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

Midterm 3

**100 Total Points
Open Book**

Read the Following Instructions:

- * Answer 20 questions (5 points each) out of the available 25 questions
 - * Cross out answered questions that you do not want graded. We will grade the first 20 answered questions that are not marked out.
 - * Provide answers using **full sentences**, unless instructed otherwise.
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1. (p. 337-338) Explain the roles of the median hinge point and the dorsolateral hinge points in the vertebrate neural plate.

The median hinge point is involved in folding the neural plate longitudinally, along its midline. The dorso-lateral hinge points cause the neural folds of the neural plate to come into contact.

2. (p. 339-340) Explain the role of the folate receptor in the neural folds of the forming neural rudiment.

The folate receptor is involved in the fusion of the neural folds. Taking supplements of its ligand, the vitamin folate, reduces the risk of neural tube defects in humans.

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3. (pp. 338-339) What is the difference between spina bifida and anencephaly?

Spina bifida results from the posterior neuropore failing to close. Anencephaly results from the anterior neuropore failing to close.

4. (p. 367-371) **Draw** a hair follicle and the associated structures of a person with a null mutation in the *EDARDD* gene. Label the various anatomical parts. Explain in words the differences between this follicle and the hair follicle of a normal person.

Mature melanocytes would be missing from the base of the hair follicle, and the hair itself would be blond and vellus.

5. (p. 370) Consider a man who has developed baldness because of a lack of Wnt signal secretion in the dermis of his head. What would happen if Bulge cells from this bald man's head were grafted into the base of a hair follicle of a man with normal hair? Explain your answer.

The hair shaft would continue to grow because normal signals to promote Bulge cells proliferation would be present in the normal man's follicle.

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6. (p. 391) What would happen to a group of r4 neural crest cells were exposed to Fgf8? Explain why this result would occur.

The r4 neural crest cells would not express of *Hoxa2*, if they were exposed to Fgf8. This would shift the fate of the r4 neural crest cells to form Meckel's cartilage and its derivatives (malleus and incus), or endochondral bone.

7. (p. 375) Figure 10.3. Draw the fate map of the anterior ectoderm in a vertebrate embryo that has abnormal, constant Wnt signaling during anterior ectoderm specification. Explain the differences between this fate map and the fate map of a normal embryo.

Placodal cells would be absent. These regions of the fate map would be transfated into neural crest cells.

8. (pp. 406-409) In a transgenic frog, Eph receptors are abnormally expressed in retinotectal neurons, uniformly, in the nasal-temporal dimension. This means that ALL of the retinotectal neurons have the concentration of Eph receptors. Draw the resulting distribution of retinotectal neuron projections, where they terminate in the frog optic tectum, which has a gradient of ephrin ligands.

The neurons would localize to a single band in the optic tectum. This band would be determined by the balance of attractive and repulsive interactions the neurons have with the ephrin gradient that is present on the optic tectum.

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9. (pp. 415-418) **Draw** the body segments that would result if a dominant negative (i.e. inactive) construct of the Notch receptor was electroporated into the presumptive intersomitic furrow of the -1 presumptive somite. Explain your reasoning.

The intersomitic furrow would not form because a functional Notch receptor is needed to activate *Mesp2* and activate *Hairy1*. Without expression of these two genes, neighboring cells in a presumptive intersomitic furrow region cannot express the correct pattern of Ephrin and Eph receptor to pattern and form an intersomitic furrow.

10. (p. 421) **Draw a dorsal view** of a chick late-stage embryo (with skeletal structures) in which coccygeal somites (i.e. tail somites) from a donor embryo are transplanted into the thoracic region of a recipient embryo.

The thoracic region will form vertebrae that lack ribs. This is because the somites retain their AP identity after transplantation.

11. (pp. 427-428). Hercules was a demigod (i.e. half-mortal, half-god) in the mythology of ancient Greece. He was extremely strong, with large muscles. Explain how a mutation in *myostatin* could result in a Hercules-like phenotype in humans.

Muscle growth is negatively regulated by *myostatin*. A loss-of-function mutation in *myostatin* could allow for both muscle hyperplasia (more fibers) and hypertrophy (larger muscle fibers).

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12. (p. 430) What would happen to bone repair in a broken bone if BMP signaling was blocked? Explain your reasoning.

Proliferating chondrocytes would not differentiate into prehypertrophic chondrocytes. Bone repair could not proceed because osteoblasts could not be specified.

13. (pp. 441-443) Cloaca means “sewer” in Latin. Adult amphibians, reptiles and birds all have a cloaca, which empties both the urinary and alimentary tracts. However, the cloaca is only present in mammals during early embryonic development. What is the developmental fate of the cloaca in mice and humans?

During embryonic development, the cloaca in mice and humans is split into a urinary sinus and the rectum by a urogenital septum. The ureter forms from the posterior segment of the urinary sinus, and the bladder forms from the anterior region of the urinary sinus.

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14. (p. 449) What is the anatomical difference between the somatopleure and the splanchnopleure?

The somatopleure is the ectoderm and lateral plate mesoderm that lie dorsal to the embryonic coelom. The splanchnopleure is the lateral plate mesoderm and endoderm that lie ventral to the embryonic coelom.

15. (pp. 448-449) Could a normal heart form in a chick embryo that lacked endoderm? Would the heart form an endocardium? Explain your reasoning for both questions.

The embryo without endoderm would be unable to form a normal heart because cardiogenic mesoderm is normally induced by endoderm.

If cardiogenic mesoderm was formed, it would have to migrate and accumulate in a space between the splanchnic mesoderm and the gut endoderm. Endoderm is also needed for the splanchnopleure to fold inward to form the myocardium. The embryo without endoderm would form two separated abnormal hearts. This condition is known as cardia bifida. Each of these hearts could form an endocardium from its cardiogenic mesoderm.

16. (pp. 455-457) Draw the pattern of blood flow in the mammalian embryo (starting at the heart) illustrated in Figure 12.10B, to the placenta, then back. Use arrows to show the direction of flow, and make sure to distinguish between arteries and veins. Circle the area destined to become the belly button and label it.

More points were awarded for clarity. See blood flow in the fetal human on p. 457.

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17. (pp. 473-474) What type of birth defect would you predict if pharyngeal arch 3 and pharyngeal arch 4 fused into a single solid structure?

No pharyngeal pouch would be present to harbor the parathyroid primordium. One pair of parathyroid glands would be missing if this parathyroid primordium failed to form. The thymus primordium would likewise be missing, so it also would not form.

18. (pp.434-435) Draw the urinary tract in a male human that would eventually form if the nephrogenic cord was removed at the pronephrous stage of development. Explain the reasoning of your drawing in words.

Removal of the nephrogenic cord would prevent the mesonephros and metanephros from forming. The pronephros would eventually degenerate, leaving only the nephric duct.

19. (pp. 467-468) What would happen if mutant HSC cells did not possess N-cadherins?

The HSC cells would not be able to bind to osteocytes and would therefore not be positioned to properly receive osteoblast-mediated signals via the Notch and RTK pathways. Without these signals, they would not be attracted to their niche, would not remain plastic, and would not be stimulated to proliferate and self-renew.

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20. Does the blastopore become transformed into anus in all deuterostomes? Provide an embryological example (or examples) that justifies your answer.

The blastopore does not become transformed into the anus in many types of deuterostomes, including vertebrates. Human and chick embryos close their blastopore (i.e. finish the regression of the primitive streak) before the cloacal membrane opens to form an opening for alimentary tract (i.e. the anus). The primitive streak and cloacal membranes are two different anatomical structures.

21. (p. 566-568) The Greek demigod Hercules defeated the mythical serpent Hydra by cutting off its multiple regenerating heads, then cauterizing (i.e. seal with heat) their stumps with fire. Perhaps Hercules was using knowledge gained from ancient embryological textbooks. Could you prevent the regeneration of the head of a coelenterate hydra with cauterization? Explain your answer.

No, a new head would form just below the site of cauterization. The head inhibition gradient from the hypostome would be removed by cauterization. A new head organizer would form in the absent of a head inhibition gradient. Thus, even the mighty Hercules could not defeat the regeneration capabilities of a coelenterate hydra.

22. (pp. 568-570) What would happen if the expression of *shinguard* was repressed throughout a hydra? Explain your answer in molecular terms.

***Shinguard* normally inhibits *wnt* expression, which is necessary for head formation. It is expressed in and near the basal disc. Without *shinguard*, new bodies could form anywhere in the hydra body axis. This would include the basal disc area, where new heads are not normally formed.**

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23. (p. 577) Increased methylation of the estrogen receptor gene occurs as a function of aging. Explain how this might be connected with age related diseases.

Errors in methylation can result in the inactivation of certain genes. The estrogen receptor is needed for the function of smooth muscle around blood vessels. Loss of vascular tone can lead to swelling in the legs. Methylation of the estrogen receptor is more prominent in atherosclerotic plaques than surrounding vascular tissue. Thus, methylation of the estrogen receptor gene may play a role in the aging of the vascular system.

24. (p.574) Some UW Huskies are headed to southern destinations for spring break. Remember, UV light causes p53 activity to increase by inducing DNA damage. Explain why this might cause the skin of a UW Husky to peel off if they get too much sun.

p53 activates apoptosis via a disinhibition of FOXO. Large numbers of epidermal cells undergoing apoptosis at the same time will cause a sheet of epidermis to peel off from the rest of the epidermis. p53 activation would also cause an arrest of the cell cycle of injured cells.

25. What is the difference between the theories of epigenesis and preformation? Explain how the two theories are consistent (or inconsistent) with our current understanding of fertilization and heredity. (*Hint: referring to the Jacquard loom may help you structure your answer.*)

ANSWER: Preformation is the theory that prior to fertilization (or "quickenning"), living organisms exist in the germ of a parent as miniaturized versions of themselves (which contain miniaturized versions of their future progeny). Epigenesis is the theory that embryos are organized *de novo* from otherwise undifferentiated matter in each generation. Most historians of science hold that epigenesis ultimately proved true, because embryos do come into being through a series of inductive events that generate ordered tissues from collections of proteins, nucleic acids, and the like; however the theory of preformation is not entirely wrong. Fully formed miniatures of living organisms do not exist in their parents' germ lines, but the instructions for making them do, encoded in DNA. Significantly, at the time the two theories came into being, the idea of controlling a process through mechanical execution of coded instructions did not really exist. It was only after the invention of devices such as 1801's Jacquard loom (which produced patterned fabric in response to instructions on punch cards) that the public began to become aware of those sorts of models.