Problem Set 1 BB2920 – Genetics C-2017 Due **in class** Friday 1/20/17

**Problem 1 (30 points)**

You are working on an off-campus MQP in the Galapagos, and are taking a break from your studies for a stroll down the beach when you notice a particularly unique-looking tortoise. The little tortoise seems pretty friendly, so you scoop it up and bring it back to the lab to show your advisor. Your advisor examines the little tortoise with great interest, and informs you that you may have just identified a new tortoise species!

Excited, you head back to the beach to track 100 individuals of the species and make notes on their physical traits.

Describe an example of **(a)** continuous variation and **(b)** discontinuous variation in the phenotypes of your new species. Draw a graph and include an explanation of your observations.

(Notes: Yes, I want you to just make up the data for the phenotypes and the graph! Be creative! I expect lots of *DIFFERENT* responses, as there are pretty much an infinite number of possible phenotypes you could make up. Please don’t consider the animals’ sex; assume you cannot tell male from female by a simple visual inspection. Also you can’t use the examples in parts e or f. C’mon! Make up something else! )

Graphs should have a clearly labeled title, axes, and units, and the data should add up to 100 individuals.

**(c, d)** You manage to obtain a small tissue sample from the tail of one (very angry!) tortoise, and you prepare a karyotype from the cells. You find 52 chromosomes. How many chromosomes would there be in:

**(c)** a normal somatic cell?

**(d)** a gametic cell?

**(e)** You do some additional analysis on the DNA sample to examine the structure of the tortoise’s chromatin. After digestion of the DNA sample with a nuclease, the DNA appears to have separated into 120bp fragments attached to a core of histone proteins. Further analysis of the histone core reveals histones in the following proportions:

H1 12.5%

H2A 25%

H2B 25%

H3 0%

H4 25%

H7 (a new histone) 12.5%

On the basis of these observations, what conclusions could you make about the probable structure of the nucleosome in this tortoise species?

**(f)** You notice that while most of your tortoises have dark brown spots on their shells, a small number have no spots at all. You send DNA samples from spotted and spot-less individuals back to WPI for DNA sequence analysis, and discover that the spot-less individual is missing a large portion of a gene that encodes the pigment melanin. That explains the absence of the spots! Would your approach to studying this tortoise phenotype be considered an example of forward or reverse genetics? Briefly explain.

**Problem 2 (15 points)**

You have a 1.4 kb DNA fragment that contains exactly 730 adenine nucleotides.

Show all of your work for the calculations below:

**(a)** What ***percentage*** of total nucleotides are guanine?

**(b)** Exactly how many hydrogen bonds hold the two strands together?

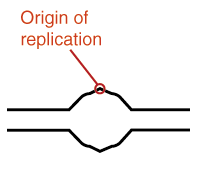
**(c)** How many thymine nucleotides are present on the 5’ strand? Explain your reasoning in a sentence.

**Problem 3: 16 points**

Below is a replication fork diagram. The origin of replication is indicated with the red circle. Add into this diagram (clearly labeled!) the following features (you may re-draw the diagram entirely if you wish)

a) The location of RNA primers (there should be 4). Indicate their direction of extension using arrows. (4 points)

b) Two leading strands and two lagging strands, again indicating their direction with arrows. (4 points)



**5’**

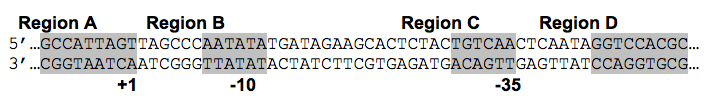
c) Assume the sequence of the top strand of the replication fork, within the replication bubble, is as follows: (the bold, red, underlined nucleotide indicates the center of the origin and corresponds to the position of the red circle in the diagram above:

5’-TTTAGGCCGCT**A**CGTACACTGGG-3’

Write the sequence of the RNA primer (just the first 6 nucleotides) that would be needed to synthesize the leading daughter strand. Your sequence should be recorded 5’ 🡪 3’, regardless of its position on the diagram above. Begin with the nucleotide that would be complementary to the A at the center of the origin.

**Problem 4(15 points)**

Consider this region of a typical prokaryotic gene:



1. Which region of this DNA sequence (A, B, C or D) will be transcribed into RNA? \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
2. Which region(s) are bound by the Sigma70 subunit of RNA polymerase? \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
3. Which strand (top or bottom) will be the CODING strand? \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
4. Give the sequence of the first 8 bases of the transcribed RNA (5’🡪3’!) \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
5. Which region(s) are fully “*downstream”* of the promoter? \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**Problem 5 (24 points) Comparing Replication and Transcription**

The following table contains a list of statements that apply to replication, transcription, both, or neither. In each empty box, put an “X” if that statement applies to replication or transcription. (Leaving the box empty implies that this statement does not apply to replication or transcription)

|  |  |  |
| --- | --- | --- |
|  | Replication | Transcription |
| 1. Synthesis of the new strand is initiated at a promoter. |  |  |
| 2. An RNA primer is required to initiate synthesis. |  |  |
| 3. The synthesis of a new strand it initiated at the origin. |  |  |
| 4. The new strand is complementary to the template strand. |  |  |
| 5. The template strand is RNA. |  |  |
| 7. The product is RNA. |  |  |
| 8. The new strand is made 3′ to 5′. |  |  |
| 9. The new strand is made 5′ to 3′. |  |  |
| 10. The process is done only during the S-phase of the cell cycle. |  |  |
| 11. The synthesis product contains uracil |  |  |
| 12. Synthesis is bi-directional |  |  |