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 **9:30 am on Monday Oct. 15**. If you turn in your exam late, you will lose a letter grade for each day you are late. 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.
Staple all your pages (INCLUDING THE TEST PAGES) together when finished with the exam.

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.

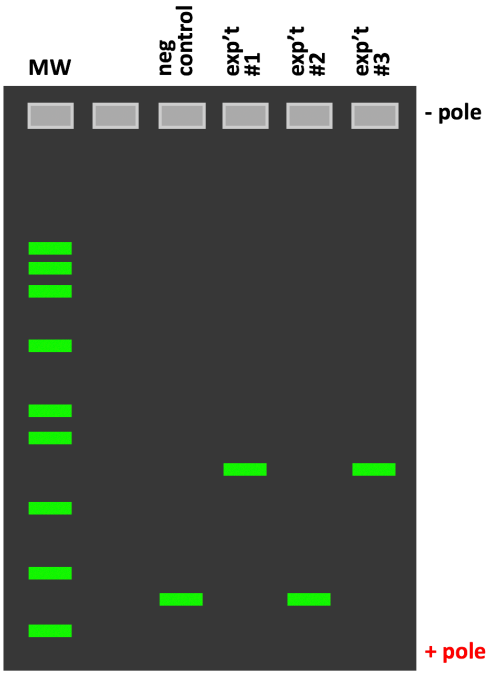
How long did this exam take you to complete?

Lab Questions:

10 pts.

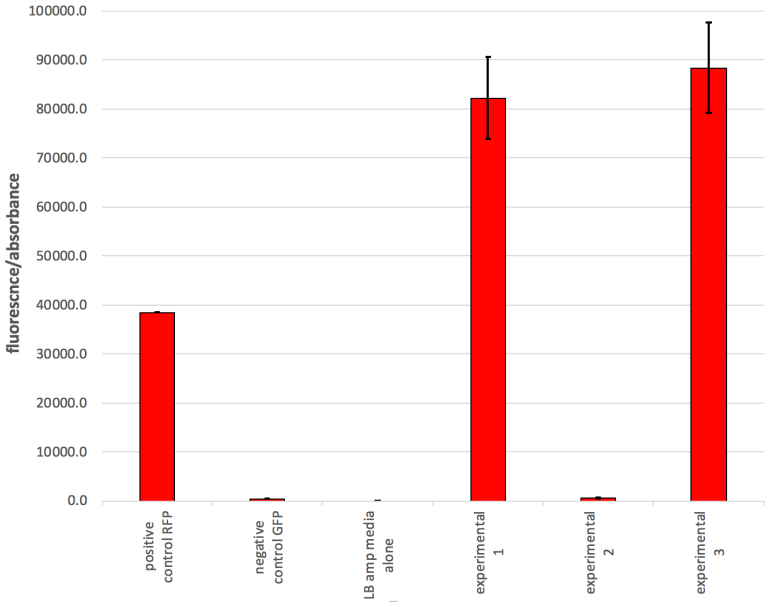
1) You have learned a lot in lab, and this is your chance to show me what you have learned.

a) While you were on your break, I generated new data using DNA control elements and *E. coli* cells similar to the strains you used in lab. Generate a bar graph using the data from the associated Excel file. You must graph all three controls as well as the 3 experimental samples. Each experimental sample was measured 3 times (A, B, C). Your graph must also contain s.e.m. error bars using these helpful Excel commands taken from the lab manual: standard deviation = STDEV; standard error of the mean (STDEV/SQRT(n)); n = sample size. Print our your graph and attach it to your hard copy exam answers. Black and white prints are fine.



b) Look at the associated PCR data using the same cells from question 1a as the DNA template source. The same general procedure was used here that you used in lab. Integrate the data from part a above with the data in this simulated gel electrophoresis of the PCR. What can you conclude about experimental samples 1, 2 and 3? Maximum of 40 words.

PCR shows that clones 1 and 3 successfully added new DNA but clone 2 did not. This is consistent with clone 2 not producing RFP above negative control.



Lecture Questions:

10 pts.

2) Nothing in biology makes sense unless viewed through the lens of evolution.

a) Use the 5 tenets of natural selection to explain why there are so many squirrels on campus with un-bushy tails whereas the rest of the town has only squirrels with bushy tails. Maximum of 20 words for each tenet.

1. Overproduction – too many squirrels

2. Variation in population – bushy and non-bushy
3. Competition for limited resources – food shelter
4. Selective advantage – no predators on campus so inferior non-bushy tails survive but in town predators kill the weak.
5. Reproduction of survivors – more non-bushy on campus

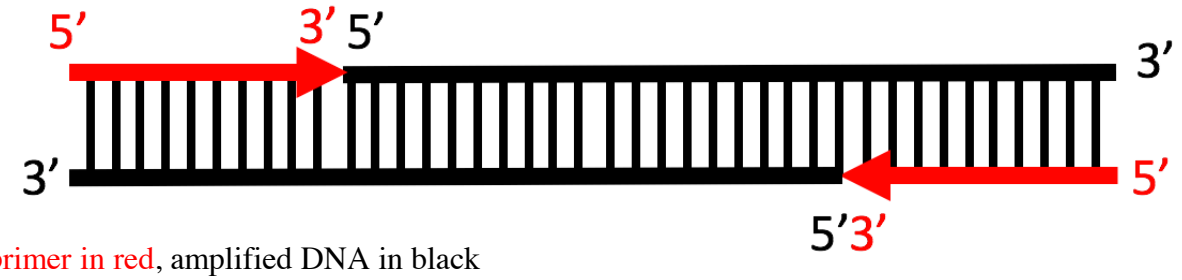
b) Distinguish between natural selection and genetic drift. Provide a hypothetical or real example to support your answer. Maximum of 45 words.
natural selection as described above
genetic drift is random survival of alleles due to chance (fire kills in radius regardless of genotype; chance meeting of sperm and egg)

10 pts.
3) The cell theory is predicated on there being cells….
a) What evidence was the catalyst for coming up with the RNA world hypothesis? Support your answer with data. Maximum of 40 words.
#18 ribozyme that acts as RNA polymerase

b) Given the following formulas, construct a mathematical argument that dividing abiotic vesicles with RNA cargo could have been the earliest lifeform to reproduce. The formula for the surface area of a sphere is $4\pi r^2$, and the formula for the volume of a sphere is $4/3\ \pi r^3$. Maximum of 40 words.
radius 3 → 4.5 μm
surface area 113 → 256 → 113 μm^2
volume 113 → 381 → 113 with spilled contents (125 μm^3) upon division

12 pts.
4) Why don't we describe DNA as having cello pairs? (light-hearted joke, not a real question)
a) What parameters accelerate the rate of new point mutations during S phase of the cell cycle? Support your answer with *two* data figures. Maximum of 40 words.
#27 different divalent cations
#31 age of DNA polymerase

b) In the space provided, draw one dsDNA molecule that has been amplified by PCR that is 40 base pairs long and which employed primers that were 10 bases long. You can use stick figures for base pairings. (This is **not** a question asking you to draw the structure of a nucleotide.) Be sure to label the 5' and 3' ends. Also include in your drawing the primers labeled with 5' and 3' ends. Use a one color ink/pencil/marker for *all* primers in your drawing, and a different color for any other DNA in your drawings. I recommend you use a ruler to keep the spacing even and have it fit in the space below.



primer in red, amplified DNA in black

14 pts.

5) Evolution is full of surprises, to us.

a) Look at the "tree of life" illustrated in figure 29. What was the methodological error made to generate this tree? What data contradict figure 29 in favor of a different view for the origin of eukaryotes? Maximum of 40 words.

They used only rRNA gene

#32 shows orthologs from bacteria and archaea, we are a product of genome fusion, circle of life

b) What features of chloroplasts and mitochondria support our understanding of their evolutionary origins? Support your answer with *three* data figures. Maximum of 30 words for each figure.

1. #23 2 outer membranes
2. #21 MRCA
3. #16 organelle genomes

18 pts.

6) Race is not based on biological traits, but it affects the biology of people.

a) Which current African individual in figure 11 is most closely related to all the current non-Africans? Explain how you reached this conclusion. Maximum of 30 words.

#18 Lisongo – shortest vertical distance (not number of branches)

b) Use data from the gallery to refute the use of race-based medicine which incorrectly interprets figure 26 to justify the use of self-identified racial categories for warfarin dosages. Maximum of 40 words.

#30 SNP for promoter is the cause (not CYP2C9)

c) Use data from the gallery to make the argument that skin color genotype cannot be used to categorize people by race. Maximum of 30 words.

People considered the same race have different skin genotype #28 = people of different races have same genotype; or #14, all skin color alleles already in Africa before migration out

12 pts.

7) One of the few rules in biology addresses shape and function.

a) How does allosteric modulation change the function of an enzyme? Support your answer with data. Maximum of 30 words.

#25 = cAMP + PKA

#20 = G alpha + adenylyl cyclase

b) Give an example of covalent modulation using data from the gallery. Explain the consequence of this modulation using the data. Maximum of 30 words.

#24 PKA and either phosphorylase kinase activated or glycogen synthase inactivated

#4 glycogen synthase inactivated

#8 phosphorylase kinase gamma activated after alpha and beta phosphorylated

14 pts.

8) Ch-ch-ch-ch-changes: it turns out David Bowie was a biologist at heart!

a) When PKA is activated, which substrate does it phosphorylate first? Support your answer with data. Maximum of 30 words.

#24 whichever one it bumps into first

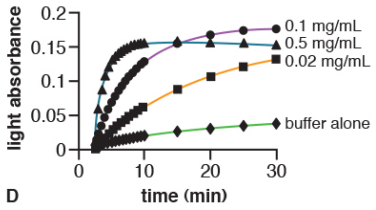
b) Summarize the regulation of phosphorylase kinase regulation as shown in figure 8. Be sure to use the data to support your answer. Maximum of 40 words.

beta 1 phosphate and gamma partially activated

alpha 2 phosphates and gamma activated further, but slower

Data Gallery

1



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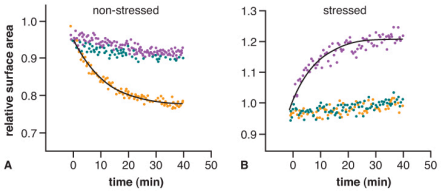

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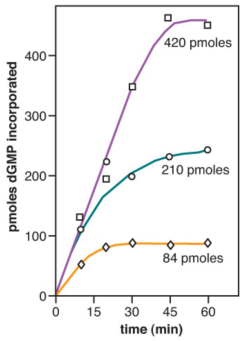

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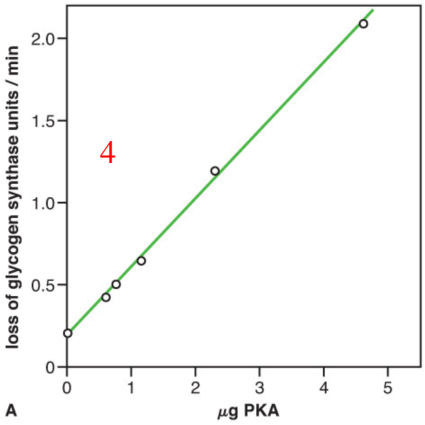

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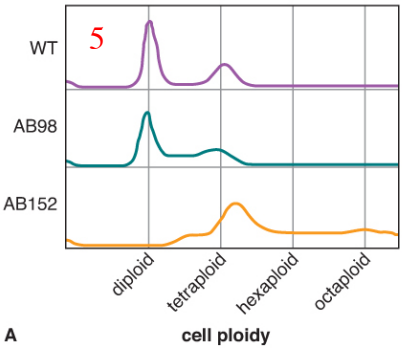

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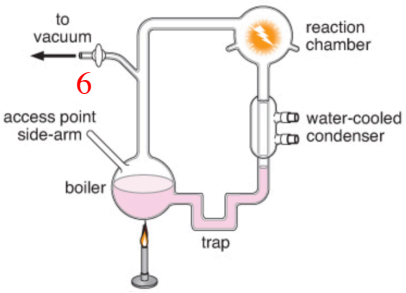

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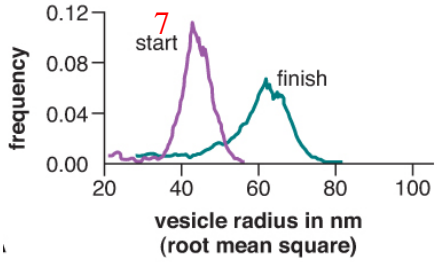

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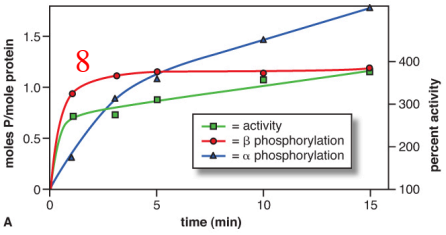

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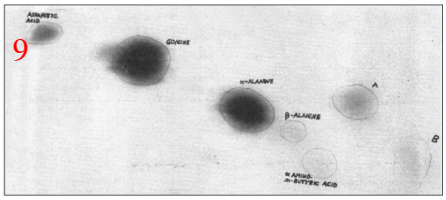

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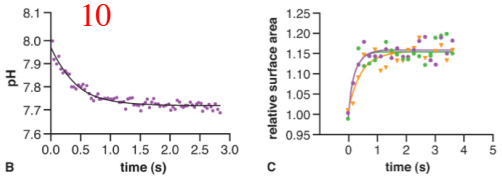

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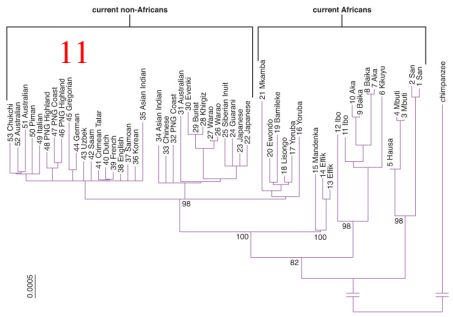

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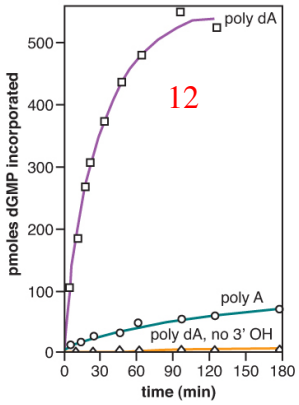

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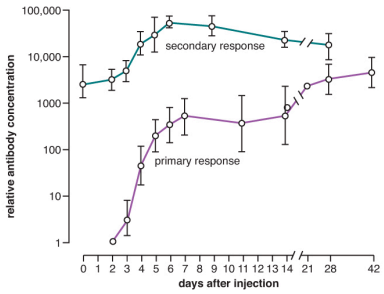
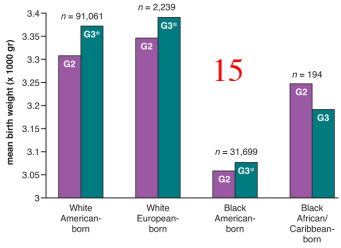


14

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

15



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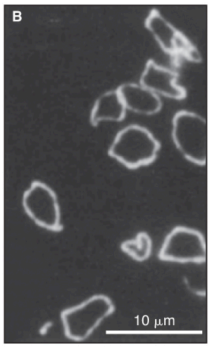

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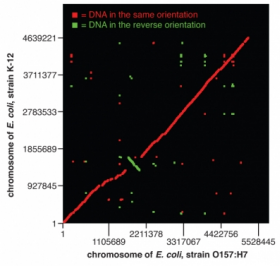

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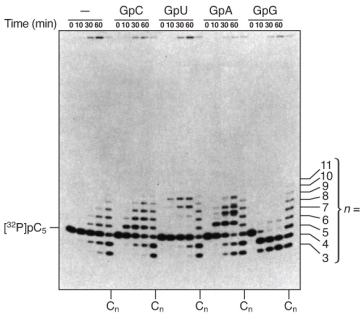

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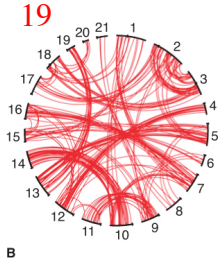

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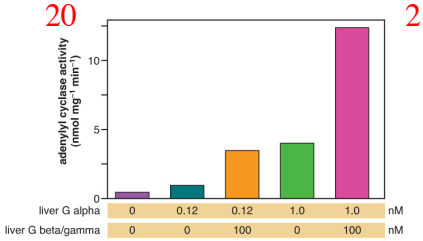

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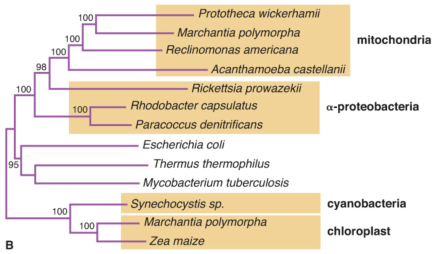

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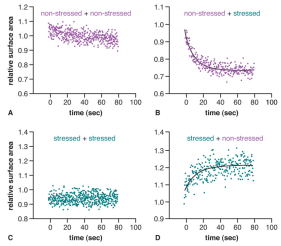

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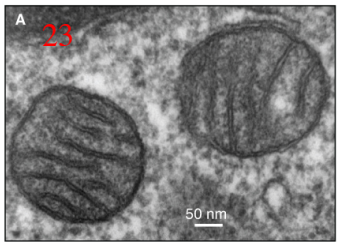

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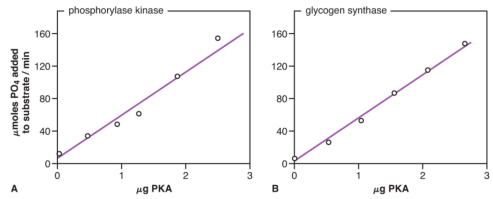

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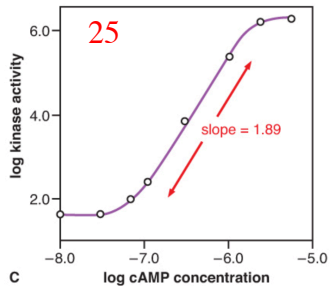

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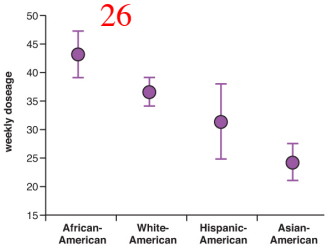


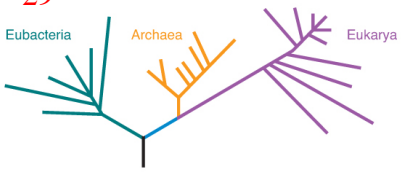
27

ions (concentration in mM)	error rate
Mg^{2+} (1.0)	1 in 41,000
Ni^{2+} (1.0)	1 in 5,030
Ni^{2+} (2.0)	1 in 1,850
Cd^{2+} (0.1)	1 in 7,810
Cd^{2+} (0.2)	1 in 5,070
Ca^{2+} (0.6)	1 in 7,520
Ca^{2+} (1.0)	1 in 5,500
Ca^{2+} (2.5)	1 in 3,760

28

CSHL HapMap populations	% homozygous A	% heterozygous	% homozygous G
CEU = Utah, Northern & Western European ancestry	98.2	1.8	0.0
HCB = Han Chinese in Bejing	2.4	14.3	83.3
JPT = Japanese in Tokyo	0.0	8.2	91.8
YRI = Yoruba in Ibadan, Nigeria	0.0	2.7	97.3
ASW = African ancestry, Southwest USA	0.0	32.7	67.3
CHB = Han Chinese in Bejing	2.4	19.5	78.1
CHD = Chinese in Metropolitan Denver	0.0	22.4	77.6
GIH = Gujarati Indians in Houston	89.7	10.3	0.0
LWK = Luhya in Webuye, Kenya	1.1	8.9	90.0
MEX = Mexican ancerstry in Los Angeles	46.0	46.0	8.0
MKK = Maasai in Kinyawa, Kenya	9.8	46.9	43.3

29



30

variants	Blacks	Whites	Asians
CYP2C9*2	rare	8-18%	rare
CYP2C9*3	1-2%	5-13%	2-5%
-1639 G→A	8-10%	35-45%	90-95%

31

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

32

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

33