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 March 16**. If you are on campus, you can drop it off at my office any time, or I will be in the classroom at normal time. 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:

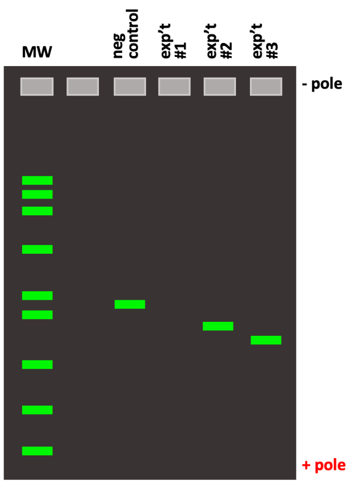
10 pts.

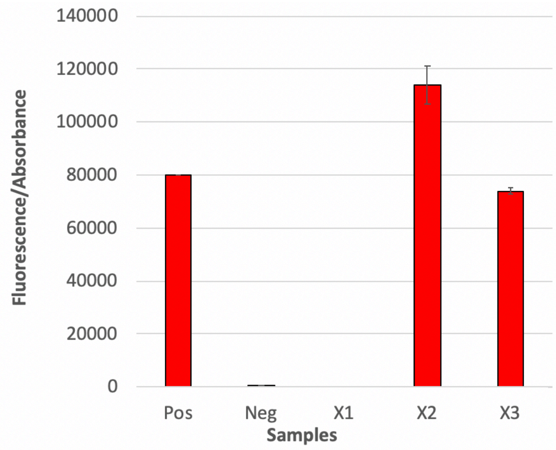
1) Use the raw data in the attached Excel file to determine how well 3 experimental clones worked. Each was tested in quadruplicate (A - D) along with the negative control, the positive control and plain LB + amp media lacking any cells. Generate a bar graph that includes standard error of the mean error bars (SEM = STDEV/SQRT(n)). **You may print your graph for hard copy submission or attach your modified Excel file with the graph. If you submit your file, please put your name in the file name to prevent confusion on my part.**

Don't graph X1, no cells.

Subtract LB media from all and don't graph it.

No error bars if N=1.





b) PCR was performed on the 3 experimental clones as well as the negative control. The PCR products were run on a gel and the "photo" is shown to the right. Use the PCR results to explain the graph you generated. Maximum of 45 words.

X1 had no PCR product, consistent with no cells in raw data. X2 amplified DNA smaller than negative control. X3 amplified DNA smaller than X2 which might explain why X3 was not as bright as X2 in graph.

Class Questions:

10 pts.

2) The lens through which all of biology makes sense.

a) There is a small pond on the cross country trail where a population of 25 salamanders live. Describe a salamander scenario for each of the four mechanisms of evolution. Maximum of 30 words for each mechanism. Various forms of correct answers:

1. Natural selection (salamanders with wings dominated)
2. Mutation (new allele in gamete caused new phenotype)
3. Gene flow (mating with animal from different population)
4. Genetic drift (runners crushed half of the animals randomly)

b) This question builds on collegiate sports. Explain how the women's basketball team experiences a form of natural selection during a national tournament that has been canceled this year. Be sure to name the five tenets of natural selection and explain how each tenet plays out. Maximum of 30 words for each tenet.

1. Overproduction – too many teams, only 1 can be champion
2. Variation in the talent and level of teamwork
3. Competition for the championship
4. Selective advantage for the team with the best combination of players
5. Coaches recruit more players like the winning team

20 pts.

3) Always look on the bright side of life…

a) Nature produced the first ribozyme. What was its function that supported the RNA world hypothesis? Support your answer with data. Maximum of 40 words.

#18, self-splicing RNA intron could function as RNA polymerase showing that proteins and DNA not necessary for first organisms.

b) Explain how abiotic vesicles can evolve due to a primitive form of natural selection. Support your answer with 4 figures from the data gallery. Maximum of 35 words for each figure.

#6 clay catalyzed formation of many vesicles (over production)

#10 variation (with and without RNA cargo) and competition in vesicles, selective advantage for those that are stressed.

#7 vesicles can divide and will spill some content (reproduction)

#2 vesicles can store energy in pH gradient as they grow

12 pts.

4) You must be new here…

a) Explain how environmental factors can accelerate one mechanism of evolution during S phase. Support your answer with data. Maximum of 35 words.

DNA polymerase makes more mistakes when exposed to certain cations such as Cd^{2+}.

b) Use figure 29 and an arrow (electronic or drawn) to point to a feature in that figure which shows only one genome experienced a duplication event.

Many acceptable answers. Any spot off the diagonal that did not have a symmetrical partner on the other side of diagonal.

c) Synthesize the information in figures 16, 30 and 33 to explain how my allergies to grass <u>evolved</u> to be so strong. Maximum of 45 words.

#16 shows that B cells can form memory cells from which subsequent generations of B cell evolve.

#30 shows that DNA polymerases can make mutations when copying DNA. (age is NOT relevant since that was in vitro and B cells are in vivo).

#33 This shows a change in allele frequency (primary to secondary) and increased antibody affinity

14 pts.

5) Wow, that was fast.

a) A common misconception is that evolution must take place slowly, with small changes in DNA. Disprove this misconception for the two examples below and support your answer with data. Maximum of 35 words for each example.

- origin of vertebrates #24 whole genome duplication
- origin of eukaryotes #31 fusion of bacteria and archaea genomes

b) How did mitochondria evolve in the first cell? Support your answer with two data figures. Maximum of 30 words for each figure. Any combination of 2:

#14 engulfed cell and mitochondria still has 2 outer membranes from engulfed cell

#21 MRCA proteobacteria

#23 remnant genome of circular DNA

10 pts.

6) We are all related through lines of common ancestry.

a) Use three figures to support this statement: all genetic diversity found in current non-Africans is also present in current Africans. Maximum of 35 words for each figure.

#28 skin tones vary but not by race and genotypes don't segregate by race either

#11 MRCA between current some Africans and all non-Africans.

#9 light color skin gene originated in African before migration out

b) Use two figures to disprove the common misconception about race-based medicine that some erroneously support with figure 26. Maximum of 40 words for each figure.

#4 warfarin pathway regulated by variations in promoter, strong promoter G is ancestral.

#32 promoter SNP determines effective dosage, not race, though G frequency does correlate with data in figure 26.

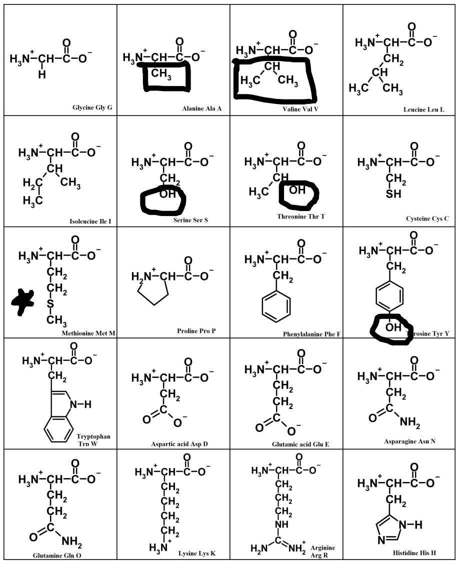
12 pts.

7) All 20 amino acids are in the diagram to the right.

a) draw a circle (electronic or by hand) around the **atoms** that can be modulated by kinases. Only 3 right answers

b) Draw a box around the **atoms** in two amino acids that make them hydrophobic. Multiple right answers

c) Draw a star next to the atom that could mislead you into thinking the side chain is hydrophilic when actually the side chain is hydrophobic. One right answer, a couple acceptable alternatives



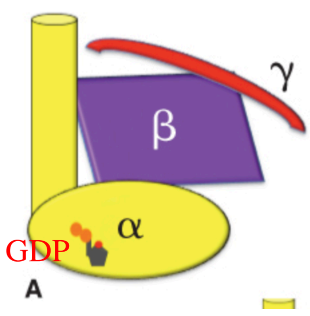
12 pts.

8) Enzymes are essential to life.

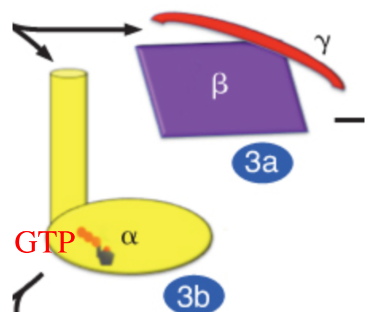
a) Search through the data figures to find examples of two hallmarks of signal transduction. Indicate which figure and how it exemplifies one hallmark. You cannot use the same figure for more than one hallmark. Maximum of 40 words for each figure. Multiple correct answers

1. Specificity of shape (#22) epinephrine leads to glucose secretion but antagonist does not
2. #12, change of shape, change of function
3. #25, amplification with G protein α leading to more cAMP production when it can recharge by interacting with β and γ.

b) Sketch the quaternary structure of a G protein in active and inactive stages. Label all the important parts.



Inactive



active

c) Propose how the complex regulation of phosphorylase kinase in figure 8 is adaptive enough to contribute to natural selection. Maximum of 45 words.

You had to address that complex regulation provided a range of responses, not just on/off. Mild fright could lead to low levels of glucose release, for example.

Data Gallery

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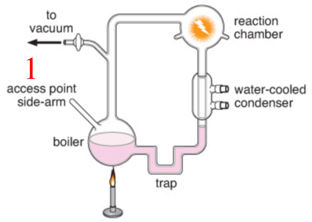

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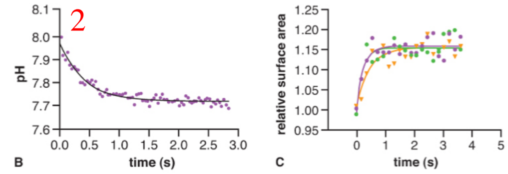

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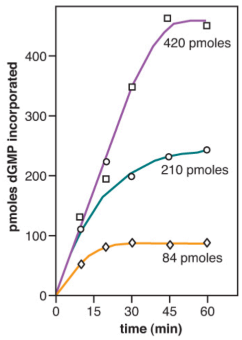

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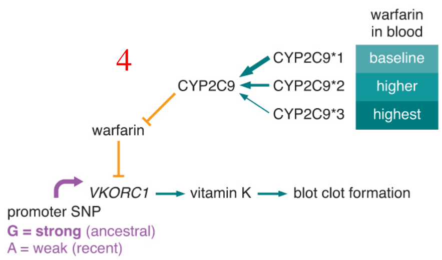

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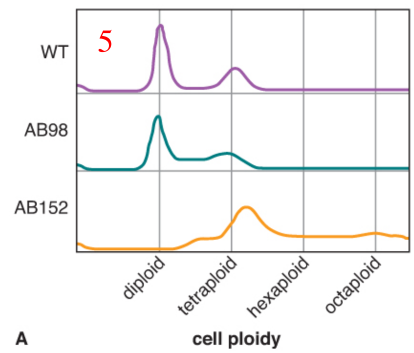

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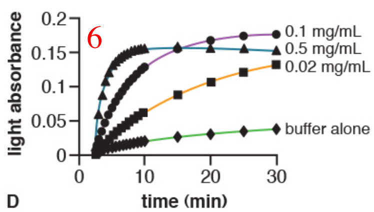

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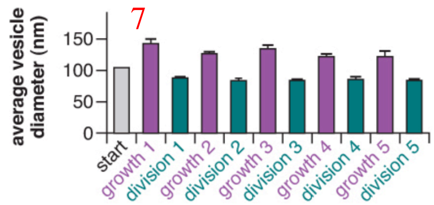

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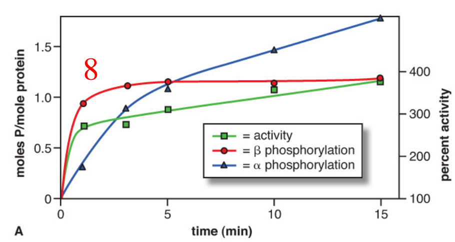
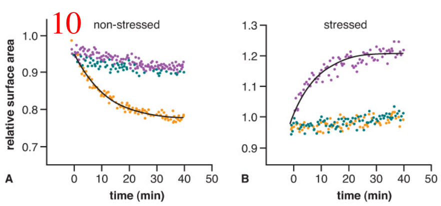


9

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

10



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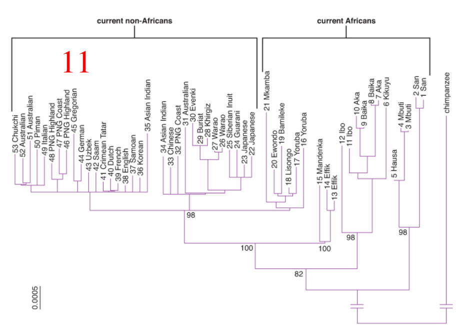

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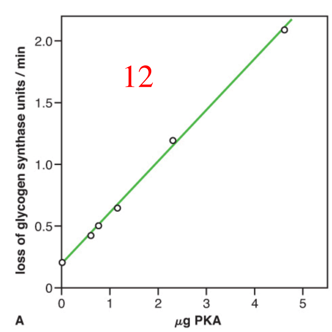

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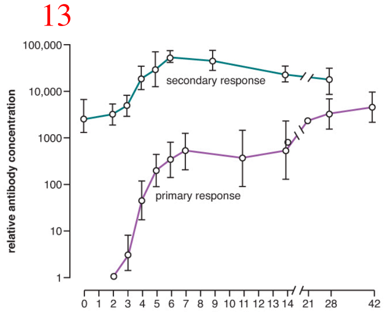

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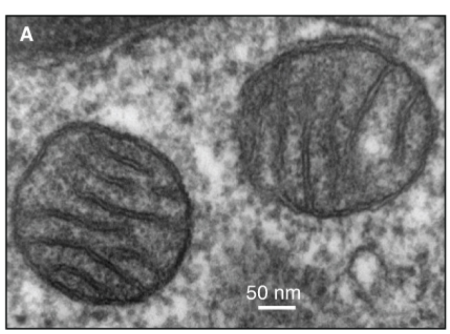

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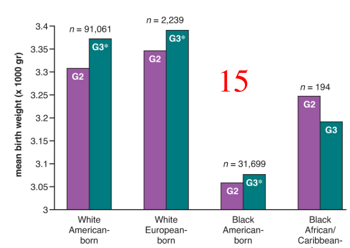

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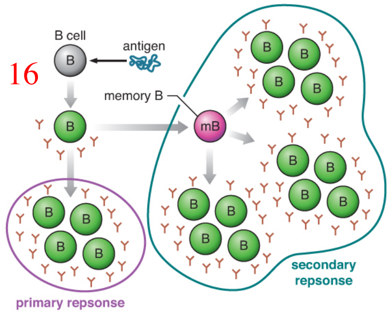

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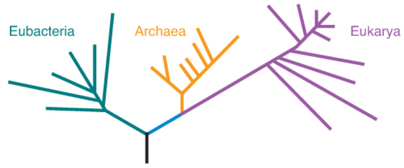

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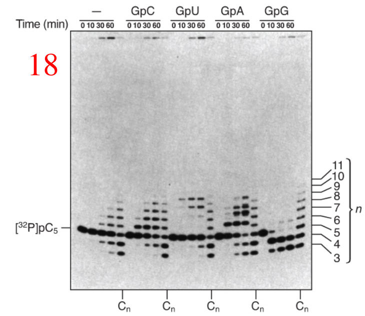

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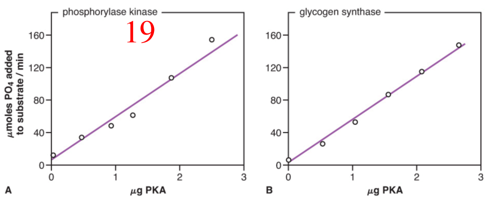

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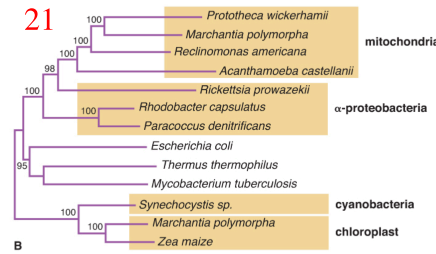

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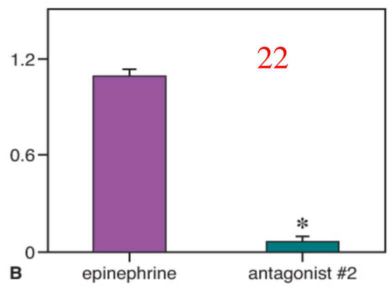

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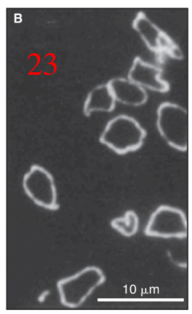

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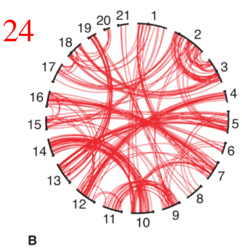

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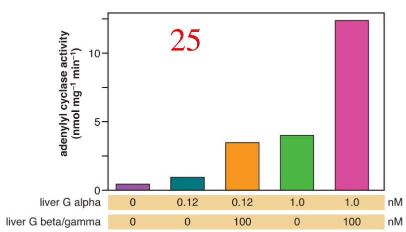

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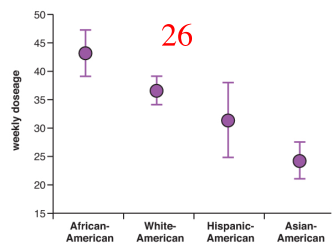


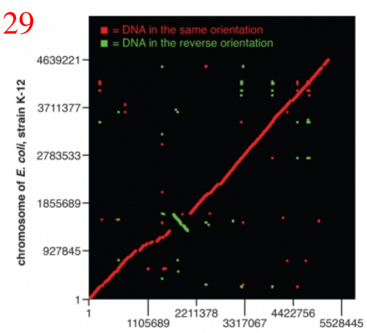
27

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 ancerstry, Southwest USA	0.0	32.7	67.3
CHB = Han Chinese in Bejing	2.4	19.5	78.1
CHD = Chinese in Metroplolitan 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



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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

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

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%

33