**Name _____**

# Biology 411 - Developmental Biology
# Winter Quarter 2007

# Midterm 1

**100 Total Points**
**Open Book**

30 questions - 3 pts each  1 extra-credit question - 3 points
5 questions - 2 pts each
Provide answers using full sentences, unless instructed otherwise.

Chapters 1 and 2

1. (2 pts) Evolution of Germ Layers (yes or no) (p. 43)

__**YES**__ a. Are all schizocoelous animals triploblastic?

__**YES**__ b. Are all protostomes triploblastic?

__**NO**__ c. Are species in the Porifera diploblastic?

__**YES**__ d. Are there metazoans that possess mouths, but are neither protostomes or deuterostomes?

2. (p. 33). Draw your prediction of phenotype of a *Volvox carteri* colony that possesses a null mutation in the *Lag* gene. Briefly explain your reasoning.

**The *Lag* gene is necessary for the specification of gonidia. Without gonidia, the colony is composed solely of somatic cells.**

3. (p. 16) Are the pectoral fin of a shark and the flipper of a dolphin: "homologous", "analogous", or "both"? Explain the reasoning of your answer.

**The shark pectoral fin and dolphin flipper are both homologous and analogous. Both are derived from an ancestral fish pectoral fin. Both are analogous in function (i.e. swimming)**

4. Within an aggregating mass of *Dictyostelium* amoebae, experimentally add Fab fragments of an antibody to the cAMP receptor. What effect do you think this inhibition of the cAMP receptor would have on the phenotype of the cell mass? (p. 37)

**The Fab fragments should block intercellular transmission of cAMP signals. Aggregation of the amobae should be inhibited.**

5. Describe how an embryonic fate map is constructed.

**Groups of embryonic cells in an embryo are labeled using either radioactivity or dyes, or by grafting genetically identifiable cells into an embryo. The embryo is allowed to develop. The later positions of the labeled cells are determined. A fate map is generated whyen territories reflecting the future position of cells are labeled on early stages of the embryo.**

6. Are von Baer rules of vertebrate embryogenesis compatible with Ernst Haeckel's view that "ontogeny recapitulates phylogeny"? Explain why or why not. (p. 9)

**No. von Baer stated that the early embryo of a higher animal is never like a lower animal, but only like its early embryo.**

7. (2 pts) Associate the following vertebrate tissue types with their progenitor embryonic germ layer. Place a mark in each box that applies

| **Cell Type** | **Ectoderm** | **Mesoderm** | **Endoderm** |
|---|---|---|---|
| Glial cell | X | | |
| Intestinal cell | | | X |
| erythrocyte | | X | |
| chondrocyte | | X | |
| notochordal cell | | X | |
| epidermal cell | X | | |
| dermal cell | | X | |
| pigment cell | X | | |

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Chapters 3 and 4

8. Describe a classic embryological experiment (performed in the early 20th century) first demonstrated that prospective potency is greater than prospective fate?

**Hans Dreisch's experiment conducted an experiment in which sea urchin embryos were compressed between two coverslips at the 8-cell stage to force nuclei into abnormal locations. After nuclei had been displaced, and cell cleavage had locked them into these abnormal locations, the mechanical pressure was released. The embryos developed normally, even though nuclei fated to become endoderm now formed ectoderm. This showed that the prospective potency of cell nuclei was greater than their prospective fate.**

**Dreisch also separated a 4-cell stage sea urchin embryo and found that the separated cells developed into complete larvae. This shows that individual blastomeres are still totipotent, even though their original fate is to give rise to a specific region of the embryo.**

9. Explain why the "French Flag" analogy for positional information (p. 63) would not work to explain cell fate specification in ascidian tunicate embryos.

**Ascidian tunicate embryos have autonomous specification of cell fate. Individual cells do not change their identity or fate in response to positional information signals from their neighbors.**

10. Explain the difference between totipotent versus pluripotent in terms of cell fate.

**Totipotent indicates that a cell can give rise to all cell types, whereas pluirpotent indicates that a cell can give rise to progeny with a restricted (i.e. limited) set of cell fates.**

11. Liver cells and heart cells were intermixed and cultured in a calcium-free medium. Draw the expected outcome. Explain why, or why not, the cells would sort out. (p. 72)

**The cells cannot sort out because cadherins require extracellular calcium to bind to adjacent homotypic cells (i.e. cells of the same cell type). The liver and heart cells would be expected to remain intermixed.**

12. Explain why polytene chromosomes were selected and used by early developmental geneticists, such as T.H. Morgan, to map the location of *Drosophila* genes. (p. 87)

**Polytene chromosomes contain hundreds of identical copies of chromosomal DNA organized into a giant linear array. After staining with dyes, the heterochromatic regions of the polytene chromosome are visible as discrete bands in isolated chromosome preparations. These bands were visible bioassays for early developmental geneticists, allowing gene locations to be correlated with chromosomal changes (e.g. chromosome deletions, crossing over, etc.).**

13. Why do genetic engineers inject transgenic DNA into the female pronucleus of a fertilized mammalian egg rather than injecting into the zygotic nucleus after the female and male pronuclei have fused? (p. 93)

**The transgenic DNA must integrate into chromosomes before S phase of the first cell cycle, in order for it to be replicated and segregated to daughter cells of the first cell division. Injecting into the zygotic nucleus does not leave adequate time for DNA integration.**

14, What is the difference between a microarray and a macroarray? (p. 91)

**Microarrays detect the presence of multiple cDNAs from a cell or tissue, amplified through RT-PCR. A Macroarray is similar to a microarray in construction, but has larger spots to allow visual detection of the cDNAs.**

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15. Why is a neomycin resistance gene inserted along with a transgene when making a knockout strain of mice? (p. 95)

**The neomycin resistance gene is inserted to select for cultured embryonic stem cells that have incorporated a transgene designed to knockout a gene of interest.**

Chapter 5 and Chapter 21

16. (2 pts) Nucleosomes uncoil in response to what enzymatic action? (provide a one word answer)

**Acetylation**

17. For a given organism, explain why the proteome can be much larger than the genome.

**The proteome is larger than the genome largely to the process of alternative splicing of mRNA transcripts. Different versions of a protein can be made from a single gene.**

18. Explain how the enhancer-trap technique can result in a disruption of gene function (p. 115)

**Using the enhancer-trap reporter technique, a reporter gene is inserted randomly into the genome of an organism. If the gene lands in the coding region of the gene, the reporter gene expression will be governed by the enhancers and repressors of the disrupted gene's promoter. The function of the endogenous gene can become abolished after insertion of the reporter gene, since the coding region for the gene's product is often disrupted.**

19. What phenotype will probably result from a human zygote that has both a deletion of paternal chromosome 15 and a methylated Angelman Syndrome locus on the maternal chromosome? Explain why. (p. 118)

**This is a lethal condition. A functional Angelman Syndrome gene is required for viability.**

20. Explain why genetic imprinting, which occurs during gametogenesis, is not transmitted to the progeny (i.e. offspring) of a zygote. (p. 122)

**Methylation of chromosomes is removed during formation of the germ line. Thus, the genetic imprinting that occurred during gametogenesis for the first generation is removed before gametogenesis occurs for the subsequent generation.**

21. Explain why the XIST gene does not have to be translated in order to form a Barr Body. (p. 123)

**XIST RNA, rather than XIST protein, complexes with the X chromosome to form the Barr Body.**

22. What would be the state of a paternal X chromosome in the cytotrophoblast syncytium? (p,. 121)

**The paternal X chromosome would be methylated and inactivated.**

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23. In terms of resistance to sex-linked genetic diseases, how can cellular mosaicism provide a selective advantage to human females over males? (Discussion Group, JAMA paper)

**In human females, random X chromosomes inactivation among cells in the morula stage assures that organ are composed of cellular progeny that possess either a maternal or a paternal X chromosome. Males only possess maternally-inherited X chromosomes. Defective maternal X chromosome genes are counterbalanced by the normal function of neighboring cells with a functional gene on the paternally-inherited X chromosome.**

24. What is the difference between reproductive versus therapeutic cloning? (p. 684)

**Reproductive cloning is used to reproduce an entire individual, whereas therapeutic cloning involves harvesting embryonic stem cells from a cloned embryo for medical purposes. The cloned embryo from which embryonic stem cells are harvested is subsequently destroyed.**

Chapter 6

25. Explain how a cholesterol-lowering drug might affect human embryonic development by interfering with the Sonic Hedgehog pathway? What phenotype might occur? (p. 152)

**Cholesterol is needed for the catalytic cleavage of Sonic Hedgehog, and to enhance Sonic Hedgehog's extracellular diffusion. Lack of Sonic Hedgehog signaling results in cyclopia.**

26. (2 pts) Combine chick foot epidermis to a wing dermal mesenchyme, what type of cutaneous structure would result? (provide a one or two word answer)

**wing feather**

27. What role does Pax6 expression play in vertebrate eye induction? (p. 141)

**Pax 6 expression make the ectoderm competent to receive inductive signals from the optic vesicle.**

28. What role does autophosphorylation of BMP receptors play in the BMP signaling pathway?

**Autophosphorylation of BMP receptors locks the BMP receptor heterodimer into an active state.**

29. What effects would antibodies against the RGD sequence of fibronectin have on culture of mammary gland epithelial cells placed on a basal lamina substrate? (p. 167)

**Mammary gland cells would not wrap the basal lamina around themselves.**
**Genes for casein, lactoferrin, WAP, and p21 would not be transcribed.**

30. β-catenin is mutated so that it can no longer be phosphorylated. What effect would this have on the output of the canonical Wnt signaling pathway? (p. 155) Hint: Remember that GSK-3 phosphorylates β-catenin.

**β-catenin would not be degraded. The canonical Wnt signaling pathway would be activated. β-catenin would migrate to the nucleus, bind to the LEF/TCF transcription factor, and enhance the transcription of β-catenin specific target genes.**

Chapter 7

31. Why does low extracellular sodium promote polyspermy in sea urchin eggs? (p. 189)

**Low extracellular sodium reduces the influx of sodium into the cell upon fertilization. Sodium ion influx is necessary to shift the membrane potential of the fertilized egg to a more depolarized state, in order to block polyspermy.**

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32. Explain why ammonium ions activate protein synthesis in unfertilized sea urchin eggs? (hint: ammonia ions are proton acceptors).

**Ammonia ions cause the pH of the egg cytoplasm to shift to a more alkaline pH. This shift in cytoplasmic pH activates protein synthesis.**

33. (2 pts) Endoplasmic reticulum releases calcium in response to what molecule?

**$IP_3$**

34. Explain how calcium restarts the cell cycle following fertilization.

**Calcium releases from the endoplasmic reticulum triggers the degradation of MPF (mitosis-promoting factor).**

35. What role(s) does phospholipase C play in fertilization? Describe the downstream consequences of phospholipase C activation. (p. 196).

**Phospholipase C (PLC) is a transducer of the fertilization signal. After being stimulated by a *src*-family tyrosine kinase, PLC catalyzes the breakdown of phosphoinositol lipids to produce $IP_3$ and diacylglycerol, which activate intracellular calcium release from the ER and the sodium/proton exchange in the cell membrane, respectively. A rise of intracellular calcium triggers cortical granule fusion. A rise of intracellular pH produced by the sodium/proton exchanger triggers protein synthesis.**

**Extra Credit Question (3 pts)**

36. (3 pts) Explain how a pregnancy could potentially help a mother repair damaged or diseased tissues, decades after the pregnancy occurred.

**Stem cells from the fetus make it into the maternal circulation , and become lodged in maternal organs. Years, or decades later, these cells can divide, mature, and differentiate into replacement tissues.**