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 test, 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 no later than noon on Thursday Dec. 18. **HARD COPY of your EXAM IS DUE NO LATER THAN NOON THURSDAY DECEMBER 18th**. 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 will be reviewing grant proposals for the NSF by video conference on Dec. 16 and Dec. 18. I won't be able to talk with you during the review process, but you may drop off your exams during these times.

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 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 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

4 pts.

1) What was the class consensus about trying to accelerate the mutation rate of *B. subtilis* in the directed evolution experiment? Support your answer with a reasonable hypothesis to explain the consensus.

6 pts.

2) Most groups were able to evolve their population to become resistant to one or more antibiotics.

a) Explain how antibiotic resistant cells came to dominate the population.

b) Some groups found cells that were resistant to more than one antibiotic. How could cells evolve to resist an antibiotic that was not used during their directed evolution?

c) Last year, a lab group did the same type of directed evolution experiment you did this year. However, they got resistant cells on two plates but not the third. Explain how they could get this result and not have made any mistakes.

Lecture Questions:

12 pts.

3) You think you are stressed during finals, but plants face even more stress.

a) What do plants do on a regular basis in one hour that allows them to survive stress? Support your answer with data. Limit your answer to a maximum of 40 words.

b) What historic event has provided all plants with genomes that are well suited to tolerate stress? Support your answer with data. Limit your answer to a maximum of 40 words.

c) You know that mutations are random and mutation is one mechanism of evolution. Is it possible for a new species to evolve multiple, independent times and reach the same end point multiple times? Support your answer with data. Limit your answer to a maximum of 40 words.

12 pts.

4) Take a deep breath before answering this question.

a) Name three physical or chemical properties that determine when a heme would bind oxygen or not. Support each answer with data. Limit your answer to a maximum of 30 words for each answer.

1.

2.

3.

b) Sometimes a solution of hemoglobin is half saturated with oxygen. Describe what this means for any given hemoglobin molecule. Include the emergent property in your answer. Limit your answer to a maximum of 30 words.

8 pts.

5) Now it is time for a λittλe λamda for the hoλidays…
a) Why is cro produced instead of cI when no transcription factors are bound to either P_{RM} or P_R? Support your answer with data. Limit your answer to a maximum of 40 words.
b) What aspect of the cro protein prevents it from exhibiting the emergent behavior of cooperativity found in cI? Support your answer with data. Limit your answer to a maximum of 40 words.

8 pts.
6) And now for something totally random…
a) Many biologists are convinced that an acquired phenotype cannot be passed on to the next generation. Prove that they are wrong and support your answer with data. Limit your answer to a maximum of 40 words.
b) What aspect of cell circuit length enables the cell to establish different thresholds for input noise tolerance? Support your answer with a figure. Limit your answer to a maximum of 40 words.

11 pts.
7) Now that we have reached a critical amount of material in Bio113, I can ask these questions…
a) Describe how *E. coli's* use of quorum sensing differs from *V. fischeri* based on the data. Support your answer with data. Limit your answer to a maximum of 40 words.
b) What common emergent property (excluding quorum sensing) causes *V. fischeri* to produce more light as cell density increases? Support your answer with a figure. Limit your answer to a maximum of 40 words.

9 pts.
8) Here is a reference that many of you may not get, but probably all of your parents would understand… "Who you gonna call? Ghost Busters!"
a) How do individual *Dictyostelium* cells manage to move toward the source of cAMP instead of chasing cAMP waves that have passed by them? Support your answer with a figure. Limit your answer to a maximum of 40 words.
b) List three distinct benefits for the microbes that produce biofilms. Support each item in your list with data. Limit your answer to a maximum of 30 words for each item.
1.
2.
3.

8 pts.
9) Some of you may get reminded on a regular basis that your mother tolerated you growing insider her for 9 months!

a) How do we know that pregnant mammals have a functional immune system but they do not reject their non-self embryos? Support your answer with data. Limit your answer to a maximum of 40 words.
b) Explain what MHC I is and its normal role in fighting infections. Support your answer with data. Limit your answer to a maximum of 40 words.

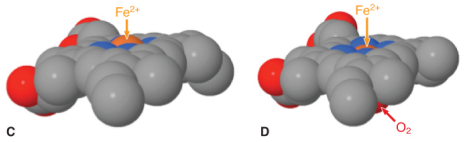
12 **pts.**
10) An appropriate set of questions between two holidays that involve a lot of food…
a) Organize the data in the gallery in a numbered list to support the existence of a lipostat. Explain how they contribute to the concept of a lipostat. Limit your answer to a maximum of 30 words for each figure in your list.
1.
2….
b) Draw a very simple picture that illustrates how the lipostat works. Support your diagram with a list of three examples of data that support the components of the lipostat and its homeostatic function.

10 pts.
11) The final, final exam question is about the ultimate phenotype…
a) Apply what you have learned about the disposable soma theory to explain why mice do not live longer, even when they are kept in safe cages. Support your answer with data. Limit your answer to a maximum of 40 words.
b) Synthesize the data supporting the disposable soma theory as the best explanation for the evolution of senescence. Limit your answer to a maximum of 50 words.

+2 pts
Bonus Question
Critique a proposed new diagnostic tool that samples human breath to detect diseases. Limit your answer to a maximum of 20 words.

Data Gallery (3 pages)

1



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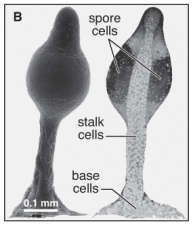

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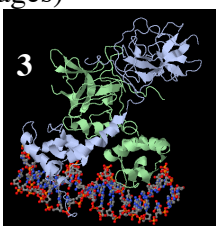

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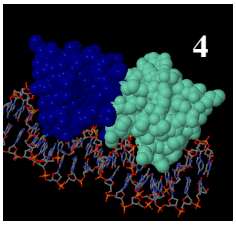

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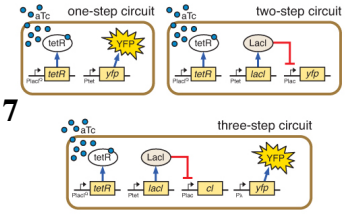
trait	high mortality rate		low mortality rate		p values
	# of flies	averages	# of flies	averages	
female development (hours)	389	254	345	272	0.0041
female dry weight (μg)	90	242	90	261	0.0156
fecundity (average # offspring)	340	40.8	322	27.0	0.0035
male development (hours)	389	260	334	276	0.0061
male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

6

genotype	age (days)	free-feeding mice			pair-fed mice		
		body weight (g)	weight change (g)	percent fat	body weight (g)	weight change (g)	percent fat
wt	20	14.6 ± 0.5*	—	9.5 ± 0.4	15.1 ± 0.6	—	n.d.
wt	48	26.1 ± 0.9	+ 11.5	9.1 ± 0.8	21.4 ± 0.8	+ 6.3	14.9 ± 0.8
ob/ob	20	17.0 ± 0.5	—	23.8 ± 1.1	17.1 ± 0.4	—	n.d.
ob/ob	48	38.6 ± 0.4	+ 21.6	42.3 ± 1.4	25.6 ± 1.0	+ 8.5	43.7 ± 1.0
db/db	20	16.8 ± 0.4	—	24.3 ± 0.9	16.6 ± 0.5	—	n.d.
db/db	48	38.2 ± 0.5	+ 21.4	36.8 ± 0.8	24.3 ± 1.2	+ 7.7	41.7 ± 0.7

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

7



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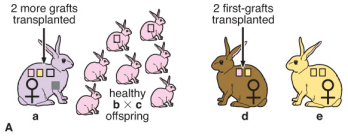
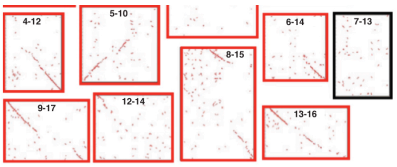


experimental conditions	baby skin transplanted to:		rabbit E skin transplanted to:	
	foster mother A	unrelated rabbit D	foster mother A	unrelated rabbit D
average days graft survived	4.0*	6.5	6.0*	7.0

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

9



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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 *Katsh etal.*, 1946; their Table 1.

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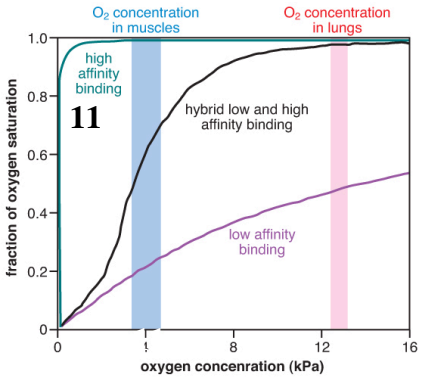

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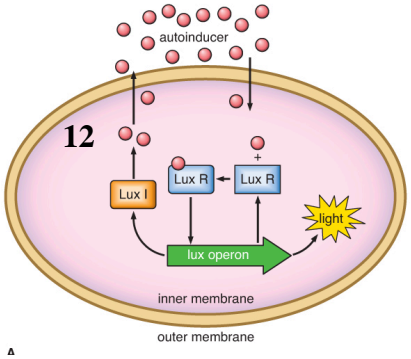

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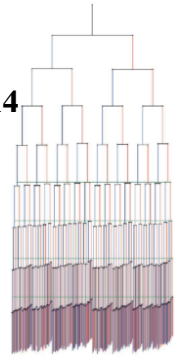
treatment	strain 1 cells	strain 2 cells
negative control media	delayed	delayed
strain 1 media	immediate	delayed
strain 1 media, filtered	immediate	nt
strain 1 media, boiled	delayed	nt
strain 2 media	delayed	immediate
strain 2 media, filtered	nt	immediate
strain 2 media, boiled	nt	immediate

14



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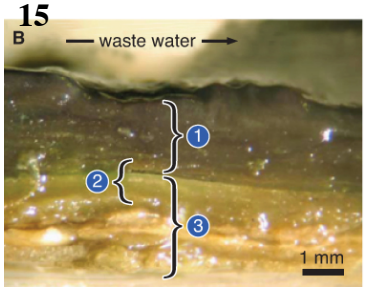

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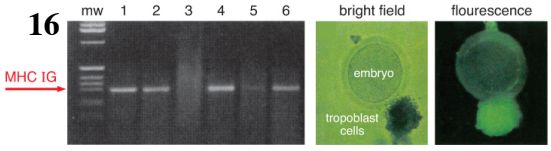

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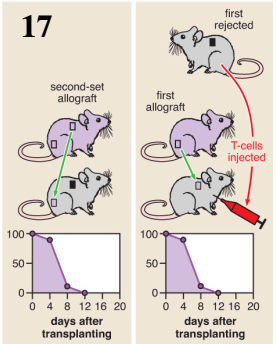

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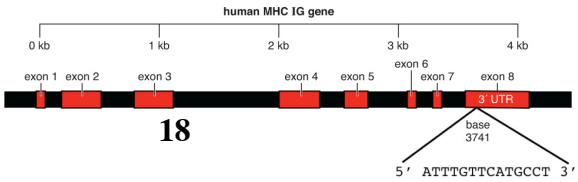

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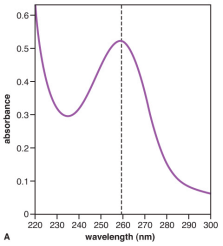

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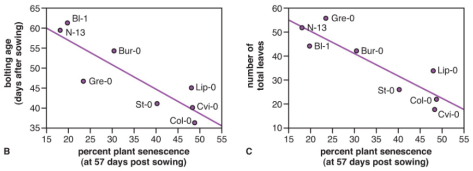

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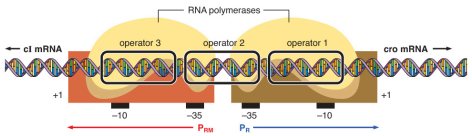

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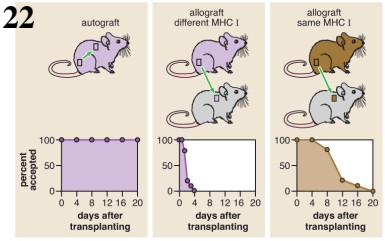

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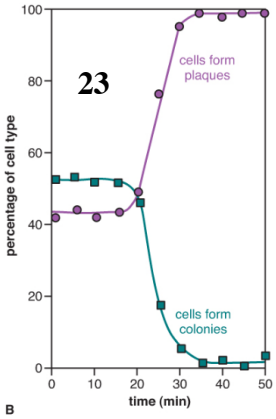

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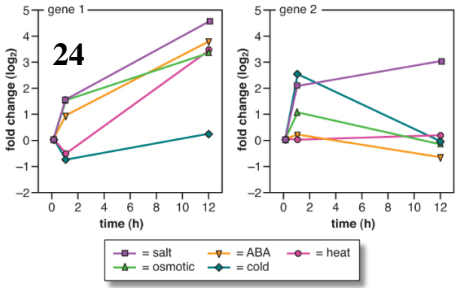

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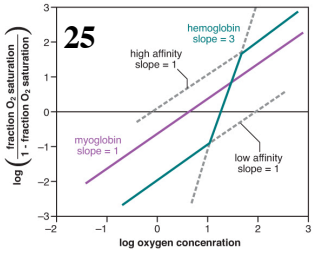

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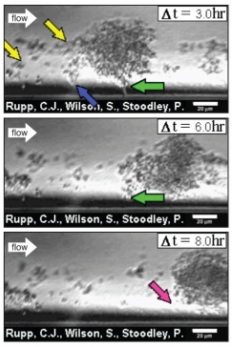

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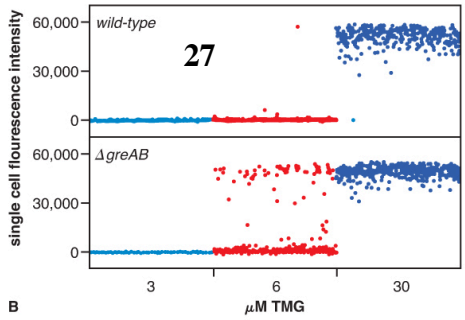

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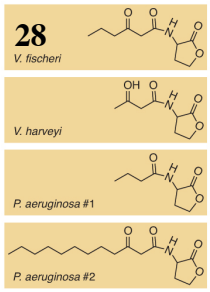

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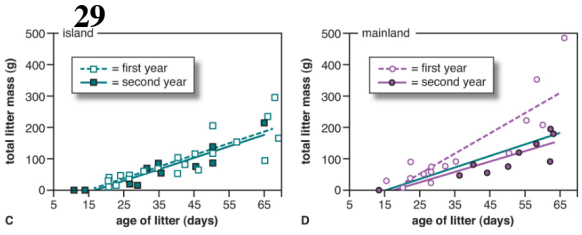

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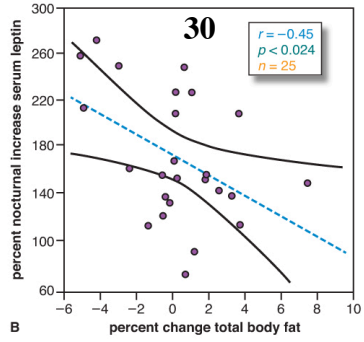

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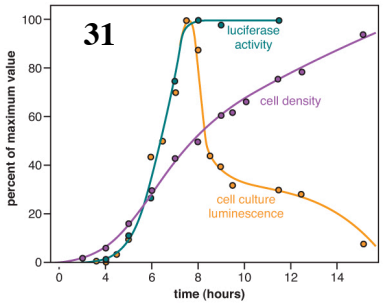

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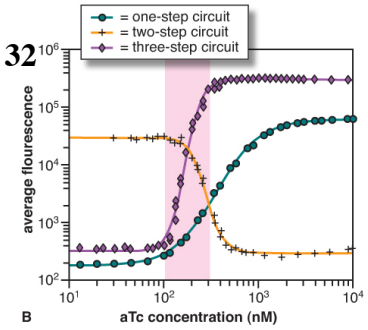

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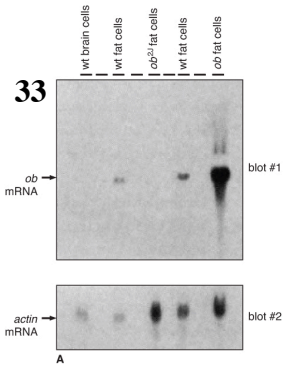

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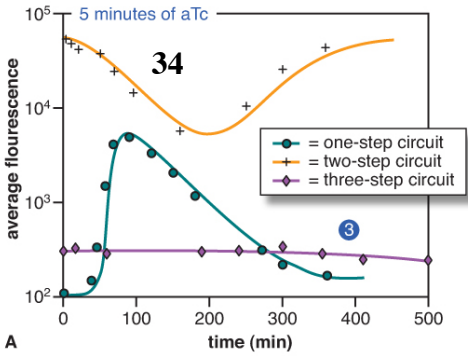

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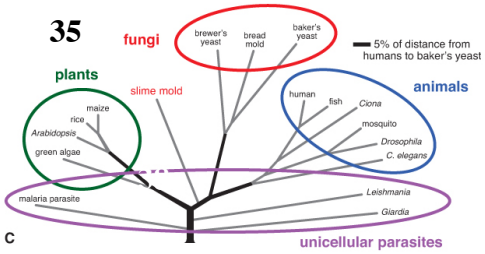

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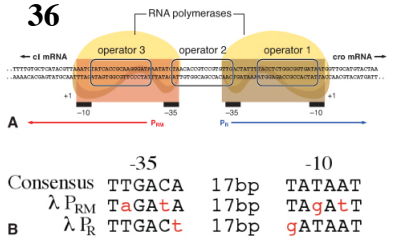

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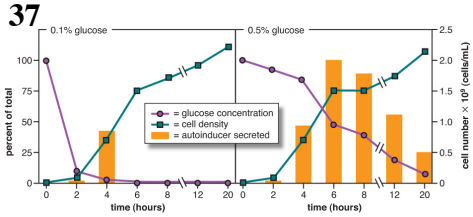

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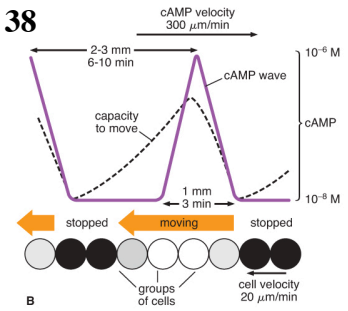

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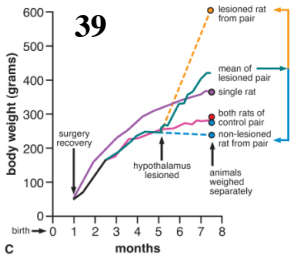

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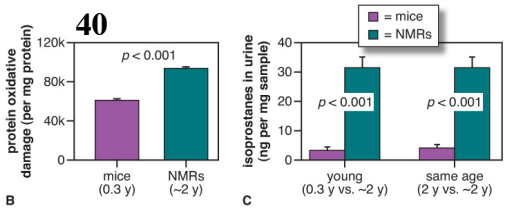

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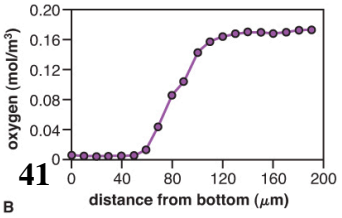

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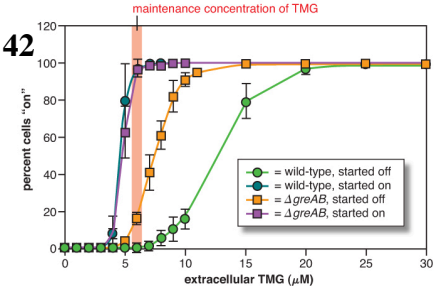

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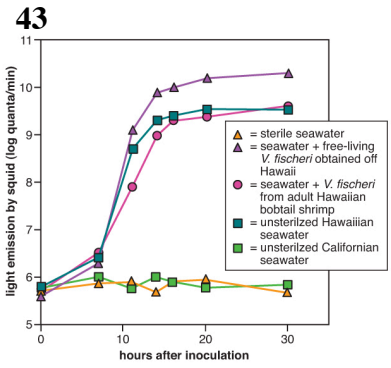

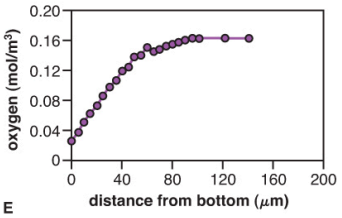

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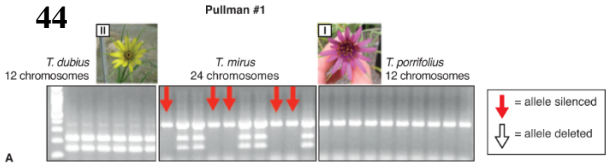

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strain	mutation frequency ($\times 10^{-6}$)	fold change in mutation frequency	phenotype switch frequency ($\times 10^{-3}$)	fold change in phenotype switch frequency
wt	1.8	1.0	2.6	1.0
ack-1	1.2	0.7	16.5	5.7*
ΔgreAB	3.0	1.7	160.0	55.0*
ΔmutS	21.5	11.9*	2.2	0.8

*$p < 0.001$ when compared to *wt*

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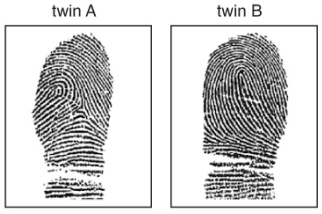
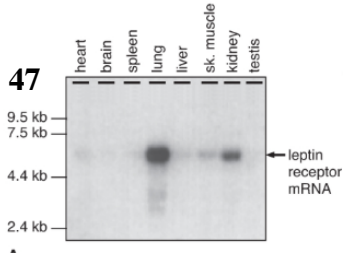
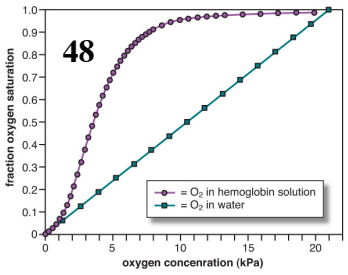


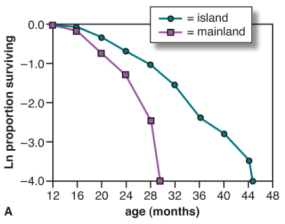
47



48



49



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