Biology 113 Closed Book Take-Home Exam #2 – Chapters 4 - 7

There is no time limit on this test, though I have tried to design one that you should be able to complete within 3 hours. There are 6 pages in the exam, including this cover sheet and the data gallery. You are not allowed to look at someone else's test, nor use your notes, old tests, the internet, any books, nor are you allowed to discuss the test with anyone until all exams are turned in no later than **10:30 am on Monday October 24**. The **answers to the questions must be typed in this Word file** unless you are asked to draw on a separate page, or you want to use scratch paper. If you do not write your answers in the appropriate location, I may not find them. Tell me where to look if you put your answer at the back of your test.

I have provided you with a "Data Gallery" in the form of figures and tables. To choose a figure in support of your answer, simply state Figure #x. You do NOT need to move the figure on your test. Do not assume how many of the data images you will use, or not use. **Simply choosing the data is not sufficient support for your answer. You must explain the significance of the data and how they support your answer.** I have given you sentence limits so be concise.

-3 pts if you do not follow this direction.
Please do not write or type your name on any page other than this cover page.

Name (please print):

Read the pledge and sign if you can do so with honor:

_____

On my honor I have neither given nor received unauthorized information regarding this work, I have followed and will continue to observe all regulations regarding it, and I am unaware of any violation of the Honor Code by others.

How long did this exam take you to complete?

Lab Questions:

16 pts.

1) By now, you are an expert at GGA. Here are some questions about the method you have done twice using pClone Red (http://parts.igem.org/Part:BBa_J119137).

a) Summarize what color colonies you expect to see with these 3 functional promoters used in combination with pClone Red and GGA. Explain *how* you reached your conclusion. (25 words maximum for each promoter)

1) expected color:__green or colorless____

How: no sticky ends, original promoter or no promoter

```
5′ TTCTTTTAATGTTTTTTTAATTGAATATTTAAGATTATAACATATATTTAAAGTGT
   ||||||||||||||||||||||||||||||||||||||||||||||||||||||||
3′ AAGAAAATTACAAAAAAATTAACTTATAAATTCTAATATTGTATATAAATTTCACA
                          -35                  -10
```

2) expected color:___red_____

How: CCGC is sticky end for bottom right; -10 points to RFP

```
5′ CCGCGGCTATTTTATTGAAAATTTCCCTTTTGTGGTATAATAGATAA
       ||||||||||||||||||||||||||||||||||||||||||
3′     CCGATAAAATAACTTTTAAAGGGAAAACACCATATTATCTATTCAGC
                 -10              -35
```

3) expected color:___red____

How: CCGC is sticky end for bottom right; -10 points to RFP

```
3′     TATTGACATTAATCTTAATTAAAAATAAGATATTAAATCAGCCAGC
       ||||||||||||||||||||||||||||||||||||||||||
5′ CCGCATAACTGTAATTAGAATTAATTTTTATTCTATAATTTAGTCG
         -10                  -35
```

b) Take this piece of DNA and run it through the obligator (http://gcat.davidson.edu/iGem10/oligos.pl). Paste in the DNA you would order from the company to maximize the chances of successful GGA using pClone Red to produce RFP (-35 underlined): TGTTAAACCTGGCTTGCGCATGCTTGTATAGACAAGTATATGTATCTACGTAAACA

```
Top1- 5' CGACTGTTAAACCTGGCTTGCGCATGCTTGTATAGACAAGTATATGTATCTACGTAAACA
Bot1- 5' CCGCTGTTTACGTAGATACATATACTTGTCTATACAAGCATGCGCAAGCCAGGTTTAACA
```

Class Questions:

20 pts.

2) Cell theory assumes cells already exist. These questions examine the evolutionary origins of the first cell.

a) What evidence in the data gallery supports the RNA world hypothesis. For each figure you select from the gallery, summarize how it supports RNA world hypothesis. (30 words maximum for each figure)
Fig 4: RNA nucleates vesicle formation
Fig 13: RNA produces osmotic stress
Fig 29: RNA as ribozyme

b) Use two figures from the data gallery to support the claim that abiotic vesicles could evolve by natural selection to become a living cell. Start with the definition of evolution. Then make a numbered list of natural selection's tenets and explain how your two figures support the tenets in your list. Include a mathematical argument as part of your answer. (35 words maximum for each tenet)
Definition: change in allele frequency in a population over time

1. Over production (not enough lipids to go around) Fig 10 – vesicles have to be fed micelles to grow
2. Variation in population Fig 13 – some vesicles have osmotic stress
3. Competition Fig 13 – stressed vesicles take lipids from non-stressed
4. Selective advantage Fig 13 – stressed vesicles grow
5. Reproduction Fig 10 – big vesicles can divide, spilling 1/3 of their contents (math)

18 pts.
3) This question focuses on evolution at the cellular level.
a) What does DNA polymerase need to compete the S phase of a cell cycle? Make a numbered list of ingredients and summarize the role of each ingredient. (30 words maximum for each ingredient)
1. Primer with 3' OH
2. dNTPs
3. template DNA

b) How does cellular evolution improve your immune response? Support your answer with 2 figures. (40 words maximum)
#19: mutations produce new alleles that encode varied affinities
#11: memory B cells start somatic hypermutation to make new alleles
#28: B cells with highest affinity antibodies reproduce the most due to survival signal

12 pts.
4) Eukaryotes are complex organisms.
a) Use the ring of life to explain the origins of eukaryotes. Support your answer with data. (35 words maximum)

#31 fused cells so that eukaryotic central dogma genes from Archaea and energy harvesting from eubacteria.

b) How did mitochondria appear in Eukaryotes? Support your answer with three figures. (30 words maximum per figure)
#15: two outer membranes like bacteria
#33 MRCA with Rickettsia
#23 mitochondria have their own genomes, similar to chloroplasts

16 pts.
5) Race cannot be defined biologically but it has biological consequences.
a) Explain one incorrect example of data used to justify race-based medicine. Then use data to explain why race should *not* be used in this example. Support your two part answer with one figure for each part. (40 words maximum)
#20: incorrectly implies race determines proper dosage
#17: shows promoter genotype is real key to proper dosage regardless of race

b) Use skin color as an example of why races cannot be defined biologically. Support your answer with data. (35 words maximum)
several correct answers such as: #12 - genes present in and out of Africa; #21 range of skin tones within populations (horizontal) and across populations (vertical); #24 DNA nearly identical and 85% of genome diversity within a race

18 pts.
6) Protein shape is vital.
a) Use figures 2 and 19 to explain the importance of shape specificity. (40 words maximum)
Fig 2: bond angle starch alpha digestible, beta cellulose not digestible.
Fig 19: change in amino acid sequence changes affinity of antibody for antigen

b) From the gallery, give one example of allosteric modulation and one example of covalent modulation. Support your answer with data and indicate the functional consequences of the modulation. (30 words maximum for each modulation example)
many to choose from

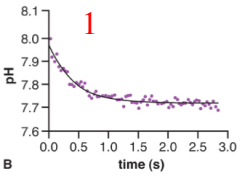
c) Summarize signal transduction and list its four hallmarks. Give one example in the data gallery for each hallmark. (30 word maximum for summary; 25 words maximum for each hallmark)
Summary: movement of information from outside cell to inside cell

1. amplification (many specific examples)

2. specificity (many specific examples)
3. change of shape, change of function (many specific examples)
4. Reset (many specific examples)

Data Gallery

1



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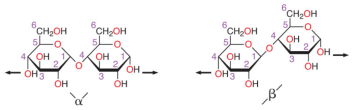

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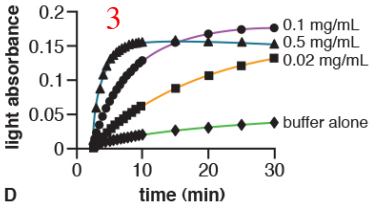

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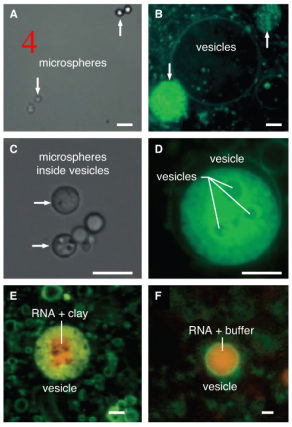

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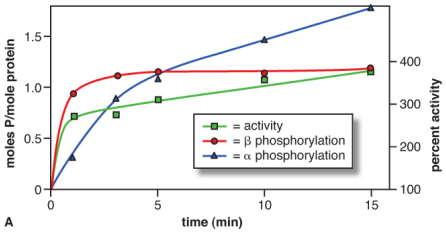

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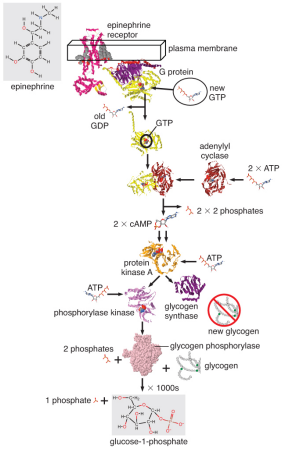

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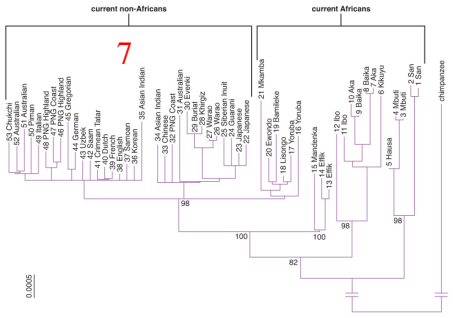

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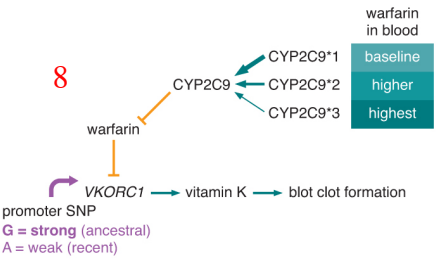

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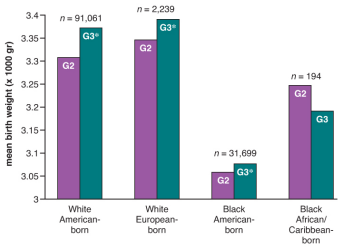

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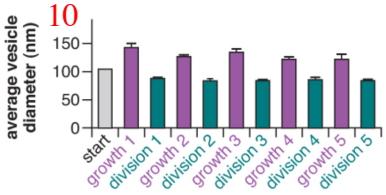

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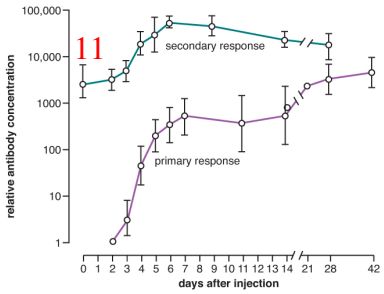
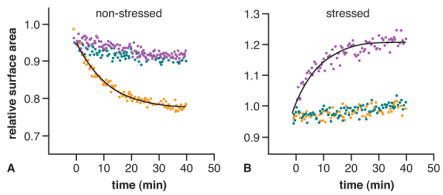


12

gene name	human variant	age of human variant
MFSD12	darker skin color	~996,000 years
OCA2#	lighter skin color	~629,000 years
DDB1	lighter skin color	~250,000 years
HERC2	lighter skin color	~247,000 years
SLC24A5	lighter skin color	~30,000 years*

*introduced to East Africa ~5,000 years ago
null allele causes albinism

13



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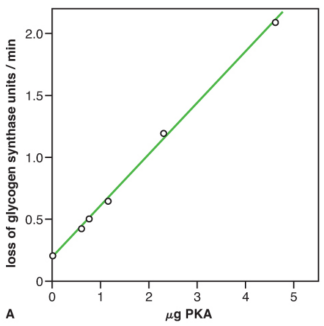

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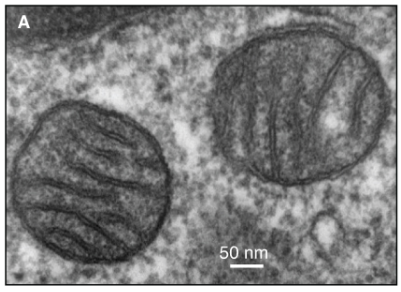

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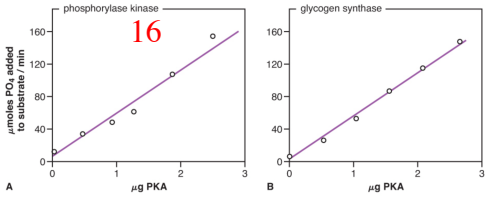
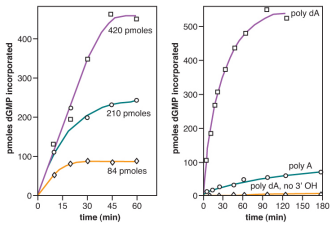
16



17

Effective Weekly Doses				
SNP genotypes	Blacks	Whites	Hispanics	Asians
GG	39.9 mg	42.7 mg	43.1 mg	42.7 mg
GA	31.5 mg	31.5 mg	32.0 mg	31.7 mg
AA	21.7 mg	21.0 mg	20.8 mg	19.6 mg

18



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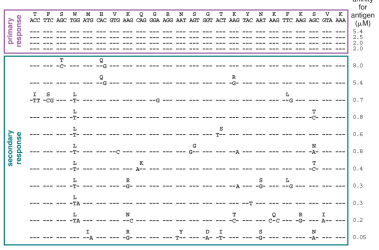

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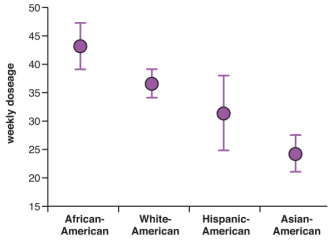

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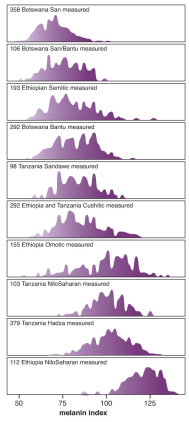

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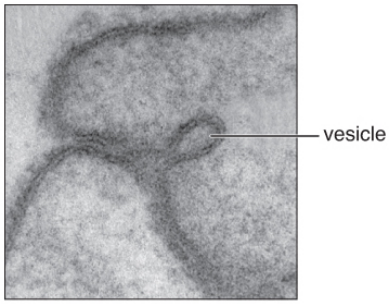

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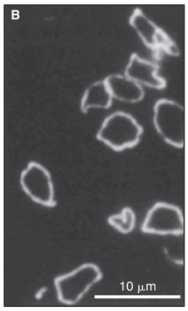
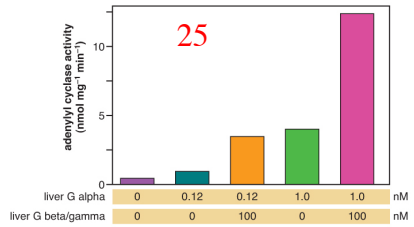


24

human genome	
3,200,000,000 genome total	total, rounded
3,196,800,000 identical DNA	99.9%
3,200,000 DNA differences	0.1%
2,720,000 differences within populations	85% of 0.1%
480,000 differences between populations	15% of 0.1%

chimp genome	
2,700,000,000 genome total	total, rounded
2,667,600,000 identical DNA	98.8%
3,240,000 DNA differences	1.2%

25



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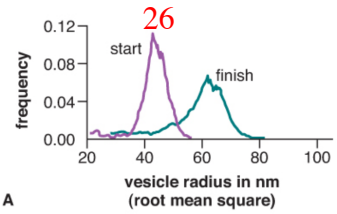
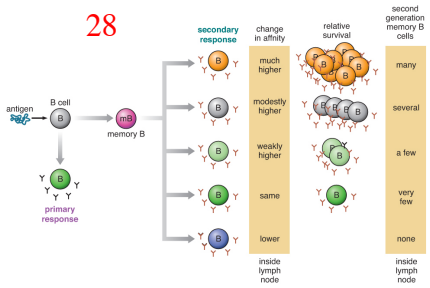


27

	White Americans	Black Americans
age-adjusted death rate (2015)[1]	753.2/100,000	876.1/100,000
prevalence of coronary heart disease (2010)[2]	5.8% (± 0.1%)	6.5% (± 0.4%)
age-adjusted cancer deaths (2010-14)[3]	166.2/100,000	194.2/100,000
infant mortality (2011-13)[4]	5.1/1,000	11.3/1,000
pregnancy-related maternal deaths (2011-13)[5]	12.7/100,000	43.5/100,000
diagnosed diabetes (2015)[6]	7.4%	12.7%
obesity (≥ 20 yrs, 2011-12)[7]	32.6% (± 4%)	47.8% (± 3.5%)
unemployment (≥ 20 years, 1st Q, 2018)[8]	3.6%	6.6%

28



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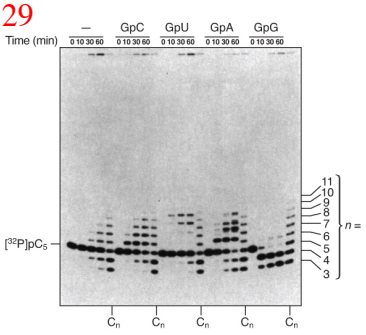

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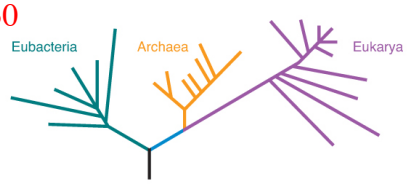

31

human protein number	protein function	protein location	best match domain
NP_001009	translation	cytoplasm/rER	archaea
NP_003185.1	transcription factor	nucleus	archaea
NP_001001937	ATP synthase	mitochondria	bacteria
NP_005521	energy harvesting	mitochondria	bacteria
NP_000393	energy harvesting	cytoplasm	bacteria
NP_004138	cell signaling	cytoplasm	archaea
NP_061816	cytoskeleton	cytoplasm	bacteria

32

DNA polymerase	ion	bases polymerized	error rate
young	Mg^{2+}	17,300	1 in 1821 bases
old	Mg^{2+}	5,400	1 in 474 bases
young	Mn^{2+}	26,800	1 in 1848 bases
old	Mn^{2+}	18,800	1 in 556 bases

33