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. 17. **HARD COPY of your EXAM IS DUE NO LATER THAN NOON THURSDAY DECEMBER 17th**. 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

2 pts.

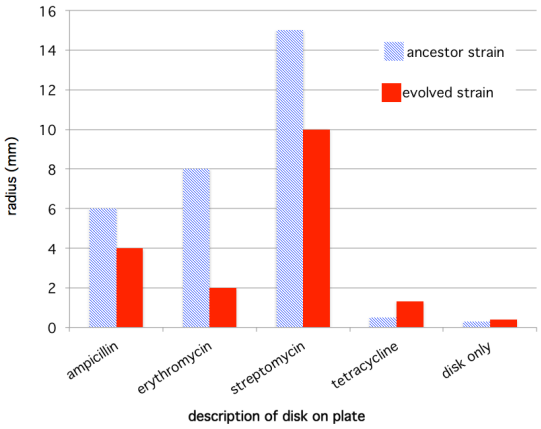
1) What is the connection between bitter taste perception by mammals and plants producing toxins? Limit your answer to a maximum of 40 words.

8 pts.

2) Directed evolution question.

a) Some lab 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? Limit your answer to a maximum of 30 words.

b) Interpret this graph from a student lab group. Limit your answer to a maximum of 50 words.



Lecture Questions:

12 pts.

3) A couple questions about our complex and green friends.

a) Recently, the weather in Davidson has been very fickle. Within one week, we have had 70° F, 25° F, sunny, and rainy days. How are the trees on campus able to survive such extreme changes. Support your answer with data. Limit your answer to a maximum of 40 words.

b) List two molecular mechanisms that newly formed tetraploid plant species could use to transcribe the alleles from one diploid parent but not the other. Indicate which (if any) result in evolution by putting * at the end of your answer. Support your answer with one data figure. Limit each mechanism to a maximum of 30 words.

1.
2.

10 pts.

4) Emergent properties at the molecular level….

a) Use data gallery figure 12 to quantify why hemoglobin is the best oxygen carrier compared to a high affinity carrier or a low affinity carrier. Limit your answer to a maximum of 50 words.

b) What emergent property does hemoglobin exhibit to maximize the delivery of oxygen to the tissues that need the most oxygen? Support your answer with data. Limit your answer to a maximum of 50 words.

12 pts.

5) More molecular emergent properties…

a) List the emergent properties involved in the λ switch to lysis from lysogeny. Support each item in your list with a figure. Limit your answer for each item in your list to a maximum of 30 words.

1.

b) List three emergent properties that are a consequence of genetic path length. Support each property with data. Limit your answer to a maximum of 40 words for each example.

1.
2.
3.

12 pts.

6) This question should brighten up your day…

a) Defend quorum sensing as evolutionarily beneficial to the squid and the bacteria compared to constitutive glowing by symbiotic *V. fischeri*. Support your answer with data (not a diagram). Limit your answer to a maximum of 60 words.

b) What evidence do you have to indicate quorum sensing in *V. fischeri* began from a common origin but has continued to evolve over time. Support your answer with two data figures. Limit your answer to a maximum of 50 words.

10 pts.

7) You are nearly done, keep going!

a) What cellular emergent property is revealed in data gallery figure 41? Limit your answer to a maximum of 40 words.

b) Describe how natural selection has resulted in slime mold assembling only cells of the same species for slug formation if multiple species all secrete cAMP. Support your answer with a figure. Limit your answer to a maximum of 50 words.

10 pts.

8) It took me a long time to conceive this question…

a) If you wanted to treat a patient with gene therapy to fix a recessive disease, what complications should you expect? Support your answer with most informative figure in the gallery. Limit your answer to a maximum of 40 words.

b) How are embryos protected from immune rejection? Support your answer with two figures from the gallery. Limit your answer to a maximum of 50 words.

12 pts.

9) This question is for my big fat geek exam.

a) Two children have normal weight, but child A has a 200% increase in nocturnal leptin and child B has a 100% increase in nocturnal leptin. Predict each child's weight six months later. Support your answer with data. Limit your answer to a maximum of 40 words.

b) Choose three figures that indicate the existence of a lipostat. Explain why you chose each figure. Limit your answer for each figure to a maximum of 40 words.

12 pts.

10) By now, you are probably feeling older and wiser…

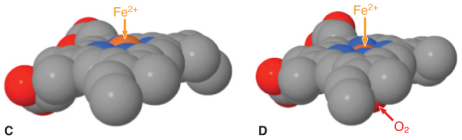
a) Use data to explain the disposable soma theory. Limit your answer to a maximum of 50 words.

b) My brother thinks that only animals senesce. Use two figures to convince my brother that he is wrong. He is a lawyer, so evidence is very compelling to him. Show him how the disposable soma theory applies to two very different types of organisms. Limit your answer to a maximum of 40 words for each figure.

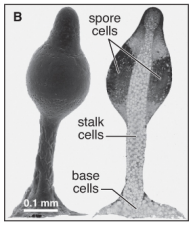
1.
2.

Data Gallery (3 pages)

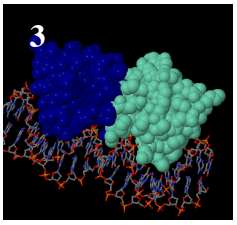
1



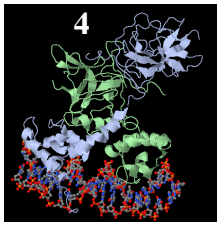
2



3



4



5

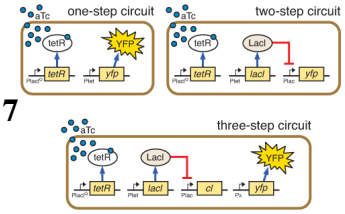
genotype	age (days)	free-feeding mice			pair-fed mice		
		body weight (g)	weight change (g)	percent fat	body weight (g)	weight change (g)	percent fat
wt	20	14.6 ± 0.5*	—	9.5 ± 0.4	15.1 ± 0.6	—	n.d.
wt	48	26.1 ± 0.9	+ 11.5	9.1 ± 0.8	21.4 ± 0.8	+ 6.3	14.9 ± 0.8
ob/ob	20	17.0 ± 0.5	—	23.8 ± 1.1	17.1 ± 0.4	—	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.

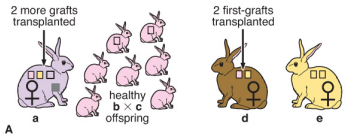
6

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

7



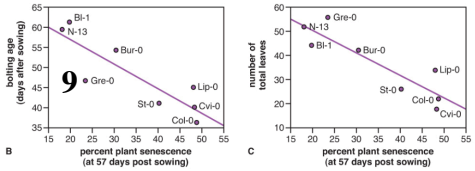
8



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

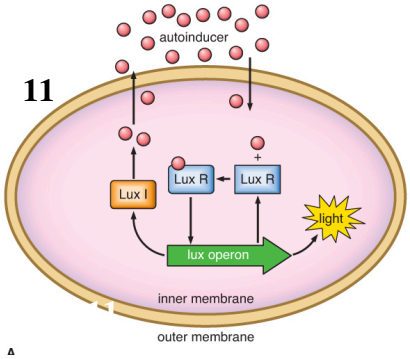


10

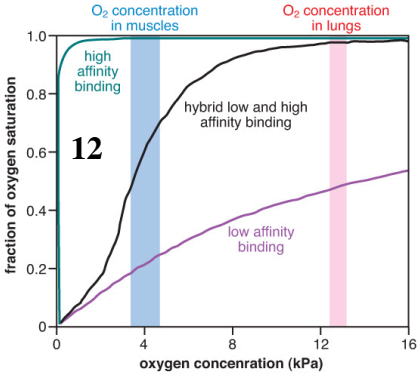
donor → recipient	number of animals	% rejected	average days to rejection ± stdev
male → female	16	0	n.a.
female → female	15	0	n.a.
female → male	15	0	n.a.
male → female	15	100	28 ± 3
male → primed female*	10	100	14 ± 2

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

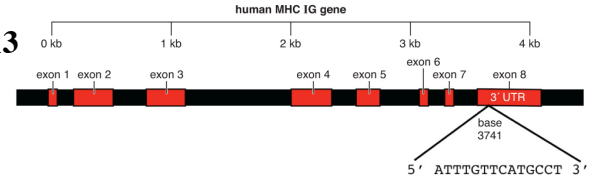
11



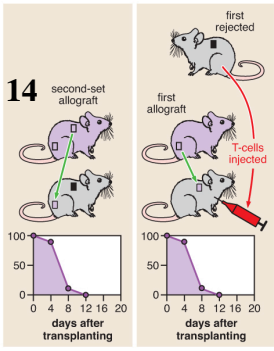
12



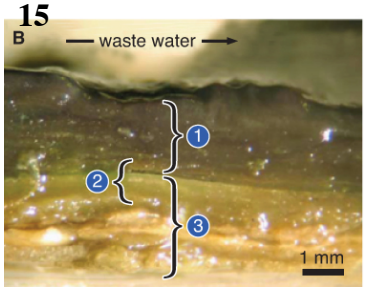
13



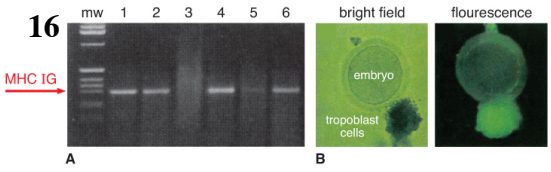
14



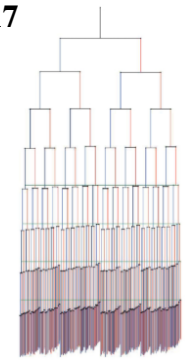
15



16



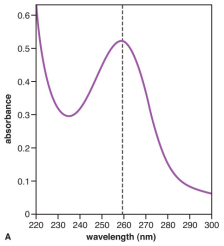
17



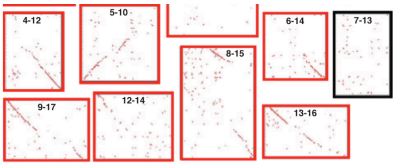
18

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

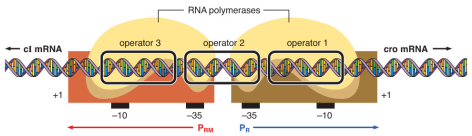
19



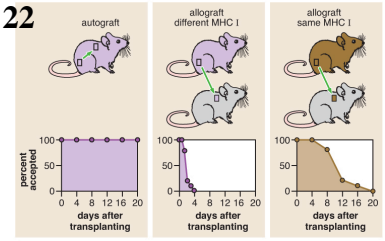
20



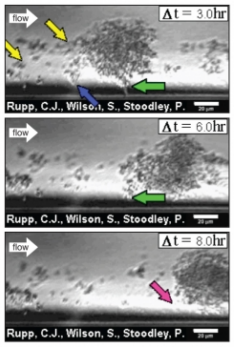
21



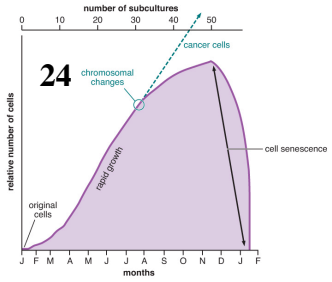
22



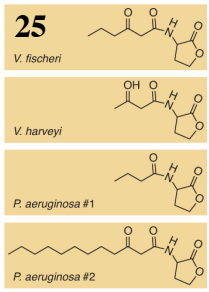
23



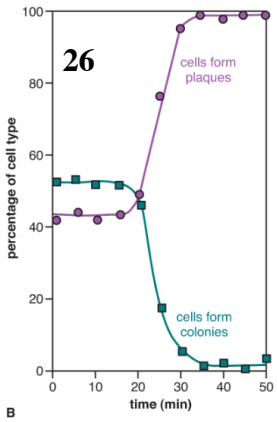
24



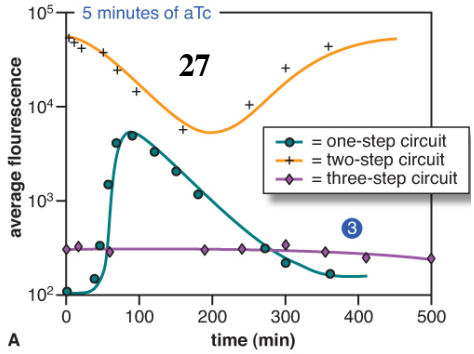
25



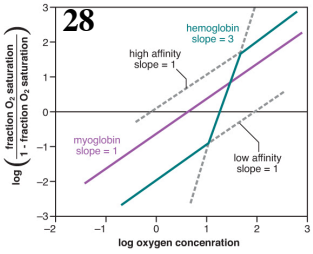
26



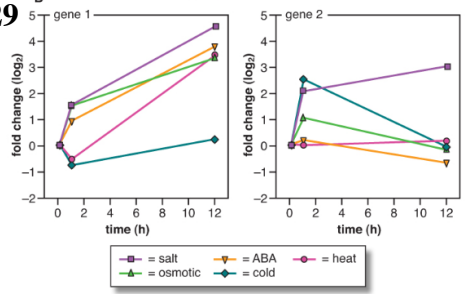
27



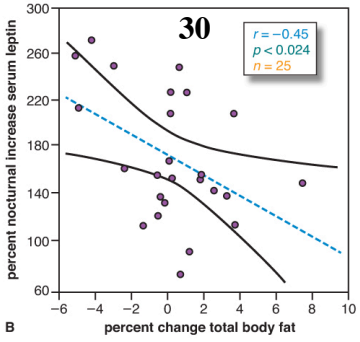
28



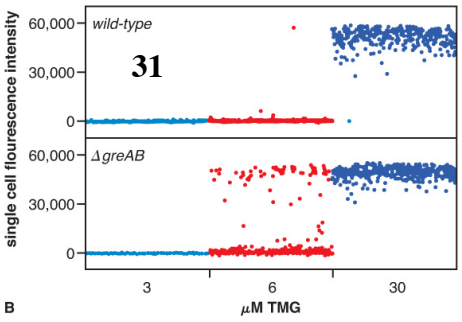
29



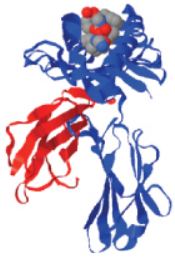
30



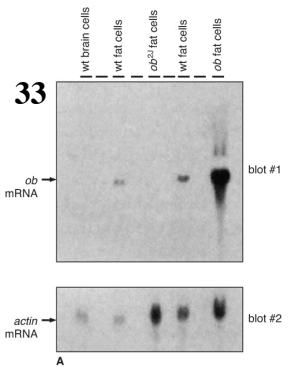
31



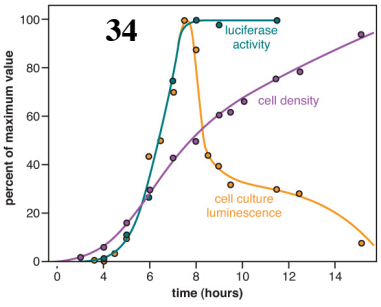
32



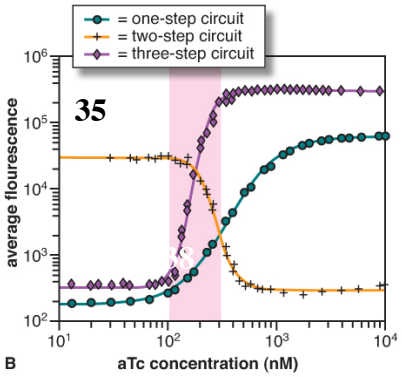
33

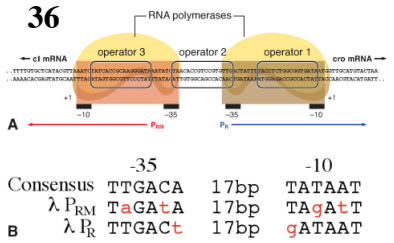


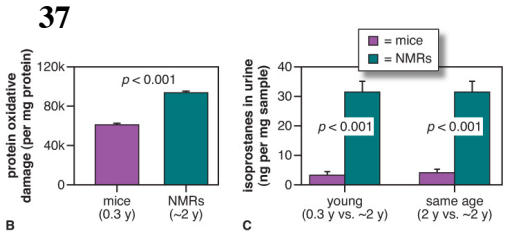
34

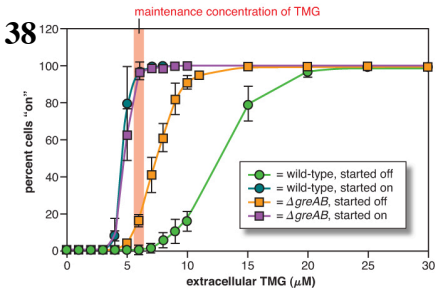


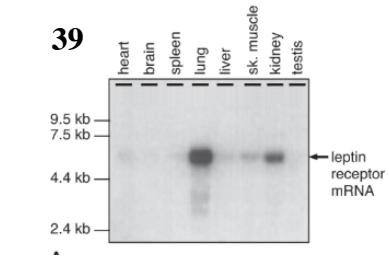
35

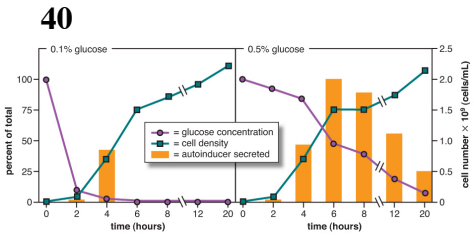


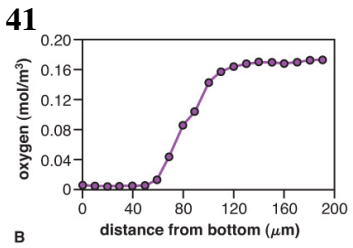

36
RNA polymerases
operator 3
operator 2
operator 1
cI mRNA
cro mRNA
A
-35
-10
Consensus TTGACA 17bp TATAAT
λ P_RM TaGAtA 17bp TAgAtT
B λ P_R TTGACt 17bp gATAAT

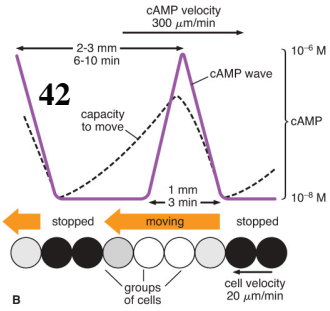

37
protein oxidative damage (per mg protein)
p < 0.001
mice (0.3 y)
NMRs (~2 y)
B
isoprostanes in urine (ng per mg sample)
= mice
= NMRs
p < 0.001
p < 0.001
young (0.3 y vs. ~2 y)
same age (2 y vs. ~2 y)
C

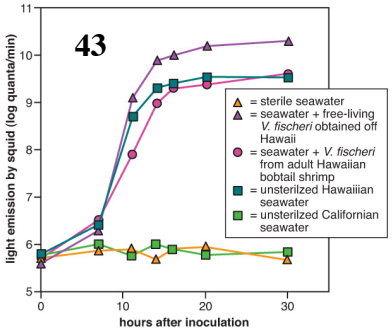

38
maintenance concentration of TMG
percent cells "on"
= wild-type, started off
= wild-type, started on
= ΔgreAB, started off
= ΔgreAB, started on
extracellular TMG (μM)

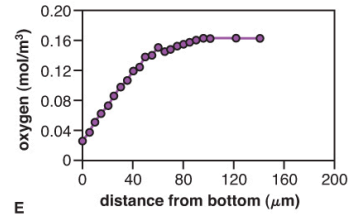

39
heart
brain
spleen
lung
liver
sk. muscle
kidney
testis
9.5 kb
7.5 kb
4.4 kb
2.4 kb
leptin receptor mRNA

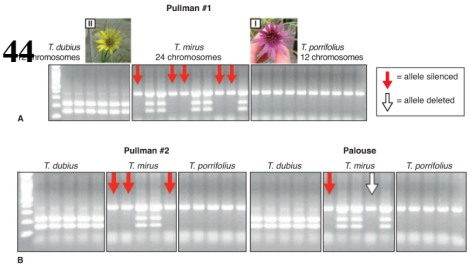

40
0.1% glucose
0.5% glucose
percent of total
cell number × 10⁸ (cells/mL)
= glucose concentration
= cell density
= autoinducer secreted
time (hours)

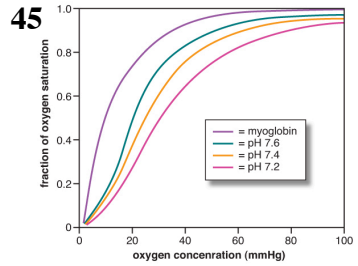

41
oxygen (mol/m³)
distance from bottom (μm)
B

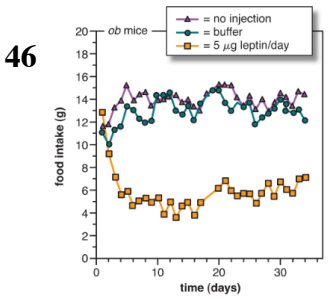

cAMP velocity 300 μm/min
2-3 mm 6-10 min
cAMP wave
42
capacity to move
cAMP
10⁻⁶ M
10⁻⁸ M
1 mm 3 min
stopped
moving
stopped
groups of cells
cell velocity 20 μm/min
B

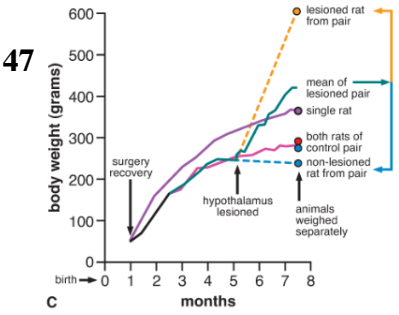

43
light emission by squid (log quanta/min)
= sterile seawater
= seawater + free-living V. fischeri obtained off Hawaii
= seawater + V. fischeri from adult Hawaiian bobtail shrimp
= unsterilzed Hawaiiian seawater
= unsterilzed Californian seawater
hours after inoculation

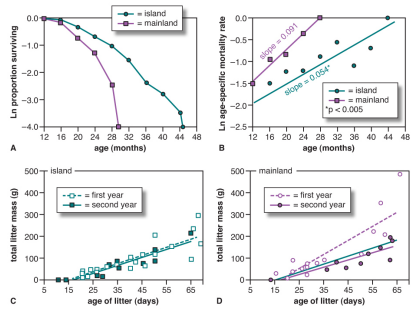

oxygen (mol/m³)
distance from bottom (μm)
E

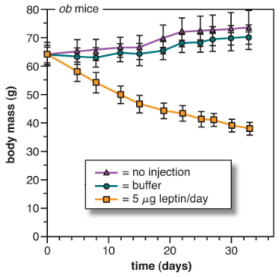

44
Pullman #1
T. dubius 2 chromosomes
T. mirus 24 chromosomes
T. porrilolius 12 chromosomes
= allele silenced
= allele deleted
A
Pullman #2
Palouse
T. dubius
T. mirus
T. porrilolius
B


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)


47
body weight (grams)
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
birth
months
C


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


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