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 by Thursday Dec. 15. **HARD COPY of your EXAM IS DUE NO LATER THAN NOON THURSDAY DECEMBER 15th**. 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

6 pts.

1) Some might think this question lacks good taste…

a) Were the brine shrimp able to taste bitter? Limit your answer to a maximum of 10 words.

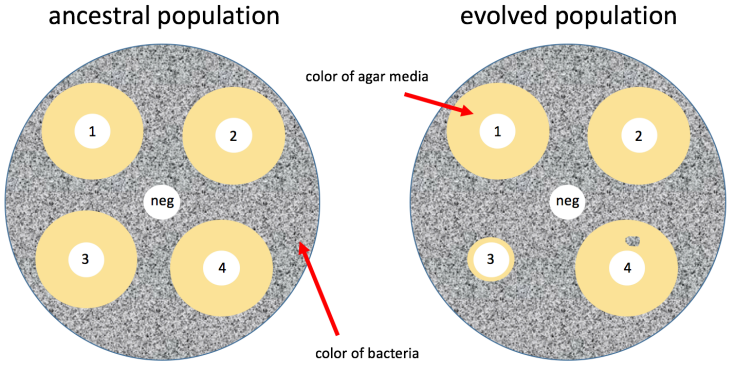
b) What is the selective pressure on plants to make the toxins they produce taste bitter instead of tasteless? Limit your answer to a maximum of 40 words.

4 pts.

2) Directed evolution question.

a) Interpret these data for antibiotics numbered 1 - 4:

Limit your answer to a maximum of 30 words.



Lecture Questions:

12 pts.

3) This question was requested by your mitochondria.

a) Calculate the **change** in hemoglobin with 4 oxygen molecules bound when a red blood cell arrives at your muscle where the oxygen concentration is 20 mmHg. Calculate the fraction of myoglobin bound with oxygen at 20 mmHg.

hemoglobin: _____ (numerical answer)

myoglobin: _____ (numerical answer)

b) Give two reasons why hemoglobin and myoglobin exhibit different oxygen binding when they are both exposed to 20 mmHg. Support one of your reasons using a figure from the data gallery. Limit your answer to a maximum of 50 words.

12 pts.

4) Phage are pretty smart for systems that lack the capacity to think.

a) What is the selective advantage for the positive and negative feedback loops for cI and cro? Limit your answer to a maximum of 30 words for each loop.

+ feedback:

- feedback:

b) What would the phenotype be in a population of λ phage if there was no cooperativity in the λ switch? Support your answer with **two** figures from the data gallery. Limit your answer to a maximum of 40 words.

12 pts.

5) This question is based on randomness in biology.

a) What role does randomness play in the establishment of phenotype in Figure 44? Support your answer with data. Limit your answer to a maximum of 40 words.
b) Describe the two most unexpected emergent properties that are determined by the number of sequential steps in a genetic circuit. Support each property with data from the gallery. Limit your answer to a maximum of 40 words for each property.
1.
2.

10 pts.
6) I hope you see the light when you answer these questions.
a) Defend quorum sensing as evolutionarily beneficial to the squid and the bacteria compared to constitutive glowing by symbiotic *V. fischeri*. Limit your answer to a maximum of 40 words.
b) Apply the data in Figure 34 to construct a mechanism for regulation of quorum sensing. You should draw your <u>complete</u> mechanism in the space provided here.

10 pts.
7) "We are not alone" is a quote taken from some solitary cells isolated from soil.
a) Disprove the statement that only eukaryotes can build structures that alter their habitat to suit their own biological processes. Support your answer with experimental data from the gallery. Limit your answer to a maximum of 40 words.
b) What mechanism allows individual slime mold cells to move toward the center of the gathering cells rather than away from it? Limit your answer to a maximum of 40 words.

10 pts.
8) These two questions address an oddity of nature that all of us have survived.
a) What are two molecular connections between a skin graft being rejected and your normal immune response to infections? Support your answer with two figures from the data gallery. Limit your answer to a maximum of 40 words.
1.

2.

b) Choose one figure that provides the best supporting data for the conclusion that pregnant mammals have a robust immune system even though they do not reject their non-self embryos. Limit your answer to a maximum of 40 words.

12 pts.

9) Here are a couple weighty questions for the exam.

a) How can two different mutant alleles of *ob* (the original *ob* mutant allele and the ob^{2J}) produce the same *ob* phenotype? Support your answer with **two** data gallery figures. Limit your answer to a maximum of 50 words.

b) Interpret the negative correlation between leptin and body fat in Figure 30. Include the 95% confidence interval in your interpretation. Limit your answer to a maximum of 50 words.

12 pts.

10) The final question is about our final hours.

a) Choose three figures that support the disposable soma theory as the best explanation for the evolution of senescence. Limit your answer to a maximum of 40 words per figure.

1.
2.
3.

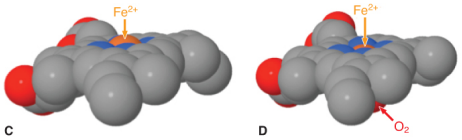
b) Construct a general model using stress and the disposable soma theory to explain how worms with increased thermotolerance can live longer. Support your answer with experimental data from the gallery. Limit your answer to a maximum of 40 words.

2 pts.

Extra Credit: What is the percent body weight change when a 3 week old squid expels the symbiotic bacteria from its body? Show your work by hand.

Data Gallery (3 pages)

1



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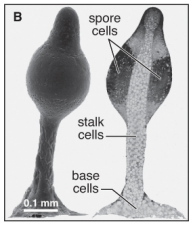

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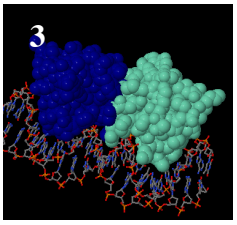

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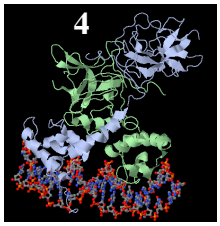


5

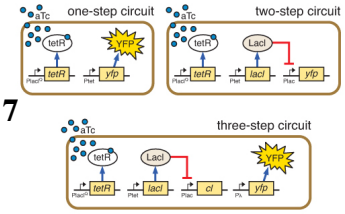
genotype	age (days)	free-feeding mice: body weight (g)	free-feeding mice: weight change (g)	free-feeding mice: percent fat	pair-fed mice: body weight (g)	pair-fed mice: weight change (g)	pair-fed mice: percent fat
wt	20	14.6 ± 0.5*	—	9.5 ± 0.4	15.1 ± 0.6	—	n.d.
wt	48	26.1 ± 0.9	+ 11.5	9.1 ± 0.8	21.4 ± 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: # of flies	high mortality rate: averages	low mortality rate: # of flies	low mortality rate: averages	p values
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

7



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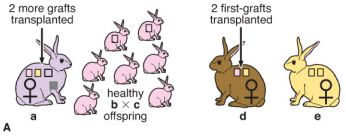
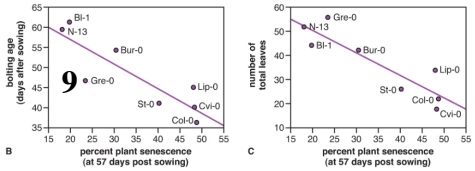


experimental conditions	baby skin transplanted to: foster mother A	baby skin transplanted to: unrelated rabbit D	rabbit E skin transplanted to: foster mother A	rabbit E skin transplanted to: unrelated rabbit D
average days graft survived	4.0*	6.5	6.0*	7.0

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

9

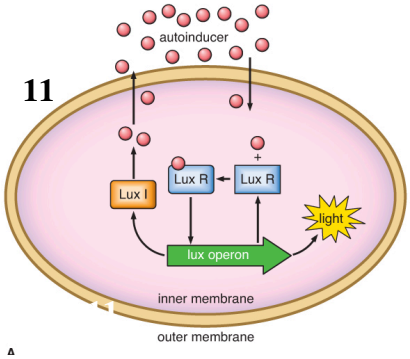


10

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.

11



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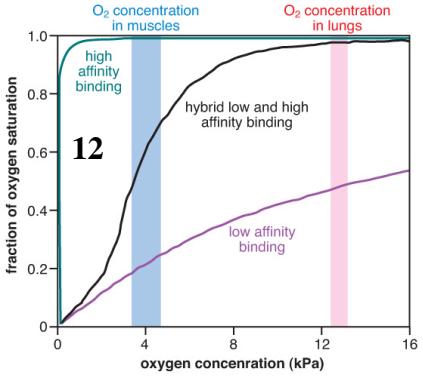

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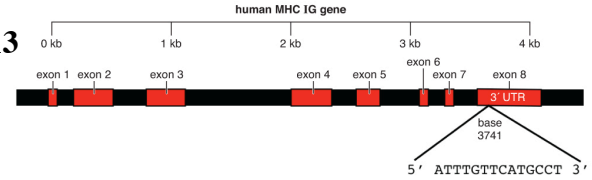

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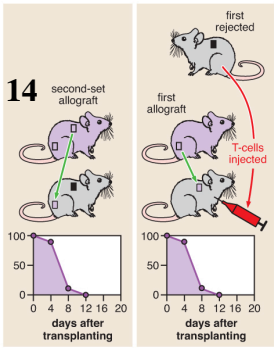

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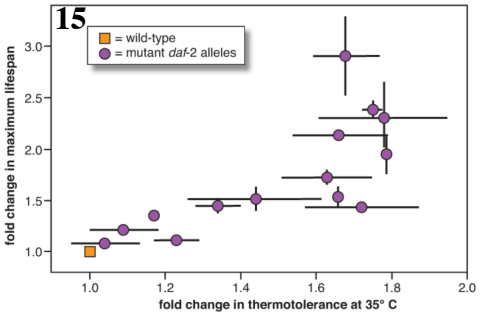

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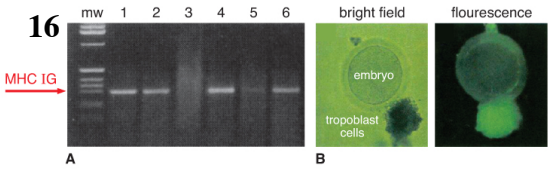

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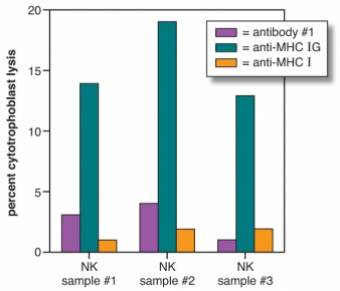
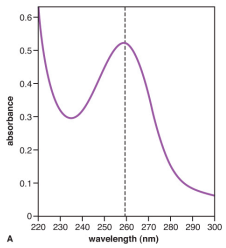


18

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

19

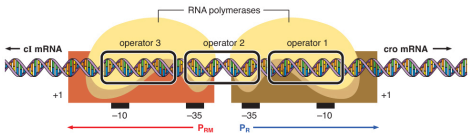


20

	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

21



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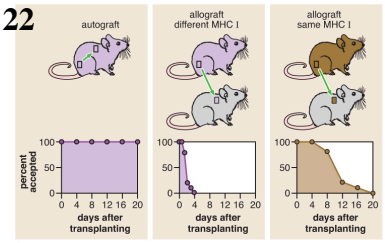

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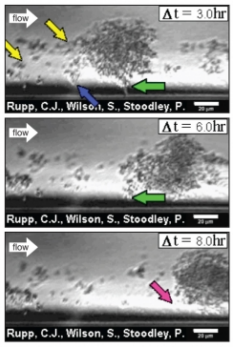

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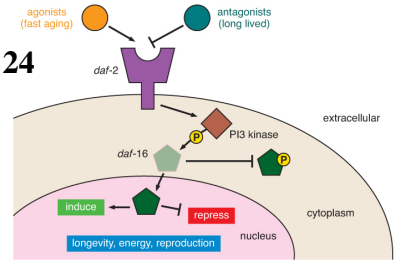

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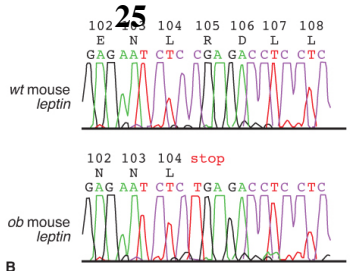

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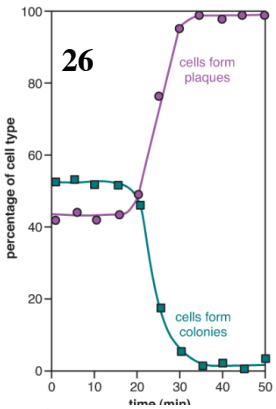

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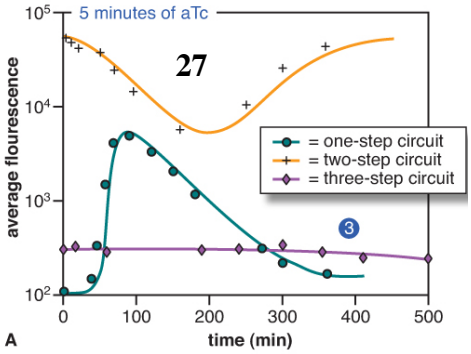

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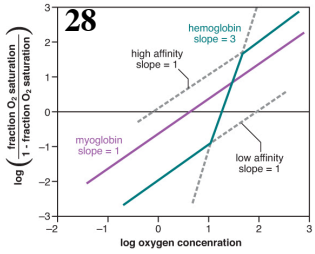

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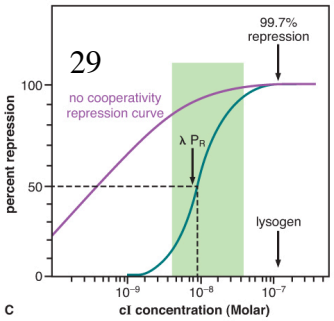

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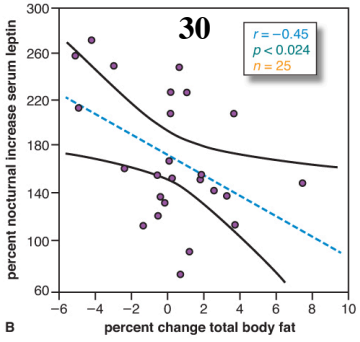

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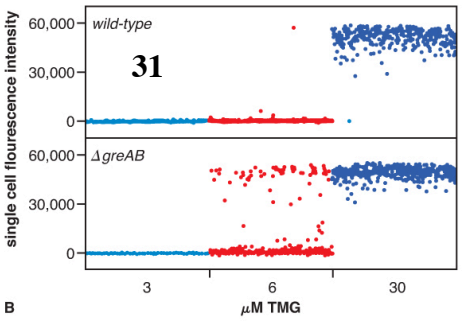

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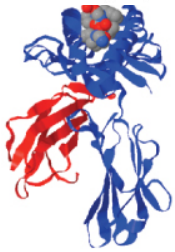

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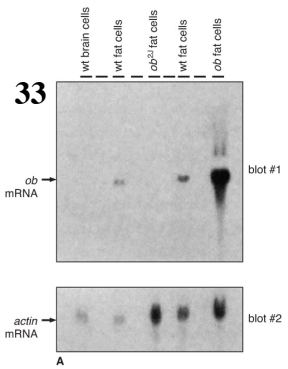

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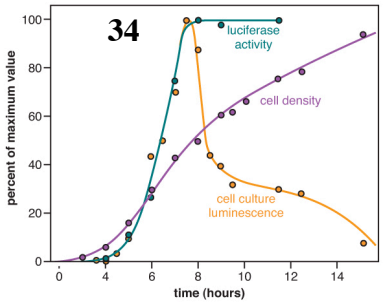

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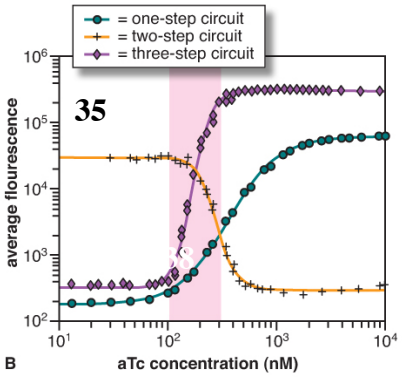
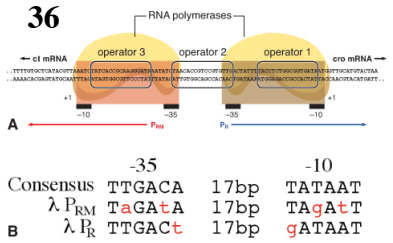
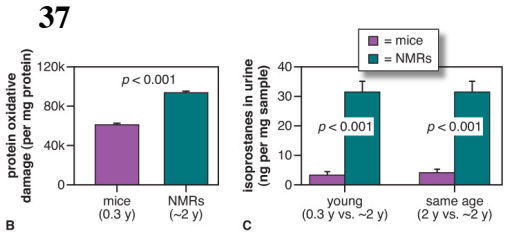
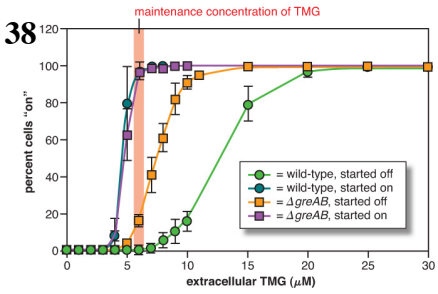
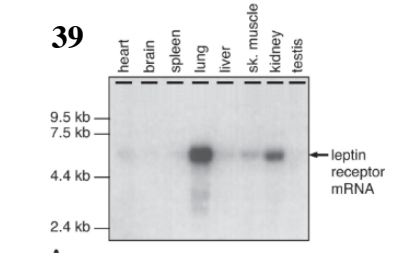
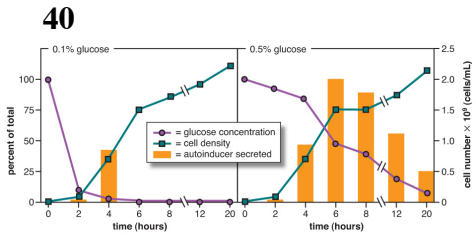


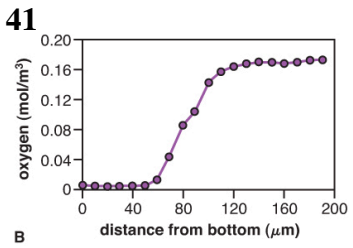

36
RNA polymerases
operator 3
operator 2
operator 1
cI mRNA
cro mRNA
A
-35
-10
Consensus TTGACA 17bp TATAAT
λ P_RM TaGAtA 17bp TAgAtT
λ P_R TTGACt 17bp gATAAT
B

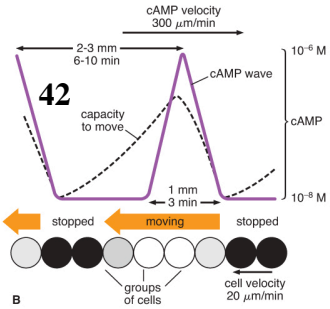

37
protein oxidative damage (per mg protein)
p < 0.001
mice (0.3 y)
NMRs (~2 y)
B
isoprostanes in urine (ng per mg sample)
= mice
= NMRs
p < 0.001
p < 0.001
young (0.3 y vs. ~2 y)
same age (2 y vs. ~2 y)
C

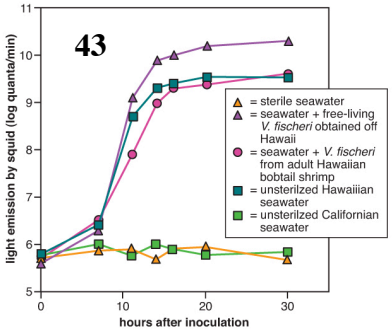

38
maintenance concentration of TMG
percent cells "on"
= wild-type, started off
= wild-type, started on
= ΔgreAB, started off
= ΔgreAB, started on
extracellular TMG (μM)

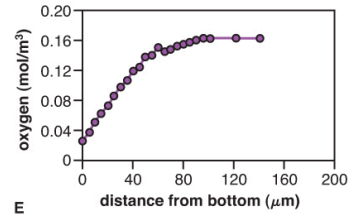

39
heart
brain
spleen
lung
liver
sk. muscle
kidney
testis
9.5 kb
7.5 kb
4.4 kb
2.4 kb
leptin receptor mRNA

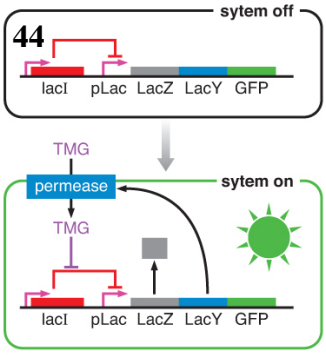

40
0.1% glucose
0.5% glucose
percent of total
cell number × 10⁹ (cells/mL)
= glucose concentration
= cell density
= autoinducer secreted
time (hours)

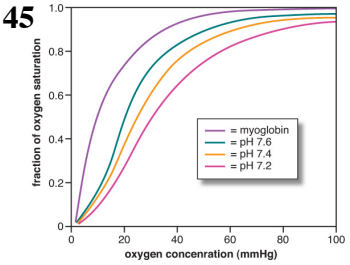

41
oxygen (mol/m³)
distance from bottom (μm)
B

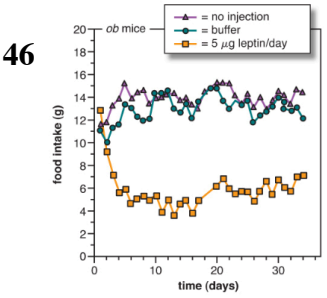

cAMP velocity 300 μm/min
2-3 mm 6-10 min
cAMP wave
42
capacity to move
cAMP
10⁻⁶ M
10⁻⁸ M
1 mm 3 min
stopped
moving
stopped
groups of cells
cell velocity 20 μm/min
B

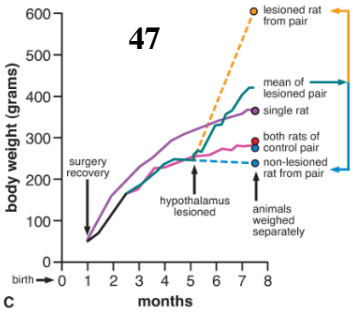

43
light emission by squid (log quanta/min)
= sterile seawater
= seawater + free-living V. fischeri obtained off Hawaii
= seawater + V. fischeri from adult Hawaiian bobtail shrimp
= unsterilzed Hawaiiian seawater
= unsterilzed Californian seawater
hours after inoculation

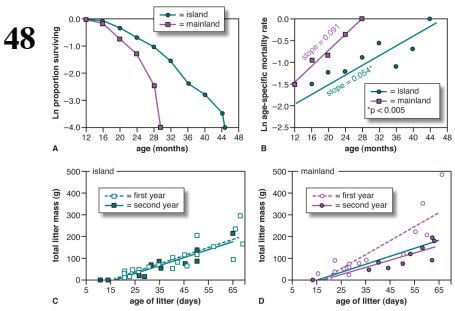

oxygen (mol/m³)
distance from bottom (μm)
E


sytem off
44
lacI pLac LacZ LacY GFP
TMG
permease
sytem on
TMG
lacI pLac LacZ LacY GFP


45
fraction of oxygen saturation
= myoglobin
= pH 7.6
= pH 7.4
= pH 7.2
oxygen concenration (mmHg)


46
ob mice
= no injection
= buffer
= 5 μg leptin/day
food intake (g)
time (days)
ob mice
body mass (g)
= no injection
= buffer
= 5 μg leptin/day
time (days)


47
lesioned rat from pair
mean of lesioned pair
single rat
both rats of control pair
non-lesioned rat from pair
surgery recovery
hypothalamus lesioned
animals weighed separately
body weight (grams)
birth
months
C


48
= island
= mainland
Ln proportion surviving
age (months)
A
Ln age-specific mortality rate
slope = 0.091
slope = 0.054
= island
= mainland
*p < 0.005
age (months)
B
island
= first year
= second year
total litter mass (g)
age of litter (days)
C
mainland
= first year
= second year
total litter mass (g)
age of litter (days)
D