

Name \_\_\_\_\_

**Biology 411 - Developmental Biology  
Winter Quarter 2011**

**Midterm 1**

**100 Total Points  
Open Book**

Choose **20** out the 25 questions to answer (4 pts each). Only the first 20 questions that are answered will be graded. Cross out answers that you do not wish to be graded.  
Provide answers using full sentences, unless instructed otherwise.

1. (from lecture) Name the process by which the triploblastic creature, *Vernanimalcula*, probably formed its mesoderm. Explain your reasoning.

***Vernanimalcula* probably formed its mesoderm through the process of gastrulation. *Vernanimalcula* is a triploblastic organism, which is a likely progenitor of later triploblastic organisms. Since gastrulation is a critical component in the development of triploblastic organisms, it is logical to suspect that the embryonic development of *Vernanimalcula* involved gastrulation.**

2. (from discussion section) Describe what the *SRY* gene does during human gestation. Describe the resulting phenotype if SRY is activated.

**The product of the *SRY* gene is a transcription factor that interacts with the androgen receptor. The activated androgen receptor activates the SRY-encoded transcription factor, which in turn activates the transcription of numerous target genes that are critical for the development of the male phenotype.**

3. (p. 26) Draw the phenotype of a long-haired Dachshund with a null mutation in one of its copies of *Fgf4*. Explain the reasoning for your drawing.

**The dog would have long hair and long legs. The extra copy of *Fgf4* (a null mutation) would no longer terminate cell division in the cartilage of the long bones of the legs of the dog feturs. The mutation in *Fgf5*, which causes the long hair, would be unaffected by a mutation in a copy of *Fgf4*.**

4. (p. 25) Is the femur bone in the leg of alligator both “analogous” and “homologous” to the femur of the human leg? Explain the reasoning of your answer.

**Yes, the leg of the alligator is both analogous and homologous to the femur of the human inner ear. It is analogous because the femur is used to support body weight during standing and locomotion. It is homologous because it is derived from a common ancestry.**

5. (pp. 61-63) Explain how one might use a microRNA could be used for a medical therapy.

**A retrovirus could be used to insert a gene sequence encoding a therapeutic miRNA into a patient's cells. Once expressed in the patient's transfected cells, the miRNA would be cut by the Dicer protein. The resulting miRNA fragments would combine with RISC to block translation of a targeted mRNA, as well as to degrade the targeted mRNA in the patient's cells.**

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6. (p. 628, p. 91) What is the difference between relational pleiotropy and phenotypic heterogeneity. Describe how the effects could be involved in the generation of cyclopia.

**Relational pleiotrophy means a gene has an indirect effect on the development of other tissues, in which the gene is not expressed. Phenotypic heterogeneity refers to similar phenotypes being generated by the action of different genes. Cyclopia could result from a number of genetic defects in the Hedgehog signaling pathway (phenotypic heterogeneity). Cyclopia could also result from a defect in the cholesterol synthesis pathway. Lack of cholesterol synthesis in the neural rudiment (an example of phenotypic heterogeneity) and adjacent tissues (an example of relational pleiotrophy) would restrict the diffusion of Sonic Hedgehog, which is needed to promote the splitting of the eye rudiment. A cyclopic embryo would result.**

7. (p. 635) Why are “DES daughters” often sterile?

**DES is a teratogen that alters the development of reproductive structures in female fetuses. The boundaries between the oviducts and the uterus are often lost, resulting in the inability of a fertilized egg to migrate from an oviduct into the uterus. The distal portions of the Müllerian ducts also often fail to fuse into a single cervical canal.**

8. (p. 35) Why does “acetylation” promote uncoiling of DNA? Describe the process and explain the mechanism.

**DNA is negatively charged. This negative charge attracts positively charged histones, which cause the DNA to condense. This electrostatic interaction can be reversed by acetylation of lysine groups on histones. The addition of acetyl groups to lysine residues on histones neutralizes the histones positive charge. This causes the nucleosomes to uncoil, and the chromatin to decondense.**

9. (pp. 48-51) Describe how Dnmt1 is involved in the maintenance of the heterochromatin of Barr bodies in replicating somatic cells of female mammals.

**A Barr body is a condensed, largely inactivated X chromosome. Regions of methylated DNA are prevalent in the heterochromatin of Barr bodies. During each cell division, the Barr body must replicate. This produces stretches of DNA that have methylation on one strand of the heterochromatin DNA. The Dnmt1 enzyme locates these regions and adds methylation to the complementary DNA strand. In this manner, Dnmt1 re-establishes methylation within Barr body heterochromatin each cell cycle.**

10. (p. 46) What type of structural motif you would expect to see in a transcription factor?

**A basic-loop-helix motif is a common structural motif among transcription factors.**

11. (p. 72-75) Predict the equilibrium configuration of mixing liver cells, heart cells, and limb bud cells. Draw the result and explain your reasoning.

**The cells will sort out and form a ball with three regions. Liver cells on the outside of the ball, heart cells in the middle, and limb bud cells in the center. Cells with the greater intercellular adhesion lie more interior in the ball than cells with less intercellular adhesion.**

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12. (p. 52) Is the Prader-Wiley Syndrome (PWS) locus, or the Angelman Syndrome (AS) locus, active in an individual with Angelman Syndrome? Explain why.

**The Prader-Wiley Syndrome locus is active in an individual with Angelman Syndrome. The individual lacks a portion of maternal chromosome 15, which includes both the PWS locus and AS locus. However, the intact paternal chromosome 15 has both loci. The AS locus is inactive, owing to imprinting (probably via promoter methylation) that occurred during gametogenesis. The PWS is active on paternal chromosome 15.**

13. (p. 60) What is the purpose of forming circularized RNA in oocytes?

**Circularization of RNA prevents the molecule from being degraded. Circular RNAs are stored in oocytes so that RNA messages can be rapidly translated upon fertilization.**

14. (p. 61) Describe how a non-protein product from one gene could affect the expression of another gene.

**A miRNA could inhibit the translation of the mRNA from another gene.**

15. (p. 99) If the *lin-12* gene product was mutated to a null phenotype in *C. elegans*, how many VPCs would form an equivalence group? Explain your reasoning.

**The 6 VPCs would still form an equivalence group, but with a more limited set of possible fates.**

**Anchor cells in the vulva would still induce P6.p cells, however, P7.p and P5.p cells would not be induced, owing to the lack of functional LIN-12 receptor. The mutation would create a new equivalence group that contains 3 cells that will form central vulval cells, as well as 3 lateral cells that will form hypodermal cells.**

16. Why is a set of 3 sequential inhibitions not found in signal transduction pathways?

**A set of double inhibition normally acts as a gateway in a signal transduction pathway. The pathway becomes activated when the inhibitor of an inhibitor becomes activated. Adding another inhibitor upstream in the pathway would not work, because the pathway would always be turned off.**

17. (p. 57) Discuss why it is advantageous to have alternative splicing of *Dscam* in neurons?

**Alternative splicing allows different versions of proteins to be made from the same mRNA transcript. This allows different isoforms (i.e. versions) of the protein to be expressed in different neurons. Dscam prevents dendrites of a given neuron from forming synapses on themselves.**

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18. In terms of X chromosome-linked, dominant gene diseases, how does cellular mosaicism usually make females more resistant to mutant alleles than males? (Discussion section, JAMA paper)

**Females have two X chromosomes. A mutant allele would likely be on only one of the X chromosomes. During embryonic development, the mutant allele would likely be inactivated if it were located on an X chromosome that became a Barr body.**

**In females, organs are composed of a mosaic of cells, with some expressing the maternal gene product and other cells expressing the paternal gene product. Thus, some cells in the organs would be capable of making normal gene product. In a male, this would not be the case.**

19. (p. 95) Describe how a mutation of the GS box in a type I BMP receptor could result in a null phenotype.

**BMP homodimers, by themselves, are not active kinases. A homodimer is composed of either two type I receptors, or two type II receptors. BMP ligand binding brings the serine/threonine kinase domain of a type I BMP receptor into contact with the GS box of a type II BMP receptor. Without a functional GS box, the resulting heterodimer could not autophosphorylate the cytoplasmic tails of the type I and type II receptors, resulting in an inactivate kinase. Thus, the mutation would be a null phenotype.**

20. (p. 93)  $\beta$ -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?

**$\beta$ -catenin would accumulate, and not be degraded. The canonical Wnt signaling pathway would thus be continuously activate.  $\beta$ -catenin would migrate to the nucleus, bind to the LEF/TCF transcription factor. Excessive transcription of  $\beta$ -catenin specific target genes would occur.**

21. (p. 91) What teratogenic risks are there for a fetus exposed to cholesterol-lowering drugs in utero? Explain your answer in molecular terms.

**Cholesterol is needed to enhance the cleavage and diffusion of the Sonic Hedgehog signaling protein. A deficiency of cholesterol, resulting from cholesterol-lowering drugs, might produce cyclopia.**

22. (p. 137-143) If calcium release and pH changes were blocked in a sea urchin egg, what cytoplasmic changes would occur in the egg after it was fertilized?

**A membrane potential change would still occur, resulting in a fast block to polyspermy. However, a fertilization membrane would not form. The zygote would not proceed with mitosis or initiate protein synthesis.**

23. (p. 128) In mammalian fertilization, describe what would happen if the acrosome reaction failed to occur.

**The sperm would not be able to penetrate the zona pellucida.**

24. (p. 146) Draw the outcome of a fertilized sea urchin egg if the sperm donated centriole failed to form a microtubule array.

**The male and female pronuclei would remain separated and not fuse to form a zygotic nucleus.**

25. (p. 126 and p. 149) What would happen if a dog sperm cell was exposed to ZP1, ZP2, and ZP3 before it contacted the surface of a dog primary oocyte? Would a primary polar body form when the sperm contacted the oocyte? Explain your reasoning.

**The dog sperm would undergo an acrosomal reaction before it reached the zona pellucida. Without an acrosomal reaction, the sperm could not reach the oocyte membrane. The oocyte would not become fertilized. The first polar body would not form.**



