

Biology 113 Closed Book Take-Home Final Exam

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 7 pages in this final exam, including this cover sheet. 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 by 5pm Thursday Dec. 13. **HARD COPY of your EXAM IS DUE NO LATER THAN 5pm THURSDAY DECEMBER 13th**. If you turn in your exam late, then you lose a letter grade for each day you are late. The **answers to the questions must be typed directly under the questions** unless the question specifically says to write the answer in different place. If you do not write your answers in the appropriate location, I may not find them.

I have provided you with a “Data Gallery” in the form of figures and tables. To choose a figure in support of your answer, state Figure #x and do NOT move the image 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, however. You must explain the significance of the data and how they support your answer. I have given you word 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 together when finished with the exam. Do not print test pages without answers. I only want to see your answers. You can type your answers right under each question.

Name (please type here):

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 CLUSTAL omega (<https://www.ebi.ac.uk/Tools/msa/clustalo/>) and three attached files to evaluate. The Word file contains two experimental sequences and one reference sequence. There are also two chromat files for the two experimental sequences. You will want to view the relevant chromat files (.ab1) to see if you can override any N bases. You can use the “find” function to locate non-N bases adjacent to the bases you want to evaluate. Once you have determined the correct bases for any Ns, then perform Clustal omega and **determine the *minimum* number of bases you would have to change to get both experimental sequences to match the reference sequence.** Maximum of 10 words for each experimental sequence.

Close:

Far: **Not relevant for S2020**

Lecture Questions:

10 pts.

2) Weight, weight, don't tell me.

a) Propose an explanation for why obesity often generates many other health complications.

Support your answer with two data figures. **Maximum of 40 words in total.**

1. leptin receptor is transcribed in many tissues #41 (old database format, not used in S2020)

2. high leptin produces high BP #26

b) Analyze one experimental human data from the gallery to explain how the lipostat works. Tell me which figure you chose. **Maximum of 40 words.**

15 pts.

3) Don't hold your breath if you want to get full credit for this question.

a) Incorporate data from two gallery images to explain why hemoglobin is an ideal delivery protein to supply oxygen where it is needed most. **Maximum of 30 words for each figure.**

1. It has hybrid affinity for oxygen #11

2. It releases more O₂ with lower pH due to high CO₂ production (and thus O₂ consumption via electron transport chain) #46

b) What molecular movement produces hemoglobin's emergent property? Support your answer with an image from the data gallery. **Maximum of 40 words.**

The change from domed in #1 left to flattened in #1 right

15 pts.

4) Don't anthropomorphize molecules, they hate that.

a) Summarize the emergent property of the lambda switch shown in data gallery #29 and how this property permits phage to choose a particular lifestyle. **Maximum of 40 words.**

Cooperativity of CI dimers causes a quick switch from the default lytic to the more benign lysogenic.

b) Use figures #27 and #35 to explain the consequence when a genetic circuit is long or short. Maximum of 30 words for each figure.

#27:

#35: Not relevant for S2020

10 pts.

5) One for all, and all for one!

a) Use the data to show how the methods in figure #34 detected two different cellular components that affect bioluminescence production. **Maximum of 40 words.**

Enzyme luciferase and substrate

b) What mechanism allows slime mold cells to migrate towards a common meeting area?

Support your answer with data. Maximum of 40 words.

Not relevant for S2020

10 pts.

6) What doesn't kill you makes you stronger.

a) What is the function of MHC I in a normal immune response (that does not involve transplants)? Support your answer with two data figures. **Maximum of 30 words for each figure.**

1. ID self #22

2. present viral proteins to T cells #14

b) Differentiate the function of MHC IG from MHC I. Support your answer with data. **Maximum of 40 words.**

MHC IG neutralizes the mother's immune response against a non-self embryo #17 #8 #19

MHC I presents peptides from proteins made in that cell's cytoplasm #28

10 pts.

7) Remember, my gray hair is dyed to give the illusion of wisdom and intelligence.

a) Apply the data in figures #9 and #16 to support the disposable soma theory. Maximum of 40 words in total.

b) Propose a mechanism that explains how an animal's physiological response to stress has an impact on longevity. Support your answer with data. Maximum of 40 words.

Not relevant for S2020

10 pts.

8) You are the summation of molecular events that began *before* you were conceived.

a) Assemble three figures from the gallery to explain the current model of how X-linked gene dosage is addressed in women. **Maximum of 30 words for each figure.**

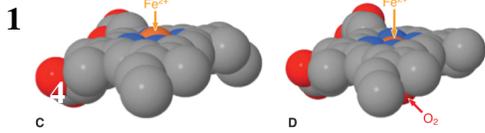
1. #12 Xist silences X if more than 1 X per cell
2. #3 one X is randomly silenced in XX cells to bring gene dosage down to 1 allele
3. #21 Tsix RNA neutralizes Xist RNA on the chromosome that will be Xa

b) Why is *Sry* necessary but not sufficient for male sex determination? Support your answer with two figures from the gallery. **Maximum of 30 words for each figure.**

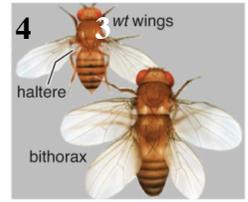
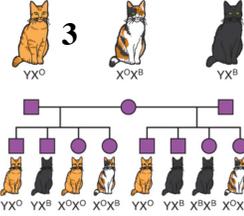
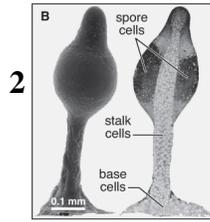
1. #30 #25 an XX mouse given Sry+ converted to male (necessary)
2. #31 many other genes are also necessary so Sry is not sufficient

c) President Trump has considered registering the genitalia of every baby born in the US as either male or female (see <https://www.nytimes.com/2018/10/21/us/politics/transgender-trump-administration-sex-definition.html>). Explain in simple terms why this concept is not supported by science. Support your answer with two data figures. **Maximum of 30 words for each figure.**

1. #48 there are intersex and hermaphrodite humans so sex is not binary
2. #43 XX sex reversal male would not fit the genetic test he imagined



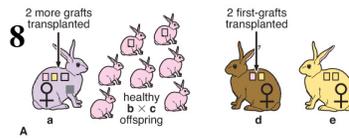
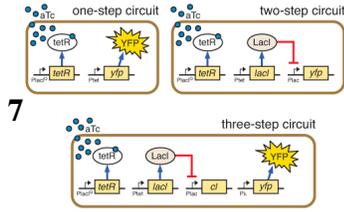
Data Gallery (3 pages)



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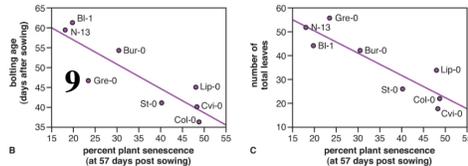
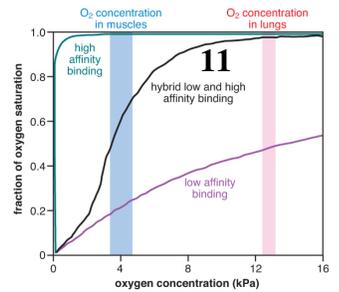
genotype	age (days)	free-feeding mice		pair-fed mice	
		body weight (g)	percent fat	body weight (g)	percent fat
wt	20	14.6 ± 0.5*	—	9.5 ± 0.4	15.1 ± 0.6
wt	48	26.1 ± 0.9	+11.5	9.1 ± 0.8	21.4 ± 0.8
ob/ob	20	17.0 ± 0.5	—	23.8 ± 1.1	17.1 ± 0.4
ob/ob	48	38.6 ± 0.4	+21.6	42.3 ± 1.4	25.6 ± 1.0
db/db	20	16.9 ± 0.4	—	24.3 ± 0.9	16.6 ± 0.5
db/db	48	38.2 ± 0.5	+21.4	36.8 ± 0.8	24.3 ± 1.2

*mean values ± standard error of the mean with 4 mice in each group.



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trait	high mortality rate		low mortality rate		p values
	# of flies	averages	# of flies	averages	
female development (hours)	389	254	345	272	0.0041
female dry weight (µg)	90	242	90	261	0.0156
fecundity (average # offspring)	340	40.8	322	27.0	0.0035
male development (hours)	389	260	334	276	0.0061
male dry weight (µg)	388	197	332	217	0.0182



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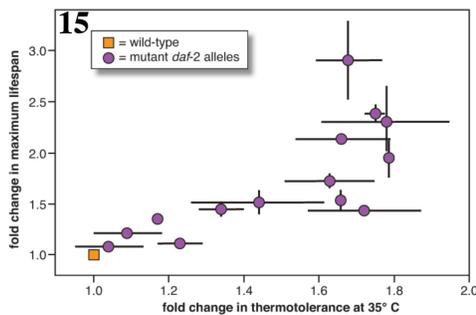
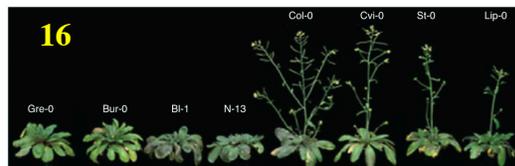
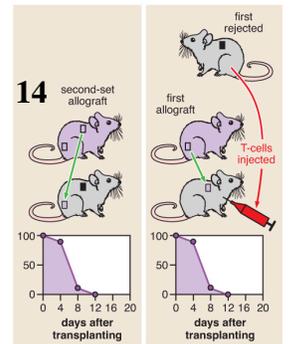
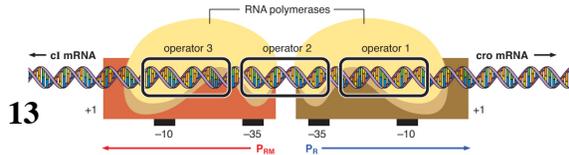
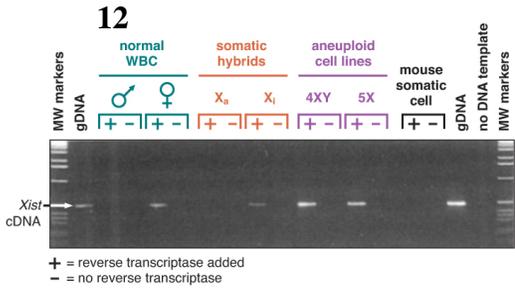
experimental conditions	baby skin transplanted to:		rabbit E skin transplanted to:	
	foster mother A	unrelated rabbit B	foster mother A	unrelated rabbit D
average days graft survived	4.0*	6.5	6.0*	7.0

*indicates $p < 0.01$; experiment replicated 5 times

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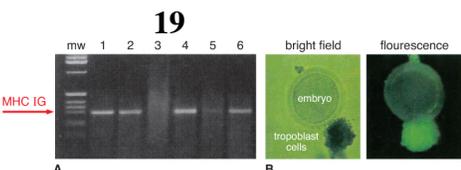
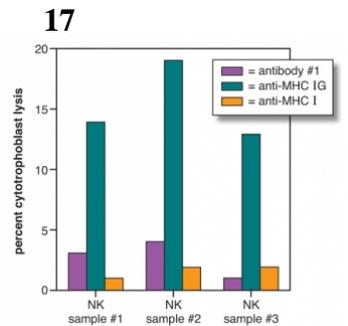
donor → recipient	number of animals	% rejected	average days to rejection ± stdev
male → female	16	0	n.a.
female → female	15	0	n.a.
female → male	15	0	n.a.
male → female	15	100	28 ± 3
male → primed female*	10	100	14 ± 2

*primed female injected with sperm two weeks prior to skin graft. Modified from Kalish *et al.*, 1946; their Table 1.



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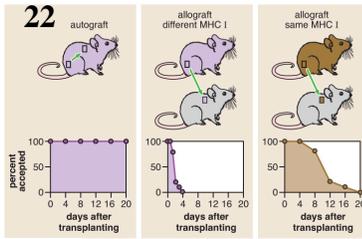
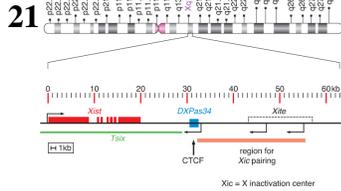
treatment	strain 1 cells	strain 2 cells
negative control media	delayed	delayed
strain 1 media	immediate	delayed
strain 1 media, filtered	immediate	nt
strain 1 media, boiled	delayed	nt
strain 2 media	delayed	immediate
strain 2 media, filtered	nt	immediate
strain 2 media, boiled	nt	immediate



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	wild-type	daf-2 mutant
median life span (d)	16.3 ± 1.3	41.0 ± 2.0
mean brood size	313 ± 42	8.5 ± 8*
average progeny (after 10 d)	0	6.6
age (d) when last egg laid	11	50

* $p < 0.005$ ± standard error



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Xist RNA	DNA methylation	histone hypoacetylation	relative X ^{GFP}	relative X ^{lbrt}
wt	wt	wt	1X	1X
deleted	wt	wt	2.5X	100X
wt	blocked	wt	19X	12X
wt	wt	blocked	1X	ND
deleted	blocked	wt	30X	4,800X
wt	blocked	blocked	29X	ND
deleted	blocked	blocked	60X	ND
wt	<i>Dnmt1</i> deleted	wt	1,500X	ND
deleted	<i>Dnmt1</i> deleted	wt	2,500X	ND

