked with a needle and cytoplasm is allowed to ooze out (1 point)



d. Indicate how the pattern of even-skipped expression (normal pattern is shown at the left) would be altered in embryos from a mother expressing 4 copies of the *bicoid* gene (1 point)



*(eve stripes are shifted posteriorly, since we expect an expansion of anterior structures)*

10. Pair rule genes in *Drosophila* are crucial for the proper segmentation of the embryo.

a. What key feature of the expression pattern of gap proteins is important for regulating the expression of pair rule genes? (2 points)

*Their spatial domains of overlap. These domains activate specific stripes of pair rule gene expression locally.*

b. Certain mutations in the pair rule gene *even-skipped* result in the loss of one or two specific stripes of *even-skipped* expression in the embryo. What defect(s) in the mutated *even-skipped* gene could account for this pattern of *even-skipped* expression? (2 points)

*These mutations would be expected to occur in enhancer elements that are known to control specific stripes of eve expression. Mutations in the coding region would affect all stripes to the same extent.*

11. Your friend, Rob Maxson, is studying an Antarctic sea urchin at McMurdo Station.

a. Rob wants to show that micromeres in the Antarctic species produce inductive signals similar to those in other sea urchins. Assuming all experiments performed in other species are possible, describe an experiment that would show the micromeres in the new species behave in a manner similar to other species (2 point)

*Transplant micromeres onto the animal pole of a recipient embryo. This should induce a secondary archenteron.*

b. Rob now performs a molecular test for proteins that are in the nucleus of micromeres in the new species. Assuming he can clone the Antarctic version of any gene found in well-studied sea urchins or make any other reagent he needs, name one molecule that Rob might expect to be at high levels in micromeres. (1 point)

Name of molecule found in nuclei of micromeres at high levels: \_\_\_\_\_β-catenin\_\_\_\_\_

c. You are a physiologist working with Rob in Antarctica, and you are testing a new inhibitor of Na<sup>+</sup>/H<sup>+</sup> exchangers using sea urchin eggs. What effects would this drug be expected to have on fertilized sea urchin eggs? Explain your reasoning (2 points)

*The Na/H exchanger is responsible for the increase in pH after fertilization that leads to maximal macromolecular synthesis. Blocking this exchanger would suppress the pH increase, thereby suppressing protein synthesis and other macromolecular synthesis.*