

Name: _____

MCB 131 Midterm 2

April 6, 2006

100 points in 80 minutes (we need to stop at 12:30 exactly).

Midterm Question	Points	Score
1.	9	_____
2.	4	_____
3.	8	_____
4.	12	_____
5.	8	_____
6.	4	_____
7.	10	_____
8.	5	_____
9.	10	_____
10.	5	_____
11.	6	_____
12.	7	_____
13.	6	_____
14.	6	_____
Total for Midterm 2	100	_____

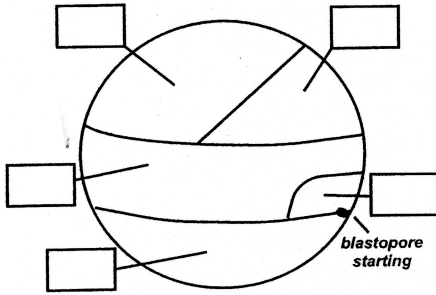
Note: Please use a pen. If you draw a picture as part of a short answer, please draw clearly and label the parts!

Number of pages you should have, including this one: 9

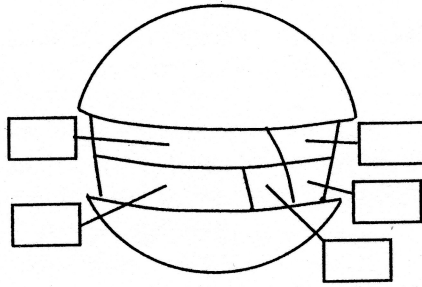
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Question 1 (9 points):

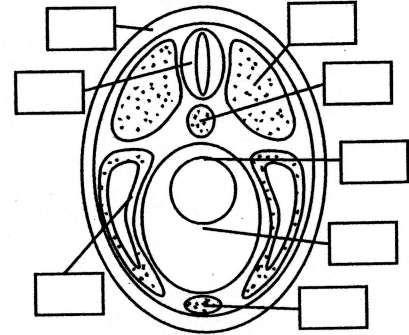
Below are three diagrams of *Xenopus* embryos with regions marked by lines and boxes. In each box put one of more of the letters from the list to identify the designated region. (Points will be deducted for excess wrong answers).



Early gastrula (surface view)



Early gastrula, deep equatorial cells shown



Tailbud embryo trunk cross section

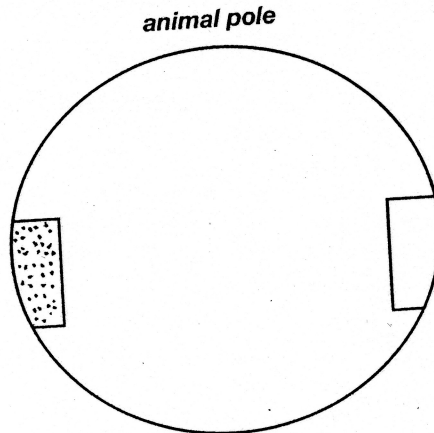
- a. prechordal (head) mesoderm
- b. gut floor
- c. somites
- d. notochord
- e. heart

- f. lateral plate mesoderm (coelom)
- g. pharyngeal endoderm/gill slits
- h. neural plate or tube
- i. gut roof and/or wall
- j. epidermis

Question 2 (4 points)

Below is drawn an early gastrula embryo into which a second organizer has been grafted, as in the Spemann-Mangold experiment. The grafted organizer is dotted, whereas the host's organizer is not. Without bothering to distinguish superficial and deep layers of cells, raw a rough fate map of this grafted embryo, showing the following territory or territories:

Neural (label **Neu**) Heart (label **H**) Epidermis (label **E**) Notochord (label **Noto**)



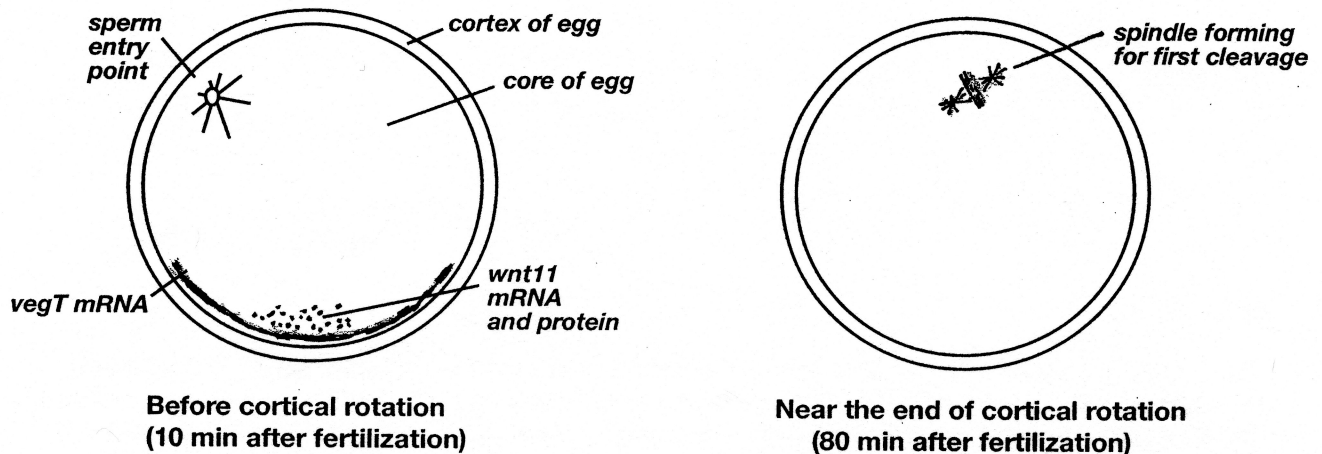
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Question 3 (8 points):

Below on the left is a cross section of a *Xenopus* egg before cortical rotation. The locations of VegT mRNA and wnt11 mRNA (and protein) are indicated. On the right is the same *Xenopus* egg just after cortical rotation.

On the figure to the right, draw and label with the appropriate letter or words:

- the displacement of the cortex relative to the core (assuming the core remains unmoved).
- the location of the parallel microtubule array during rotation. Add an arrow to indicate the plus-minus polarity of the microtubules (with the arrow point indicating the plus end of the microtubules).
- the location of wnt11 mRNA and protein after rotation.
- the location of high levels of beta-catenin protein after cortical rotation.
- the location of beta-catenin mRNA in the egg after rotation.
- the location of VegT mRNA after rotation.
- the approximate location of the grey crescent
- the approximate position at which the organizer will form in the mid- to late blastula.



Question 4 (12 points)

Give three different kinds of experimental evidence that, when taken together, implicate beta-catenin protein as a key component in the chain of events leading to organizer formation.

- A. One kind of experiment and result:

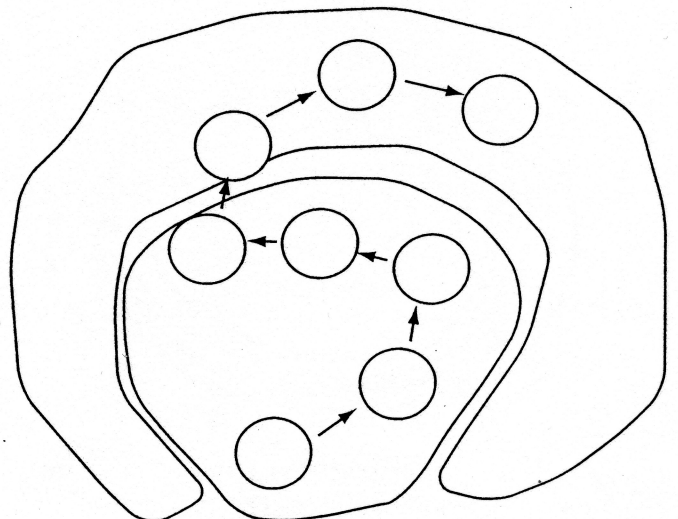
Question 4 continued

B. A second kind of experiment and result

C. A third kind of experiment and result

Question 5 (8 points): The figure below shows vegetal cells of a *Xenopus* mid-blastula embryo combined with animal cap cells of the same age. Write the most appropriate letter from the list below into each circle to indicate where each step of endo-mesoderm induction occurs within the recombine (and thereby put the letters in the correct sequence for induction to occur):

- A. *VegT* mRNA is translated to VegT protein here.
- B. Receptors for Xnr1,2,4,5,6 and *Derriere* proteins are present here.
- C. Xnr1,2,4,5,6 and *Derriere* proteins are secreted into the extracellular space here.
- D. *Xnr1,2,4,5,6* and *Derriere* mRNAs are translated into proteins here.
- E. Smad proteins of the TGF- β signal transduction pathway (of the nodal specific kind) are phosphorylated and activated here.
- F. *VegT* mRNA, which was deposited during oogenesis, is present here.
- G. Genes of mesoderm development are transcribed here.
- H. The transcription of *xnr1,2,4,5,6* and *derriere* genes is activated here.



Question 6 (4 points)

When an egg is soaked in pondwater containing dilute lithium chloride, beta-catenin protein builds up to high levels everywhere in the egg (because the GSK3 kinase is inhibited). At later stages, the organizer is formed around the entire circumference of the late blastula, but only at the equatorial level. Briefly explain why.

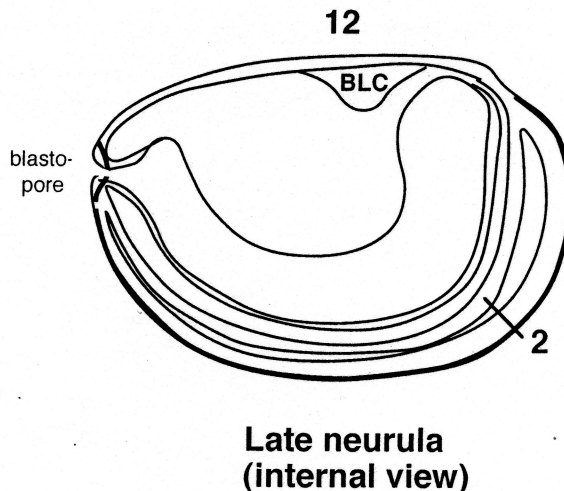
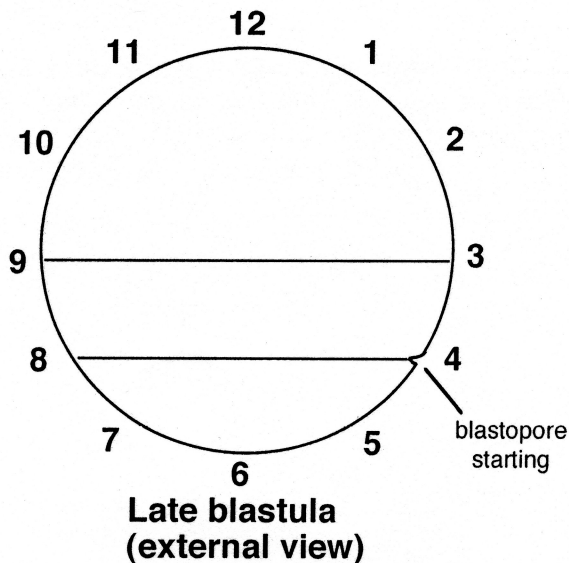
Question 7 (10 points):

In the left figure below, a *Xenopus* early gastrula embryo is drawn in surface view. Points on the bilateral plane are numbered 1 through 12.

6A. On the figure of the late neurula to the right, please locate those points after gastrulation and neurulation by marking the figure with lines and numbers. (Points 12 and 2 have been placed for you; BLC means "blastocoel").

6B. On the late neurula diagram, draw in and label with the appropriate letter or words:

- the notochord
- the head organizer
- the approximate site of the heart
- the prechordal plate (head mesoderm)
- the trunk-tail organizer
- the dorsal side
- the anterior endomesoderm (AEM)
- the site of *hox* gene expression in the neural tube
- the location of forebrain and midbrain
- the archenteron



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Question 8 (5 points):

The *Xenopus* organizer has three parts: the head organizer (HO), the trunk-tail organizer (TTO), and the anterior endomesoderm (AEM). These differ with regard to their morphogenetic activities during gastrulation, the inductive proteins they secrete, and the tissues into which they eventually differentiate. In the space before each statement below, write HO, TTO, AEM, or some combination of these, so that each statement is true:

- _____ eventually differentiate(s) into notochord
- _____ eventually differentiates to liver and anterior gut.
- _____ eventually differentiate(s) into mesoderm of the head.
- _____ engage(s) in convergent extension during gastrulation.
- _____ clusters of its cells migrate along the blastocoel wall during gastrulation.
- _____ secrete(s) Bmps antagonists such as Noggin, Chordin, and Follistatin proteins.
- _____ secrete(s) Wnt antagonists such as Dkk and Frzb proteins.
- _____ secrete(s) Cerberus protein, a Nodal antagonist.
- _____ eventually come to underlie the forebrain and midbrain.
- _____ eventually comes to underlie the hindbrain and spinal cord.

Question 9 (10 points):

Based on the Default Model for neural/epidermal development, explain each of the following experimental interventions.

9A. Introduce the mRNA for a constitutively active Bmp receptor into ectodermal animal cap cells, that is, for a receptor active even when Bmp is absent. Add high levels of Noggin, Chordin, and Follistatin. Predict epidermis or neural tissue as the outcome and briefly explain your prediction.

9B. Introduce into animal caps three anti-sense morpholinos, each about 25 bases long, that together block the translation of the mRNAs for Bmp2, Bmp4, and Bmp7 proteins. Omit Noggin, Chordin, and Follistatin. Predict epidermis or neural tissue as the outcome and briefly explain your prediction.

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Question 10 (5 points)

Consider cells that have developed to anterior neural tissue (forebrain and midbrain) in a *Xenopus* embryo.

From the list below, choose option 1 or 2 from each of the conditions **a, b, c, d, e** to put into the designated blanks, thereby arriving at a sequence of five steps for the development of anterior neural tissue:

a____ b____ c____ d____ e____, then become anterior neural tissue

- a1. were cells of the animal cap
- a2. were cells of the vegetal base (containing *vegT* mRNA)

- b1. received and responded to Xnr1,2,4,5,6 and derriere (Nodal signals).
- b2. did not receive Xnr1,2,4,5,6 and Derriere (Nodal signals).

- c1. did not briefly make and respond to Bmp signals.
- c2. did briefly make and respond to Bmp signals.

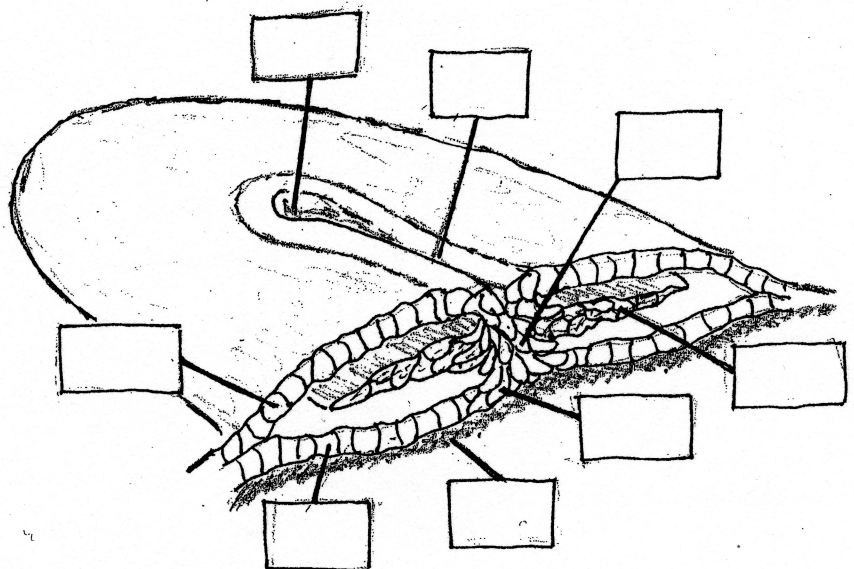
- d1. were close enough to the organizer to be exposed to Bmp antagonists such as Chordin, Noggin, and Follistatin
- d2. were too far from the organizer to be exposed to Bmp antagonists such as Chordin, Noggin, and Follistatin

- e1. were close enough to the head organizer to be exposed to Wnt antagonists such as Dickkopf and Frzb.
- e2. were too far from the head organizer to be exposed to Wnt antagonists such as Dickkopf and Frzb.

Question 11 (6 points)

In the figure below, a chick gastrula embryo has been cut across the primitive streak and tipped toward you so you can see the ingressing cells. Regions are marked by lines and boxes. Select letters from the list below and enter them in the boxes to indicate the identity of each marked region. (Some boxes may contain more than one letter).

- A. ectoderm
- B. embryonic endoderm
- C. primitive streak
- D. ingressing cells
- E. Hensen's node
- F. embryonic and extraembryonic mesoderm
- G. hypoblast/endoblast
- H. later forms lateral plate and somites
- I. site at which the prechordal mesoderm has involuted and moved anteriorly
- J. comes through the primitive streak first
- K. later forms notochord and floorplate
- L. uncleaved yolk mass

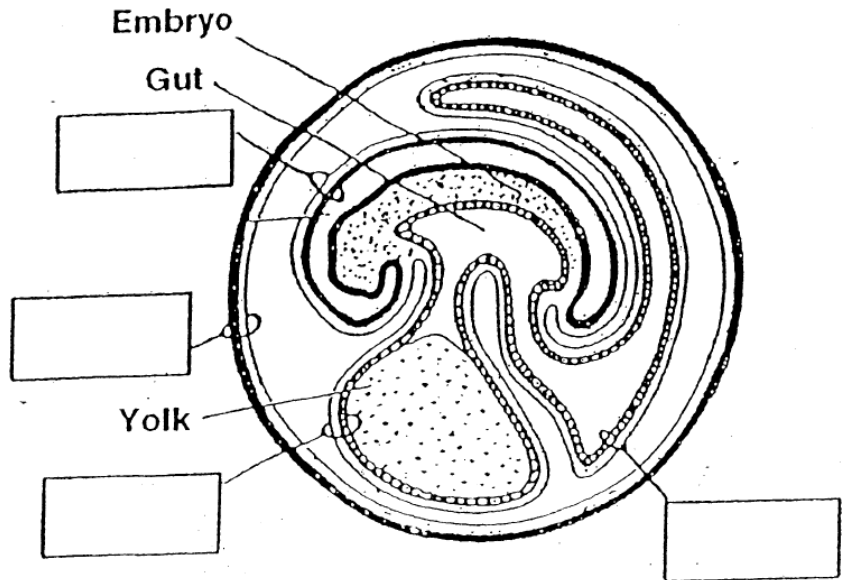


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Question 12 (7 points):

Below is a diagram of a chick embryo 9 days after egg laying. The **extraembryonic** parts are indicated by lines and boxes. Into each box, put appropriate letters from the list below to identify and describe the parts. A box may contain more than one letter.

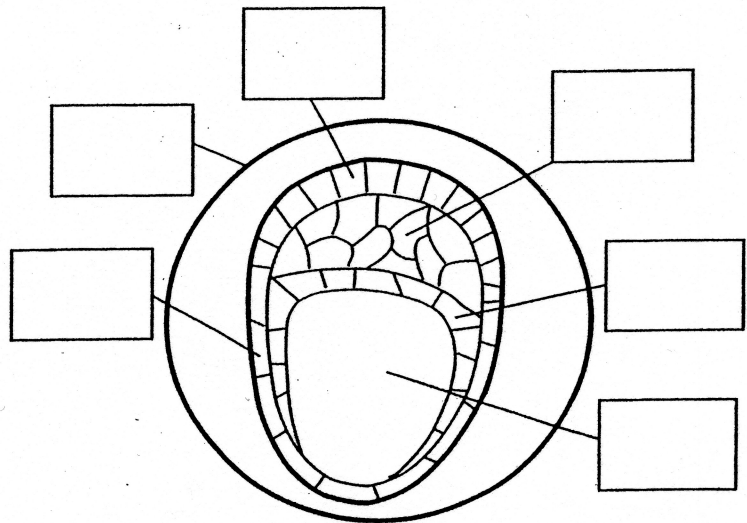
- a. allantois
- b. chorion
- c. amnion
- d. yolk sac
- e. a lining composed of ectoderm and mesoderm.
- f. a lining composed of endoderm and mesoderm.
- g. lines a cavity that surrounds the embryo in a controlled aqueous environment.
- h. lines a cavity in which metabolic wastes are stored.
- i. is involved in mobilizing nutrients for the embryo
- j. contains hypoblast and endoblast cells



Question 13 (6 points)

A cross section is shown of a 128-cell mouse blastocyst, with lines and boxes to designate particular regions. Into each box, put the appropriate letters from the list to best identify each region.

- A. epiblast
- B. mural trophoblast
- C. hypoblast
- D. polar trophoblast
- E. fertilization envelope (zona)
- F. blastocyst cavity
- G. cells that form embryonic stem cells if cultured in a Petri dish
- H. will later develop into the mouse
- I. will later develop into extraembryonic endoderm
- J. derived from the outermost cells of the 64 cell stage
- K. will be broken down before the blastocyst implants
- L. derived from inner cells of the 64 cell stage



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Question 14 (6 points)

A. By the 32 cell stage, the mouse embryo contains two irreversibly different lineages of cells-- one that will develop to trophoblast cells and one that will develop to epiblast and hypoblast cells. Describe briefly the process of compaction and cleavage by which the two lineages become irreversibly different:

B. By the 128 cell blastocyst stage, the epiblast and hypoblast lineages of cells have become irreversibly different. Describe briefly the process of blastocyst cavity formation by which the conditions are established for this differentiation to occur.