# Biology 111 Closed Book Take-Home Exam #3 – Emergent Properties

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 5 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 9:30am on Monday November 8. **A HARD COPY OF YOUR EXAM IS DUE BY 9:30 am ON MONDAY NOVEMBER 8**. If you turn in your exam late, then you lose a letter grade for each day you are late. You may use a calculator and/or ruler. The **answers to the questions must be typed under each question** unless you draw the answer. 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. You must move the appropriate image from the last two pages and incorporate them into your answers whenever you see the expression, "Use data to support your answer." Do not assume how many of the data images you will use, or not use, and you are allowed to use any data image more than once if you need to, and you can use more than one image per question. Simply placing data near your answer is not sufficient support for your answer. You must explain how the significance of the data and how they support your answer. I have given you sentence limits for each question, so be concise.

There are 0 Quick Recall questions that are multiple choice.

**-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 (INCLUDING THE TEST PAGES) together when finished with the exam.

Name (please print):

Read the pledge and sign if you can do so with honor:

_____

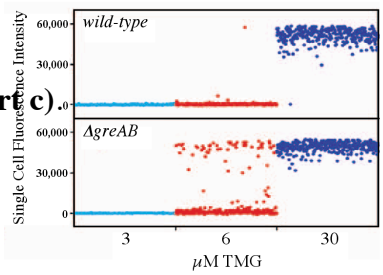
On my honor I have neither given nor received unauthorized information regarding this work, I have followed and will continue to observe all regulations regarding it, and I am unaware of any violation of the Honor Code by others.

How long did this exam take you to complete?

Lab Questions

**10 pts.**

1) Limit your answers to a maximum of **1 sentences each (only labels for part c)**.




a) How do you calculate the magnification on a light microscope?

eyepiece x objective

b) How long is a typical Chlamydomonas flagellum?

5 – 10 $\mu$m acceptable range

c) Draw a picture of Chlamydomonas with all its flagella intact.

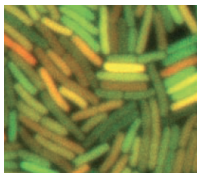
looking for overall shape, 2 flagella and any extra organelles that you could see get bonus points if drawn anatomically correct

Lecture Questions:

**10 pts.**

2) Limit your answers to a maximum of **3 sentences for each part**.

a) Provide three examples of genetically identical cells producing different phenotypes under identical environmental conditions. Each example must be accompanied by data to support your answer.



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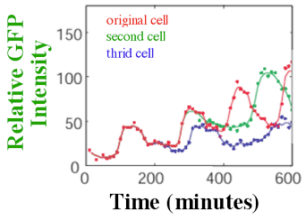


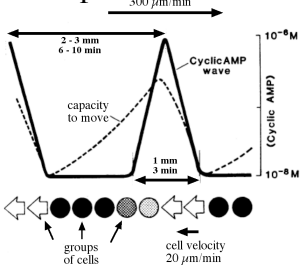


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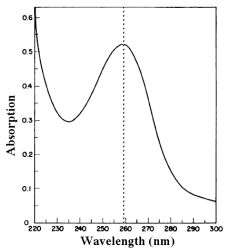
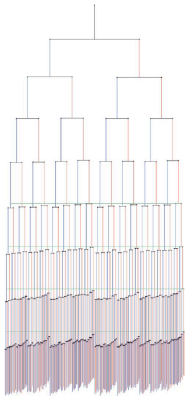


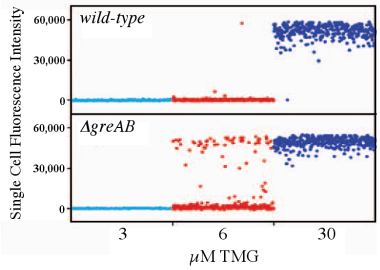



repressilator cells

slime mold cells

aging *E. coli* cells

b) How can non-genetic traits be passed on to the next generation and yet not be contradictory to insights from Mendel and Darwin? Support your answer with data.




The *ΔgreAB* cells pass on their state, on vs. off, so that all progeny inherit the phenotype difference despite their identical genotypes. Mendel address DNA inheritance which is maintained in these cells. Darwin talked about changes as a result of natural selection which does not apply in this situation.

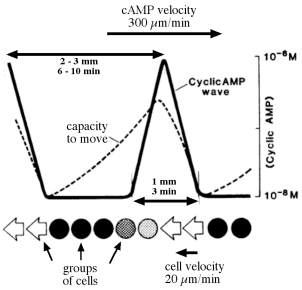
**14 pts.**

3) Limit your answers to a maximum of **3 sentences for each part but you may use 4 for part b**.

a) When watching a movie of Dictyostelium cells moving to a common site to form a slug, the wave of moving cells appear to be moving away from the center. Explain this apparent contradiction.

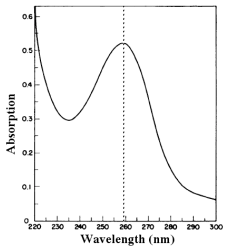
Like a line of people stepping forward, individual movement is forward, but those moving progresses backwards.

b) Use a figure to explain how individual Dictyostelium cells move unidirectionally to a common site.




They move towards cAMP concentration but have a refractory period after it has passed so they do not follow the wave backwards.

c) How did investigators determine what molecule was used to recruit Dictyostelium cells to a central location? Support your answer with data.

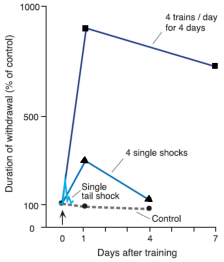



extracted it, absorption spectrum, appeared to be nucleic acid

**9 pts.**

4) Limit your answers to a maximum of **3 sentences for each part**.

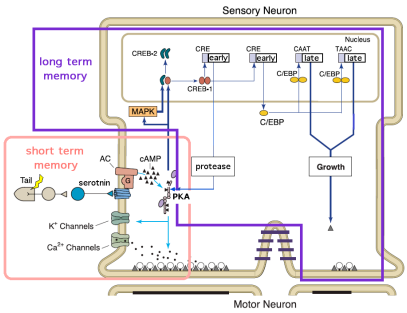
a) Describe the evidence Kandel used to demonstrate for the fist time that Aplysia was capable of learning.




the more training, the stronger the retraction and longer lasting the memory

b) Draw a picture of the experimental design that demonstrated facilitation and capture of learning. (no sentences required, only neatly written labels)

see figure 17.22




c) What protein is the pivotal molecule in converting short-term memory to long-term memory? Support your answer using a diagram.

PKA

**16 pts.**

5) Limit your answers to a maximum of **3 sentences for each part**.

a) Does a pregnant female have a functional immune system? Support your answer with data.

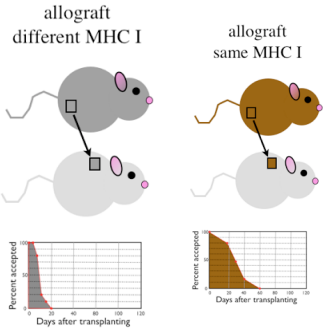
yes

| 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

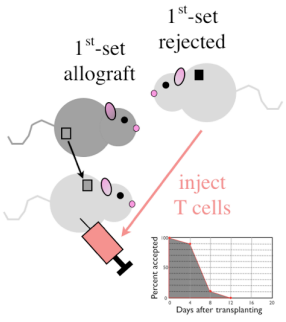
b) What molecule is the cause of the fastest tissue rejection? Support your answer with data.

MHCI



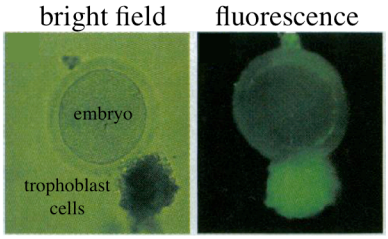

c) What cell type is the cause of graft rejection? Support your answer with data.

T cells

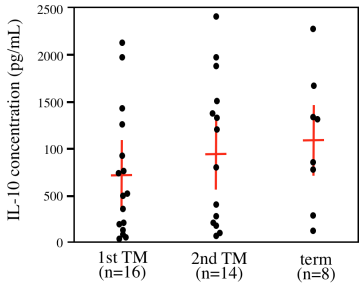



d) What protects a fetus from its mother's immune system? Support your answer with data.

MHC IG and IL10

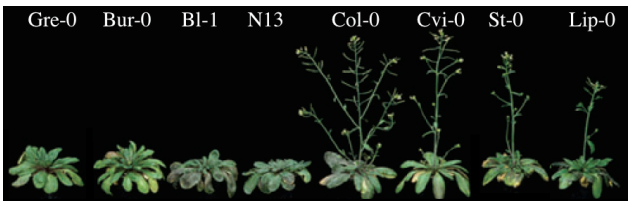


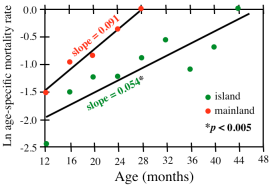

MHC IG

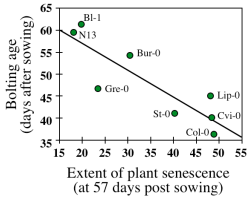


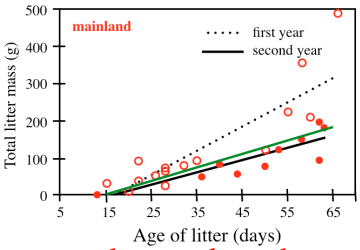

**10 pts.**

6) Explain the disposable soma theory of senescence. Support your answer with two different data examples. Limit your answers to a maximum of **4 sentences**.




live long, protect the body, reproduce later vs. live fast, die young, reproduce early and bountifully

**6 pts.**

7) List three concerns society should have about introducing new organisms into an environment? Use data to support at least one of your answers. Limit your answers to a maximum of **3 sentences**.

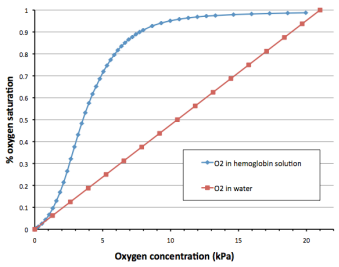
invasive species like the rabbits that overproduce

horizontal gene transfer

**8 pts.**

8) Limit your answers to a maximum of **3 sentences for each part**.

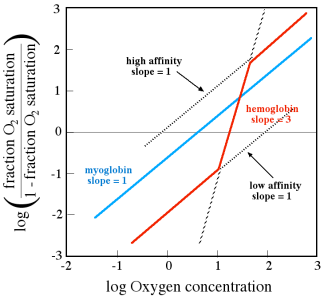
a) Describe the traits that make hemoglobin the ideal molecule for carrying oxygen from your lungs to your tissues. Make sure this answer is different from part b below.

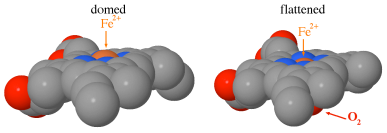


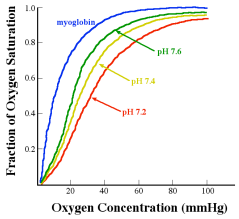

as the concentration of oxygen increases slightly, hemoglobin goes from no oxygen bound to all 4 bound

b) Provide three mechanisms that allow hemoglobin to have the property you described above? Support your answer with data.

heme moves that produces allosteric modulation
cooperativity that changes affinity
pH sensitive oxygen binding



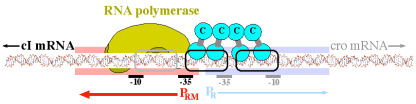

**8 pts.**

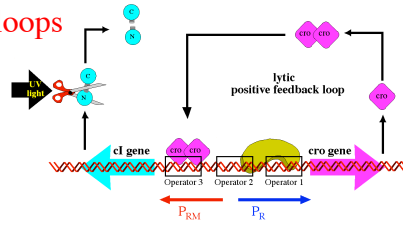
9) Limit your answers to a maximum of **3 sentences for each part**.

a) Describe two common emergent properties used by λ to "decide" the λ lifestyle. Support your answer with data.

positive and negative feedback loops

cooperativity



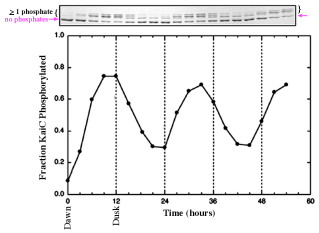

b) Explain how the choice between lytic and lysogenic are mutually exclusive. Support your answer with data.

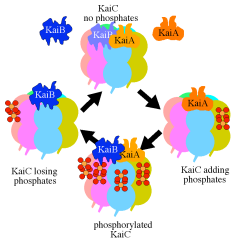
lytic is default due to higher affinity of RNA pol for $P_R$
positive feedback locks in lytic (bistable toggle switch)
cro reinforces
lysogenic cooperativity and locks in cI production

**9 pts.**

10) Limit your answers to a maximum of **3 sentences for each part**.

a) Describe how a cyanobacterim cell maintains its daily rhythm. Support your answer with data.



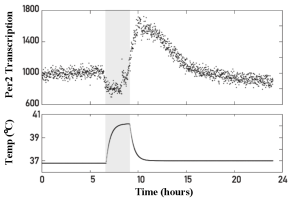



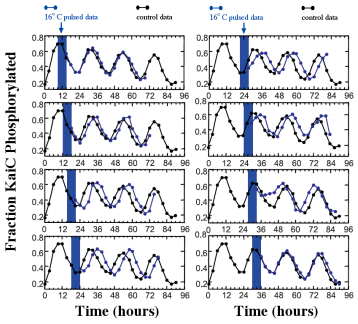

KaiC is kinase and phosphatase. Phosphorylates when KaiA bound, maximally at dusk.
KaiB binds when phosphorylated and leads to dephosphorylation, maximum at dawn.

b) Briefly explain how two different environmental signals reset circadian rhythms. Support your answer for one of these two signals with data.

temperature can shift daily cycle as shown here

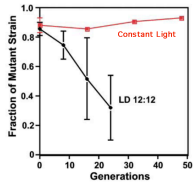
light also synchronizes




c) Do circadian rhythms provide a selective advantage? Support your answer with data.

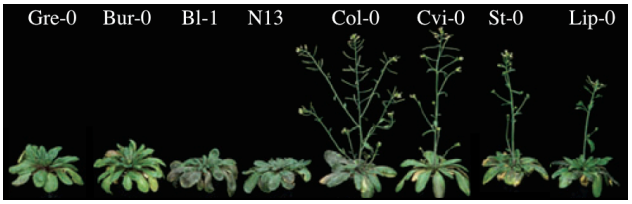
E. coli without cycle in constant light is fine but with alternating light it does not compete well with wt cells.

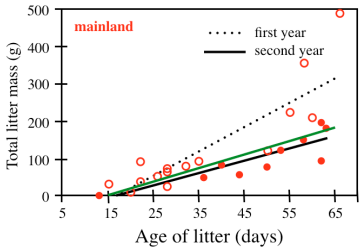


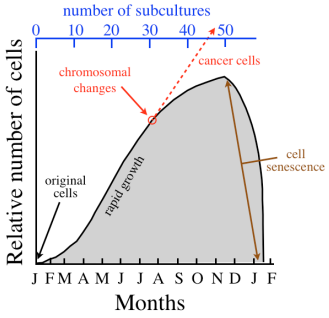
# Data Gallery

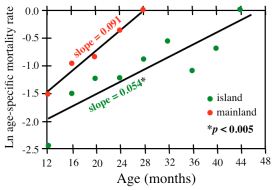
| experimental conditions | baby skin transplanted to: | | rabbit E skin transplanted to: | |
|---|---|---|---|---|
| | foster mother A | unrelated rabbit D | foster mother A | unrelated rabbit D |
| average days graft survived | 4.0 * | 6.5 | 6.0 * | 7.0 |

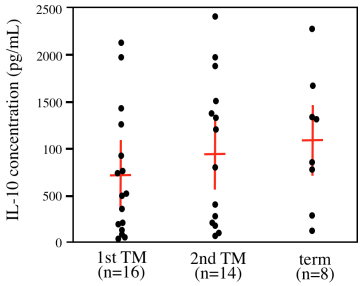
* indicates $p < 0.01$; experiment replicated 5 times

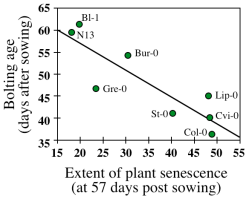


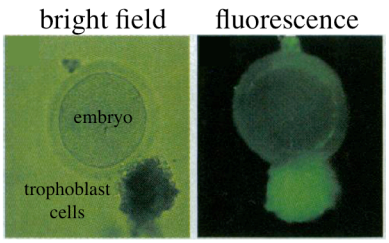



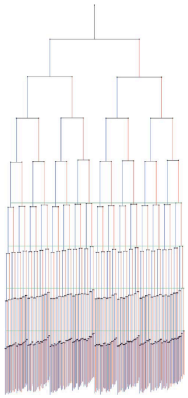



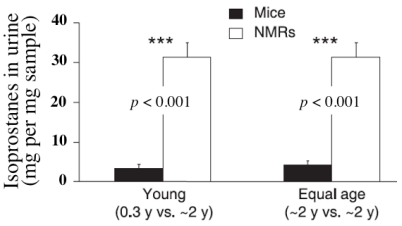



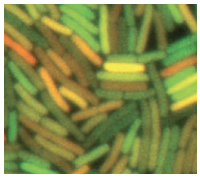



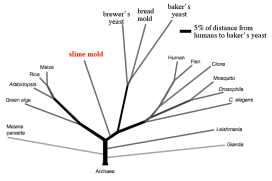



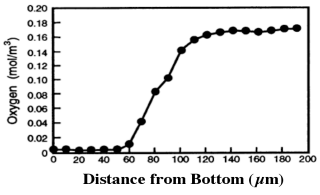



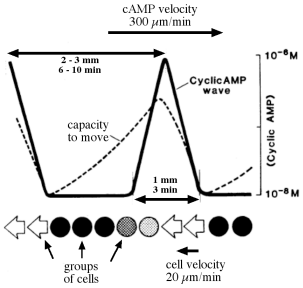



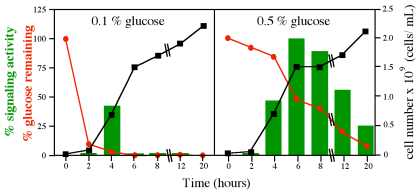


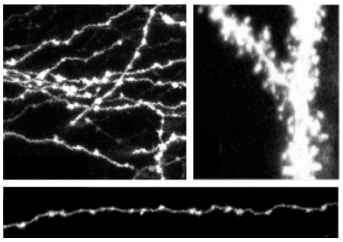



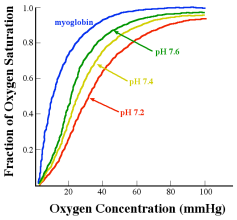


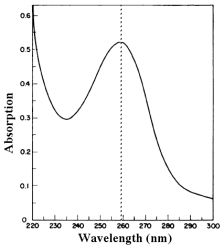



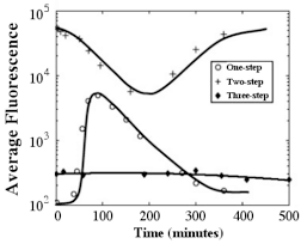



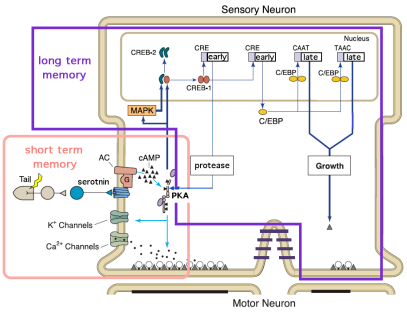



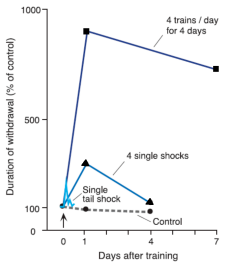


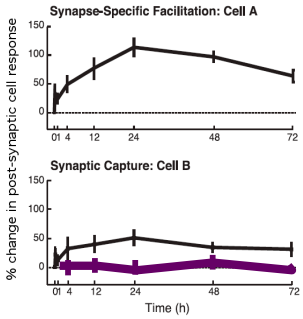


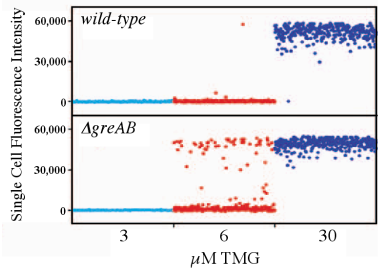



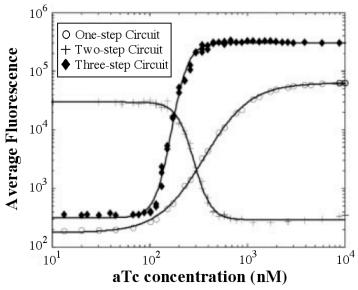

```
                    10        20        30        40        50        60        70        80        90
lambda_cro/1-61 -MEQRITLKDYAMRFGQ------TKTAKDLGVYQSAINKAIHAGR----KIFLTINAD--------GSVYAEEVKPFPSN----------
lambda_cI/1-92  MSTKKKPLTQEQLEDARRLKAIYEKKKNELGLSQESVADKMGMGQSGVGALFNGINALNAYNAALLAKILKVSVEEFSPSIAREIYEMYEAV
```

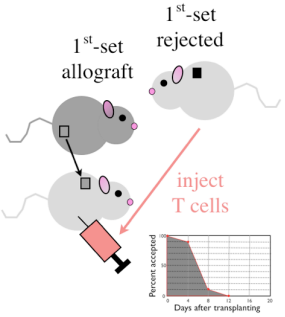

Sensory Neuron
long term memory
short term memory
CREB-2
CREB-1
CRE
early
late
CAAT
C/EBP
Nucleus
TAAC
MAPK
AC
cAMP
protease
Growth
serotnin
PKA
K+ Channels
Ca2+ Channels
Motor Neuron

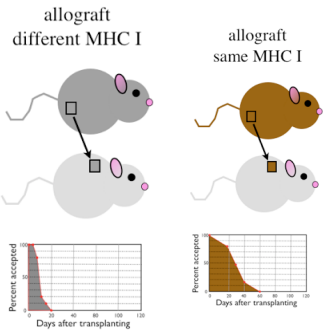

4 trains / day for 4 days
4 single shocks
Single tail shock
Control
Duration of withdrawal (% of control)
Days after training

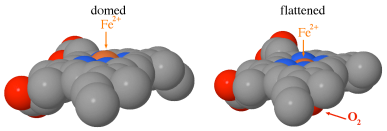

Synapse-Specific Facilitation: Cell A
Synaptic Capture: Cell B
% change in post-synaptic cell response
Time (h)

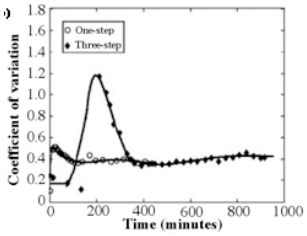

wild-type
AgreAB
Single Cell Fluorescence Intensity
μM TMG

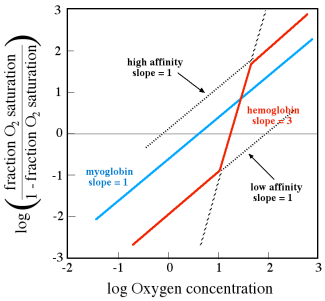

One-step Circuit
Two-step Circuit
Three-step Circuit
Average Fluorescence
aTc concentration (nM)

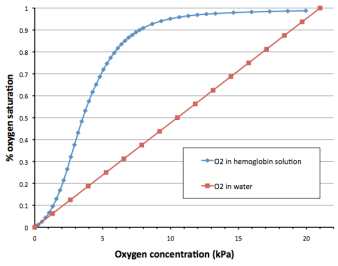

1st-set allograft
1st-set rejected
inject T cells
Percent accepted
Days after transplanting

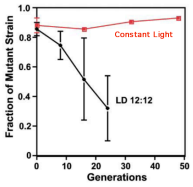

allograft different MHC I
allograft same MHC I
Percent accepted
Days after transplanting

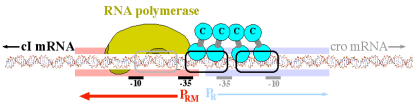

domed
flattened
Fe2+
O2

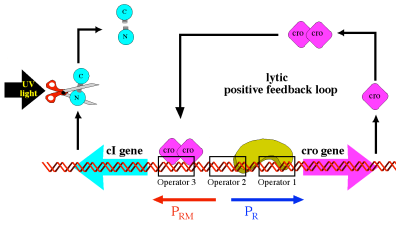

One-step
Three-step
Coefficient of variation
Time (minutes)

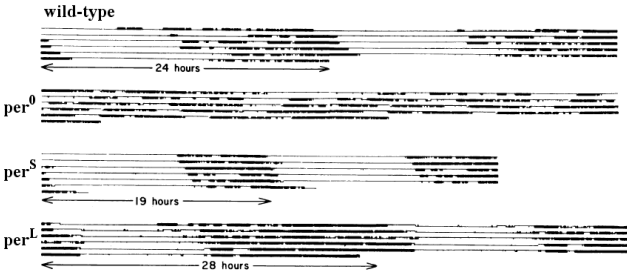

high affinity slope = 1
hemoglobin slope = 3
myoglobin slope = 1
low affinity slope = 1
log ( fraction O2 saturation / 1 - fraction O2 saturation )
log Oxygen concentration

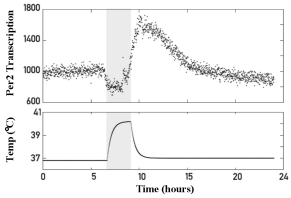

% oxygen saturation
O2 in hemoglobin solution
O2 in water
Oxygen concentration (kPa)

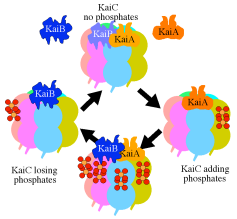

Constant Light
LD 12:12
Fraction of Mutant Strain
Generations

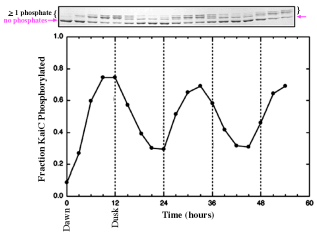

RNA polymerase
cI mRNA
cro mRNA
PRM
PR

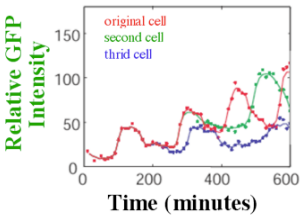

UV light
lytic positive feedback loop
cro / cro
cro
cI gene
cro gene
Operator 3
Operator 2
Operator 1
PRM
PR

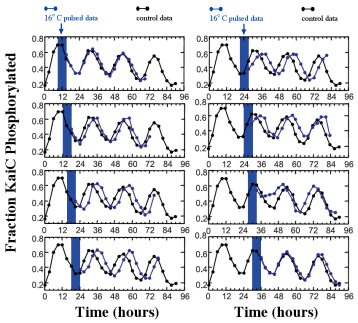

wild-type
24 hours
per0
perS
19 hours
perL
28 hours


Per2 Transcription
Temp (°C)
Time (hours)


KaiC no phosphates
KaiB
KaiA
KaiC losing phosphates
KaiC adding phosphates
phosphorylated KaiC


≥ 1 phosphate
no phosphates
Fraction KaiC Phosphorylated
Dawn
Dusk
Time (hours)


original cell
second cell
thrid cell
Relative GFP Intensity
Time (minutes)


16° C pulsed data
control data
Fraction KaiC Phosphorylated
Time (hours)