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 Thursday Dec. 14. **HARD COPY of your EXAM IS DUE NO LATER THAN NOON THURSDAY DECEMBER 14th**. 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 the attached sequence file (F2017_Exam4seqs.docx) to evaluate the two experimental sequences compared to the reference sequence. Quantify the differences you see from the online analysis. Maximum of 25 words for each sequence.

Lecture Questions:
17 pts.
2) Life is full of unexpected events….
a) What was the experimental question being asked in Figure 42 from the data gallery? Maximum of 40 words.
b) What answer did the investigators reach based on the data in Figure 42? Maximum of 40 words.
c) Describe the allosteric modulation that produces the emergent property shown in Figure 11. Support your answer with two Figures. Maximum of 40 words.

12 pts.
3) Who would have predicted this?!
a) Integrate the data in Figures 29 and 36 to describe what happens when a λ phage first infects a new host *E. coli* cell. Maximum of 50 words.
b) Why are there more "on" cells at 6 μM TMG in the lower part of Figure 31 compared to the upper part? Maximum of 40 words.

12 pts.
4) That was random….
a) Is it possible for different phenotypes to be inherited by progeny from a population of genetically identical cells? Support your answer with data. Maximum of 40 words.
b) Describe two emergent properties that are determined by the length of a genetic circuit. Support each property with data. Maximum of 40 words for each property.
1.
2.

10 pts.
5) Are we there yet?
a) Propose a mechanism to explain the induction of bioluminescence in *V. fischeri*. Support your answer with data. Maximum of 40 words.
b) Explain how quorum sensing can be used to communicate different types of information. Support your answer with two data examples from the gallery. Maximum of 50 words.

14 pts.

6) "We are all individuals!"

a) If you wanted to engineer a beneficial bacterium to produce a biofilm, generate a numbered list of the genes you would need to provide to this hypothetical species that currently cannot produce a biofilm. Assume this hypothetical species has zero genes needed to produce a biofilm, but has all other typical genes for bacteria. For each gene, state briefly its function. Maximum of 25 words for each gene.

1.

b) Summarize the major steps involved in slime mold slug formation beginning with the loss of food. Provide supporting data for each step. Maximum of 30 words for each step.

10 pts.

7) "I carried you for 9 months…"

a) Integrate the data that demonstrated how a mammalian mother can carry a non-self fetus without rejecting it. Summarize the research that refuted the two hypotheses (A and B below) that were disproven by experiments we covered. Maximum of 40 words for each hypothesis.

A.

B.

b) Formulate an explanation of which proteins are critical to an embryo's survival inside a healthy mother. Support each protein with data from the gallery. Maximum of 30 words for each protein.

1.

15 pts.

8) This is your last Bio113 exam question!

a) Draw directly on Figure 43 in the data gallery to approximate what the graph would look like if the authors had chosen 85% confidence intervals instead of the 95% as shown in the figure.

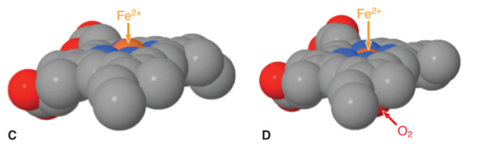
b) Compose the rationale that explains why it would be beneficial for everyone to exercise to control their weight no matter what their genotype is. Support your rationale with two data Figures in the gallery. Maximum of 40 words for each Figure.

c) Integrate disposable soma theory with the *daf-2* data and its signaling pathway to summarize the tradeoff in reproduction and longevity. Support your summary with data. Maximum of 50 words

Bonus Question (+2pts): Here is a challenging question, but one that is relevant and could produce a breakthrough in medical treatment. Propose a new conceptual approach to preventing biofilm production by bacteria (*i.e.*, don't just say use antibiotics). Your proposal should be based on what we know about how biofilms are formed. You do not need to propose any specific experiments, just think of a creative theoretical way to block biofilm formation. Your answer could be the beginnings of your new biotech startup when you graduate….

Data Gallery (3 pages)

1



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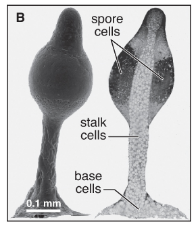

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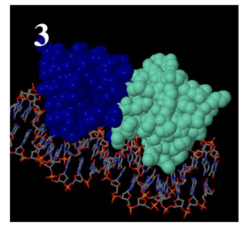

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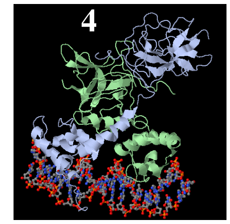

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genotype	age (days)	free-feeding mice			pair-fed mice		
		body weight (g)	weight change (g)	percent fat	body weight (g)	weight change (g)	percent fat
wt	20	14.6 ± 0.5*	—	9.5 ± 0.4	15.1 ± 0.6	—	n.d.
wt	48	26.1 ± 0.9	+ 11.5	9.1 ± 0.8	21.4 ± 0.8	+ 6.3	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.

6

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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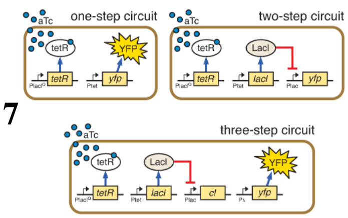

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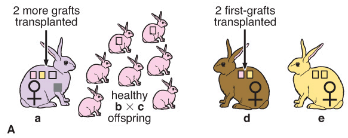

experimental conditions	baby skin transplanted to:		rabbit E skin transplanted to:	
	foster mother A	unrelated rabbit D	foster mother A	unrelated rabbit D
average days graft survived	4.0*	6.5	6.0*	7.0

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

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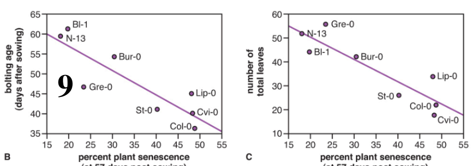

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donor → recipient	number of animals	% rejected	average days to rejection ± stdev
male → female	16	0	n.a.
female → female	15	0	n.a.
female → male	15	0	n.a.
male → female	15	100	28 ± 3
male → primed female*	10	100	14 ± 2

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

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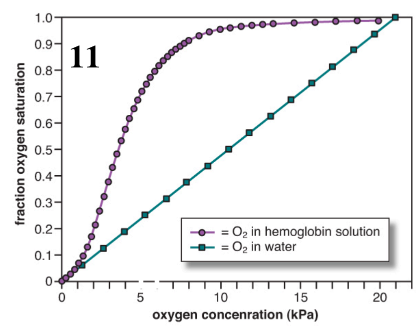

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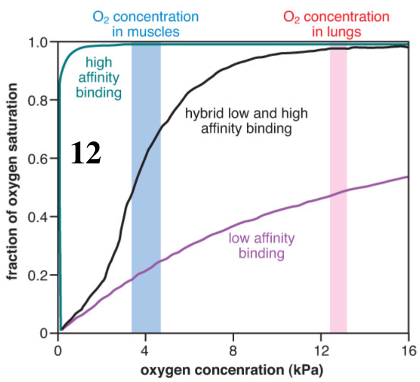

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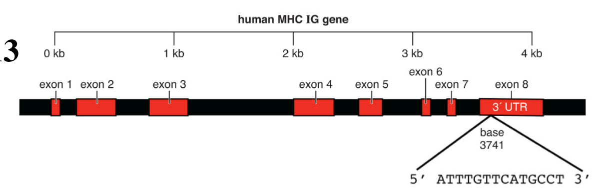

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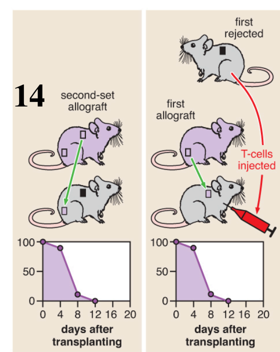

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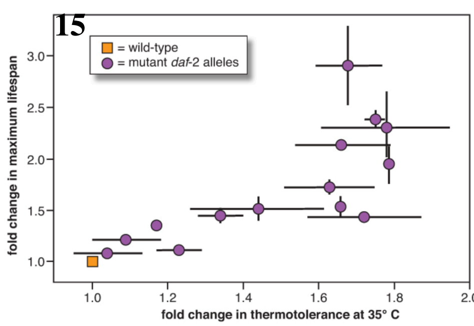

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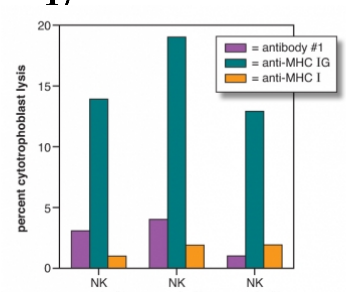
	initial body weight	final body weight (+ 11 weeks)	percent protein	percent lipid	percent dry matter
lean rats					
no exercise	224.8 ± 7.1*	301.4 ± 9.8	22.8 ± 0.34[a]	6.4 ± 0.49[a]	32.7 ± 0.51[a]
exercise	214.0 ± 10.1	297.0 ± 12.0	23.5 ± 0.23[a]	4.9 ± 0.41[a]	31.8 ± 0.61[a]
obese rats					
no exercise	210.7 ± 11.1	327.6 ± 15.2	14.8 ± 0.28[b]	39.0 ± 0.81[b]	56.6 ± 0.66[b]
exercise	218.0 ± 8.8	317.8 ± 13.3	17.3 ± 0.62[c]	27.7 ± 1.43[c]	48.2 ± 1.71[c]

17



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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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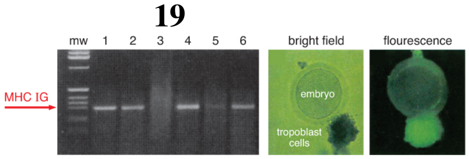

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	wild-type	*daf-2* mutant
median life span (d)	16.3 +/– 1.3	41.0 +/– 2.0
mean brood size	313 +/- 42	8.5 +/- 8*
average progeny (after 10 d)	0	6.6
age (d) when last egg laid	11	50

*p < 0.005 +/– standard error

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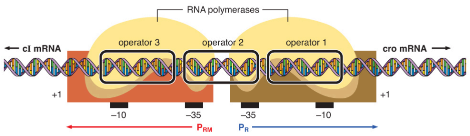

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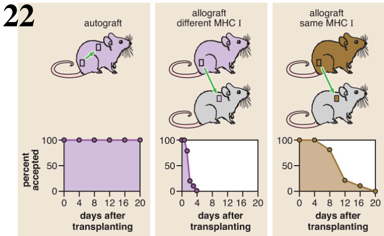

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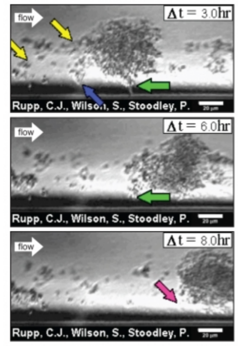

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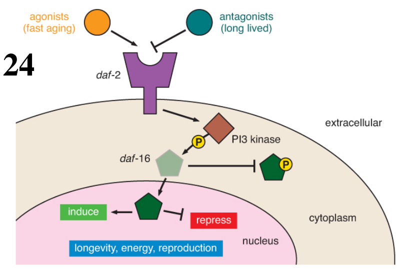

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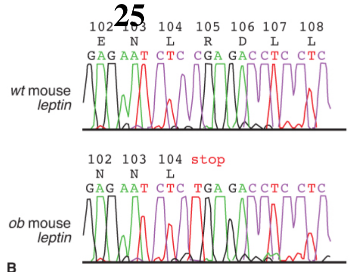

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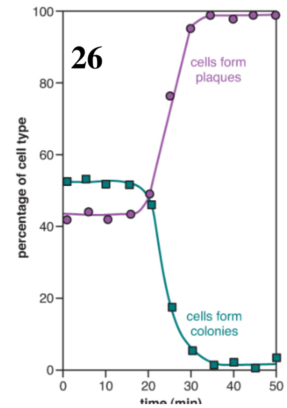

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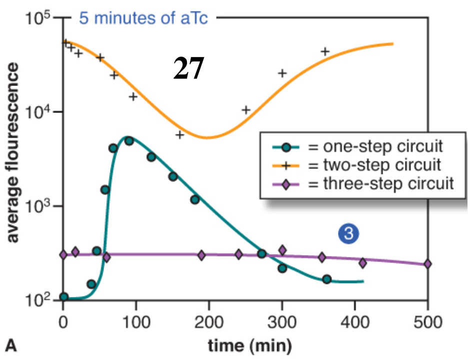

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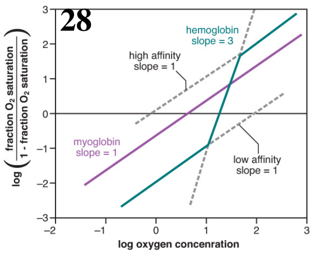

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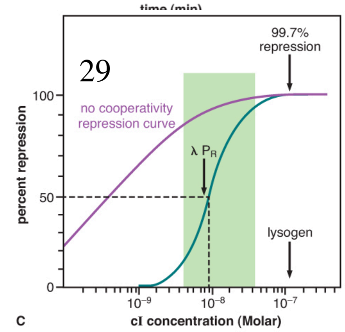

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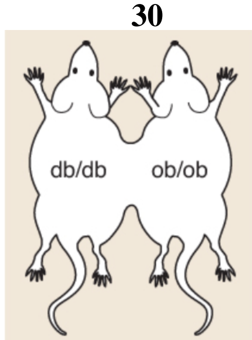

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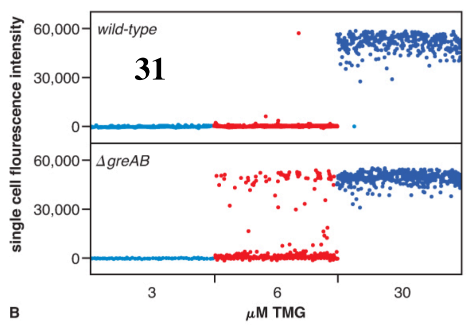

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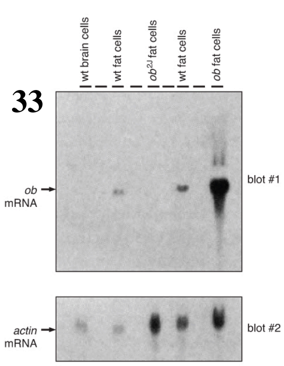

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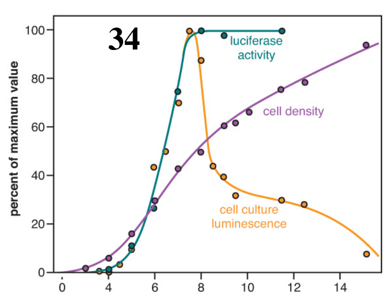

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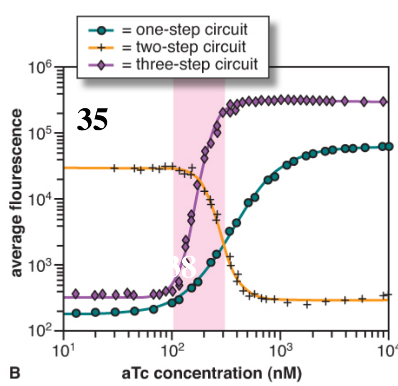

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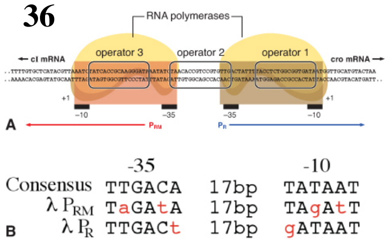

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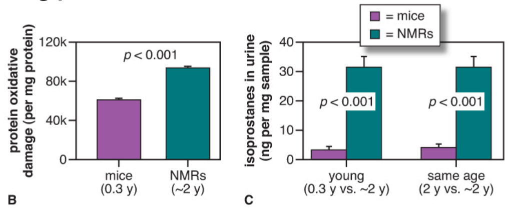

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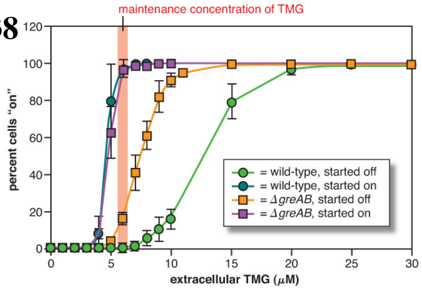

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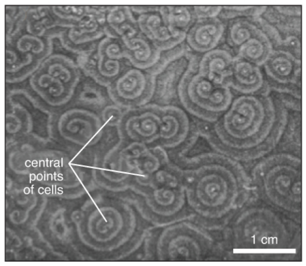

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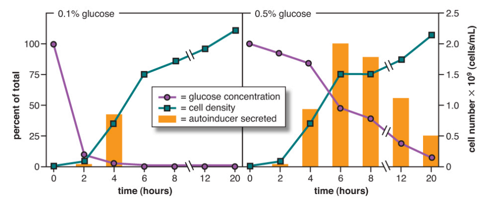

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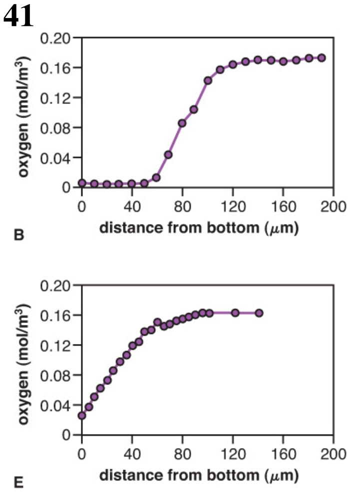

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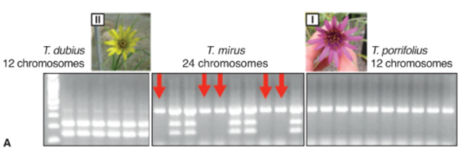

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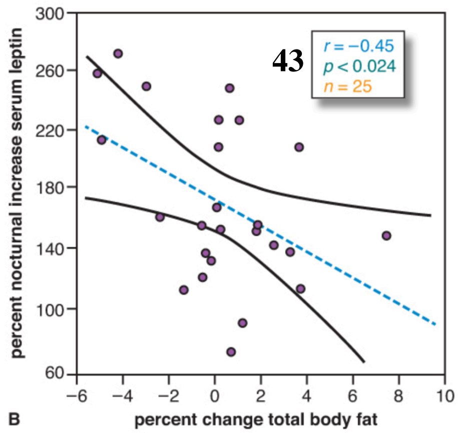

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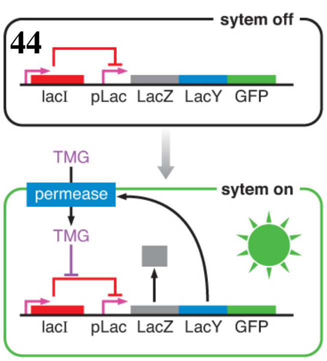

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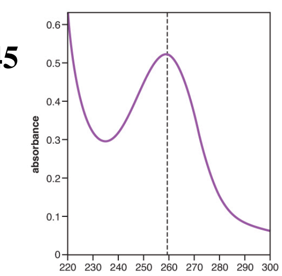

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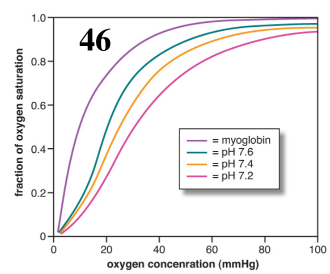

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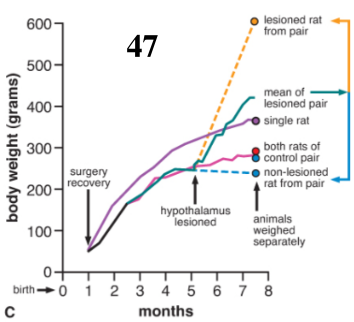

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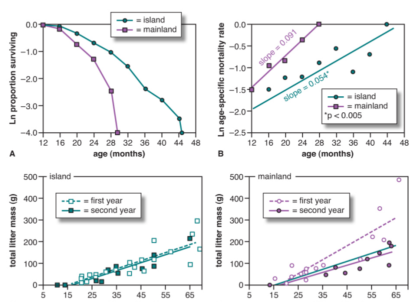

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