Biology 113 Closed Book Take-Home Exam #3 – Chapters 8 - 11

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 8 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 10:30 am on Monday Nov. 16. **EXAMS ARE DUE BY 10:30 AM ON MONDAY NOVEMBER 16**. If you turn in your exam late, you will lose a letter grade which accumulates for each day you are late. The **answers to the questions must be typed within this test** unless you want to draw on a separate page. If you do not write your answers in the appropriate location, I may not find them. Tell me where to look if you put your answer at the back of your test.

I have provided you with a "Data Gallery" in the form of figures and tables. To choose a figure in support of your answer, simply state Figure #x. You do NOT need to move the figure 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. 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 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:

8 pts.

1) Last weekend, I went camping in a cave. While there, I lost most of my gear. All I could find was a plant and some flint for making sparks. Luckily, there was some spare lab equipment and blind cave shrimp in the cave too. While I waited for the rescue drones to find me, I performed a toxicity test on the plant to determine if I could eat the plant tissue. Use this web site to analyze the data I recorded on my cell phone: http://www.quantitativeskills.com/sisa/statistics/fisher.htm

bring shrimp data generated the same way you generated data

Treatment	# Alive	# Dead
Water control	77	3
Methanol control	73	7
Plant A roots	39	41
Plant A leaves	66	14

a) What was my null hypothesis? (maximum of 20 words)

There is no difference between the plant tissue and methanol control.

b) What was the purpose of the water and methanol controls? (maximum of 30 words)

Water shows how many would die naturally, methanol tests if the solvent was more toxic than water.

c) Did the controls work as expected? Support your answer with data. (maximum of 30 words)

Yes, water and methanol had very low mortality so the null hypothesis cannot be rejected (methanol = water) p = 0.1639359

d) Is either part of this plant toxic as defined by the brine shrimp assay? Support your answer with data. (maximum of 30 words)

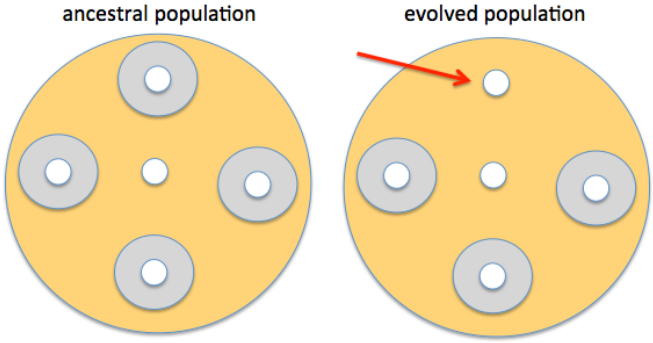
Roots are toxic and null hypothesis rejected (p = 0).

Leaves are not toxic, null hypothesis not rejected (p = 0.0794714)

4 pts.

2) In the space provided below, draw a picture of the final results you expect to see next week if your bacterial population has evolved antibiotic resistance. Include in your drawing the appropriate controls.

Draw here:



Lecture Questions:

8 pts.

3) Two questions about cells.

a) Using all the available data, what are nanobacteria? Support your answer with data from *two figures*. (maximum of 35 words)

Nanobacteria are not real

salt crystals that entrapped human protein in a "colony" (#29) and a protein blot (#26)

antibody to human protein bound to "nanobacterial protein"

b) Organize the information related to energy needs, time, number and volume that support the statement that all cells must be small. Support your answer with information from *two figures*. (maximum of 40 words)

volume grows faster than surface area, energy needs (vol) outpace supply (surface) #27

diffusion rates are too slow for big cells to respond quickly #30

12 pts.

4) some questions about neurons

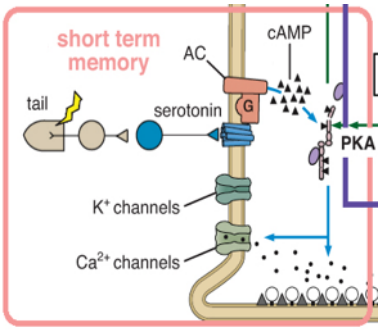
a) How is the chemical signal of a neurotransmitter converted into an electrical signal that is sufficient to travel the length of a neuron. Focus on the conversion, not the travel part. Support your answer with information from *two figures*. (maximum of 40 words)

threshold to initiate action potential #43 & #10

b) What molecular event constraints an action potential so that it only moves in one direction down the axon? Support your answer with data showing the one direction movement. (maximum of 40 words)

refractory period of voltage-gated Na+ channels #10

c) On a separate piece of paper, draw a picture of exocytosis in a neuron where short term memory is present. Be sure to label all the key components and players in the exocytosis process.



also label calcium, phosphates on Ca2+ channel and secretory vesicle proteins, proteins on inside of membrane

12 pts.

5) some questions about muscles

a) Analyze the data that explain how muscles grow bigger when you exercise a lot. Support your answer with data. (maximum of 40 words)

hypertrophy = more protein #37 top

hyperplasia = more nuclei #37 bottom

b) After a muscle cell is depolarized, describe the chemical signal that allows the cell to contract and from where the signal comes? Support your answer with a figure. (maximum of 40 words)

depolarize down T-tubules, SR opens calcium channels, calcium floods cytoplasm #44

c) For a muscle that is contracting, explain why one category of fibers within a sarcomere moves and the other remains stationary. Support your answer with *two figures*. (maximum of 40 words)

myosin does not move because pulling equally on both ends

actin moves because pulled to center by myosin #42 & 38

12 pts.

6) some questions about memory formation

a) How did Kandel know that *Aplysia* could learn and store a long term memory? Support your answer with *two data figures*. (maximum of 35 words)

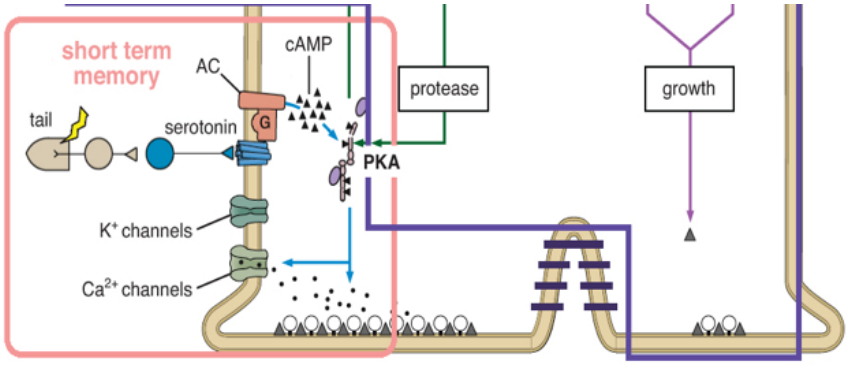
increased retraction in absence of shock if previously trained #34

in vitro memory by increased secretion after training #36

b) Describe the feedback loop that plays a central role in long-term memory formation. Support your answer with a figure. (maximum of 40 words)

PKA → MAPK → creb1/2 phosphorylated → protease → more activated PKA #33

c) On a separate piece of paper, draw a picture of exocytosis in a neuron where <u>long term memory</u> is present. Be sure to label all the key components and players in the exocytosis process.



needed short term + new proteins at synapes

12 pts.

7) some questions about cellular respiration

a) What is the sign (positive or negative) of the ΔG for this redox reaction? Explain your answer. (maximum of 20 words)

$FADH_2$ → FAD

negative ΔG with less potential energy to do work

b) Animals consume many forms of carbon for food. In what chemical forms are the carbons after the first portions of cellular respiration but prior to the citric acid cycle? For this question, just focus on the carbons, not the energy harvested so far. Support your answer with *two figures*. (maximum of 40 words)

all foods are broken into 2-carbon bits (acetyl-CoA) prior to entering citric acid cycle #25 & 28

c) Citric acid is composed of six carbons. What happens to each of the six carbons after one round of the citric acid cycle? Support your answer with *two figures*. (maximum of 30 words)

2 carbons fully oxidized to CO_2, the remaining 4 carbons recycled back into citric acid #25 & 28

d) What chemicals temporarily store the energy harvested during the citric acid cycle? List them in order from the most amount of stored energy per molecule (#1) to the least stored energy per molecule (last number).

1. NADH
2. $FADH_2$
3. GTP

12 pts.

8) more questions about cellular respiration

a) How does carbon monoxide kill you? Support your answer using at least two figures. (maximum of 40 words)

CO binds to complex IV of electron transport chain, stops all H^+ gradient and leaves NADH and $FADH_2$ reduced; no ATP produced = death #7 & 8

b) Soon we will study how hemoglobin carries oxygen. Explain all the functions of oxygen in your body. Support your answer with a figure. (maximum of 30 words)

oxygen accepts electrons from electron transport chain; only function #7

c) Of the three types of food (lipids, proteins and carbohydrates), which one is regulated to be digested last through homeostatic mechanisms? Support your answer with data from the *one most compelling data figure*. (maximum of 40 words)

proteins are last because GTP blocks deaminiation; lipids and carbohydrates continue #2C

10 pts.

9) some questions about photosynthesis

a) What is the main function of water consumption for plants when they photosynthesize? Support your answer with a figure. (maximum of 30 words)

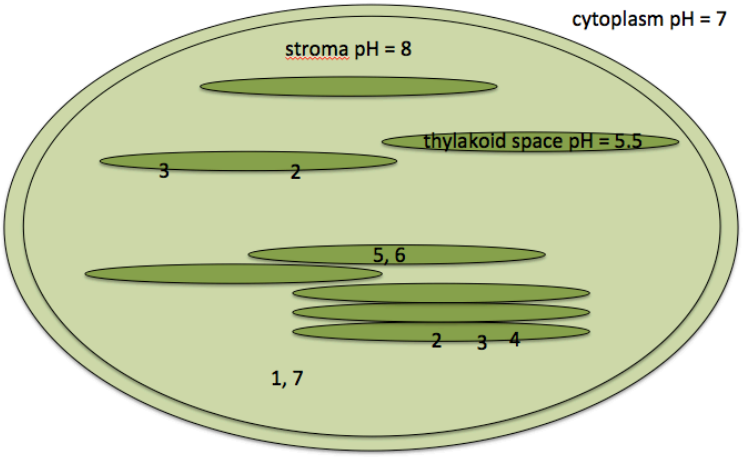
supply electrons to PS II in non-cyclic electron flow #17 & 21A

b) Describe the abiotic factor that determines the homeostasis of cyclic vs. non-cyclic electron flow when plants harvest light energy? Support your answer with a figure. (maximum of 40 words)

light color/intensity bright/blue = kinase antenna complex, unstacked, cyclic (water not consumed)

red/dim = phosphatase, stacked, noncyclic (water consumed) #21B

c) On a separate sheet of paper, draw a picture of a chloroplast and illustrate these components using the numbers here: 1 = location of new ATP production; 2 = ATP synthase; 3 = photosystem I; 4 = photosystem II; 5 = water splitting; 6 = oxygen production; 7 = carbon fixation. Also label the approximate pH in the stroma, cytoplasm and thylakoid space.

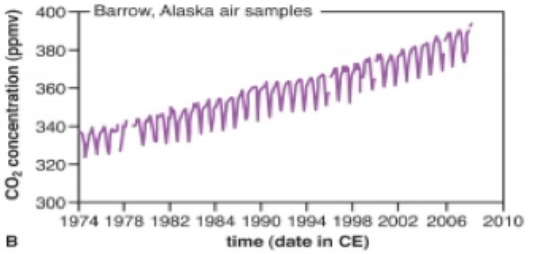


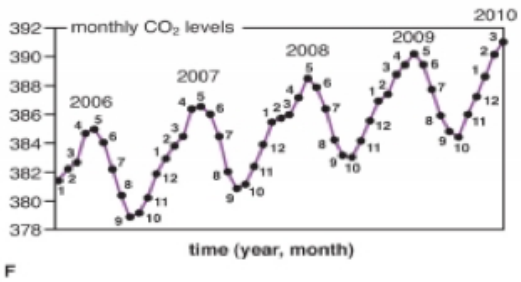
10 pts.

10) You may have read recent stories how oil companies Exxon Mobil, Shell Oil, BP *etc*. were paying climate change deniers despite Shell's own scientists agreeing that climate change is real and caused by humans (*NY Times*, Nov. 6, 2015).

a) Sketch one image that shows the change in CO_2 levels over time that deniers used to argue that the change was just a part of the natural cycle of CO_2 when in fact, the upward trend is clear. Support your answer with a figure.

#3 either figure was acceptable





b) What two homeostatic mechanisms regulate the rate of carbon fixation? Support your answer with data. (maximum of 30 words for each one)

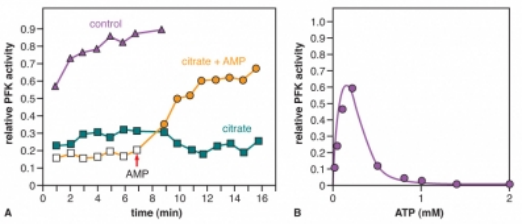
1. pH, rubisco works better at elevated pH (lights on in the stroma) #22
2. Mg2+, rubisco works better at elevated Mg2+ (lights on in the stroma) #22

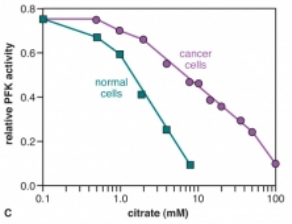
c) What high-energy molecules are consumed to provide energy for carbon fixation? Support your answer with a figure. (maximum of 30 words for each one)

1. ATP #18
2. NADPH #18

Data Gallery

1





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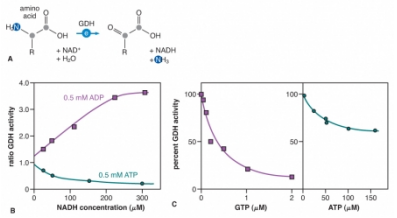
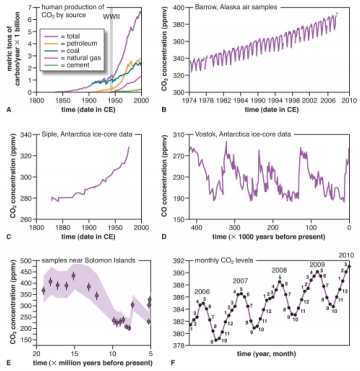


lipids tested	16 carbons	14 carbons	8 carbons	4 carbons
family 1	high activity	high activity	low activity	high activity
family 2	low activity	high activity	high activity	high activity
family 3	high activity	high activity	high activity	low activity
family 4	high activity	low activity	high activity	high activity

3



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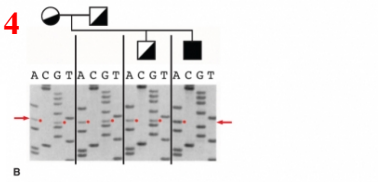

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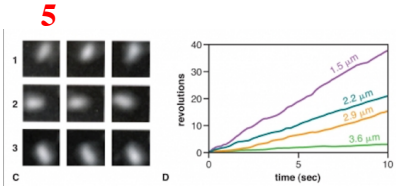

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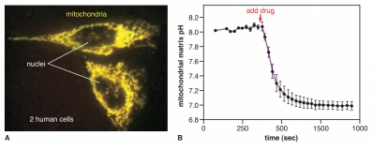

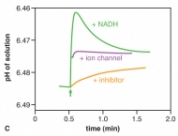

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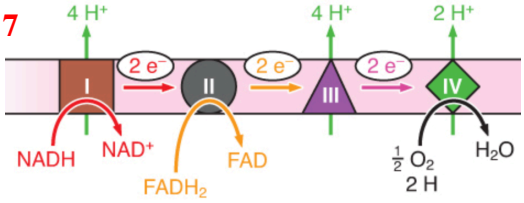

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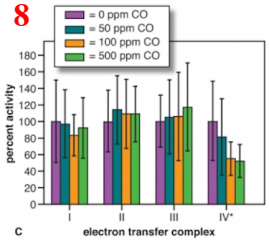

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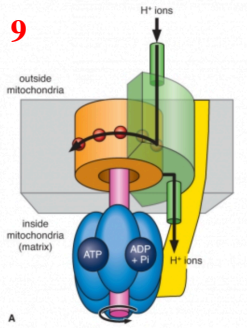

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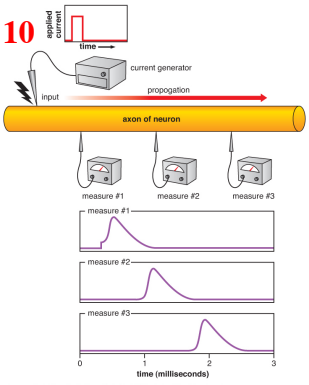

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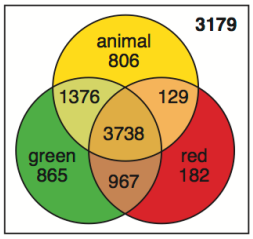

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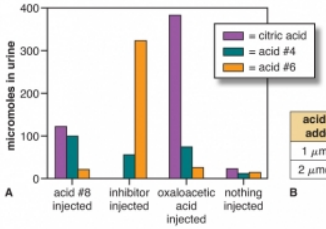
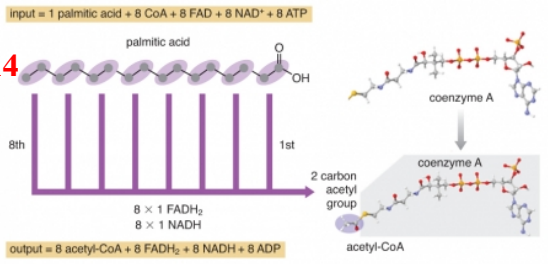


acid #8 added	oxygen uptake (calculated)	oxygen uptake (measured)
1 μmole	6 μmoles	47.2 μmoles
2 μmoles	12 μmoles	69.4 μmoles

13

gene name	average copy number	copy number range
ftsZ	80,600	35,800–198,800
dnaA	48,700	29,800–153,000
recA	120,000	60,300–205,000
16S rRNA	368,000	241,000–737,000

14



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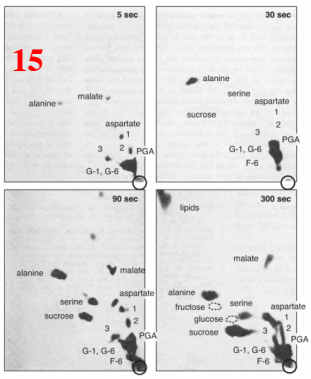

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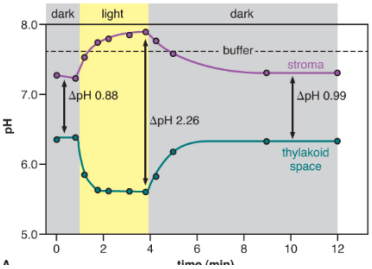

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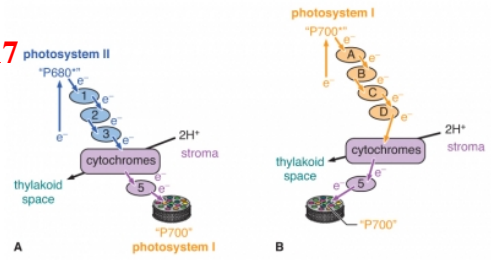

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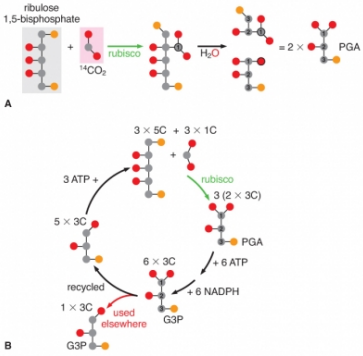

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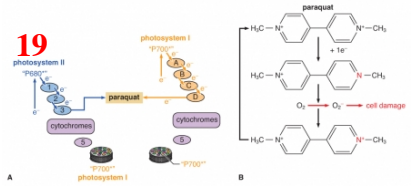

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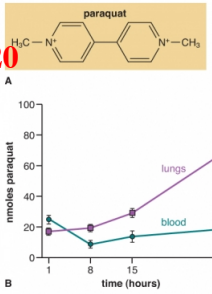

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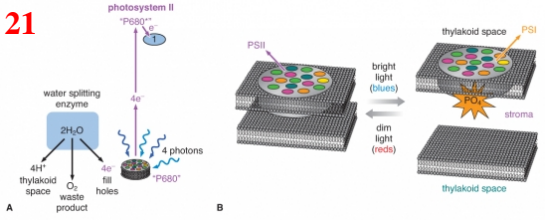

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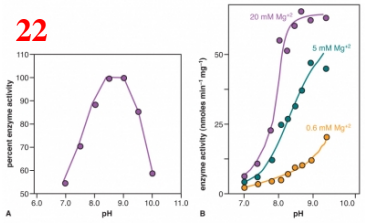

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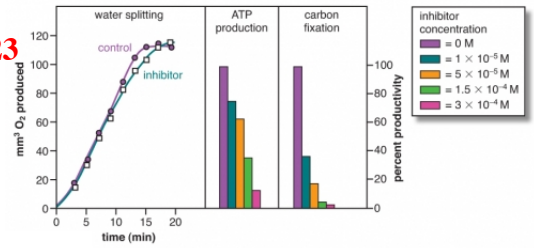

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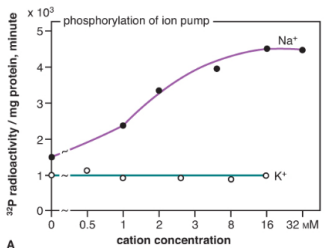

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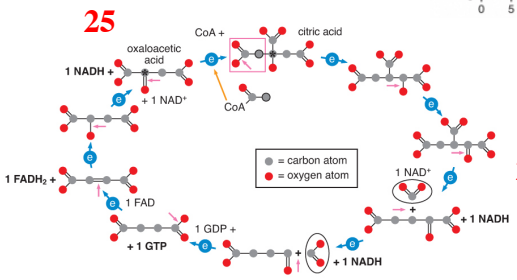

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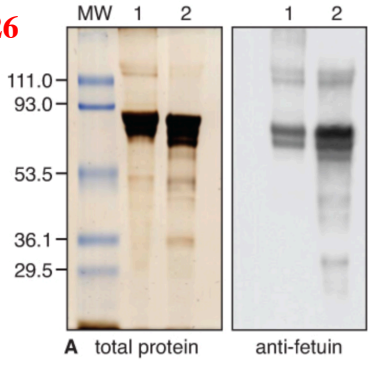

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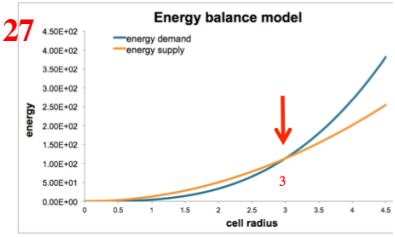

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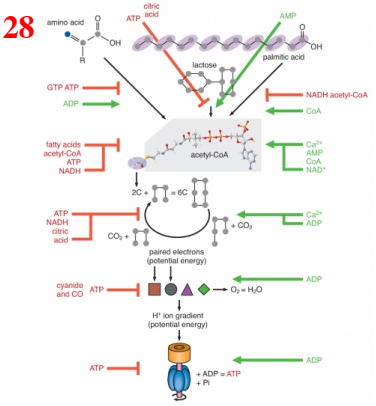

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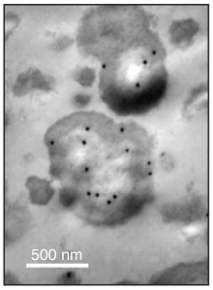


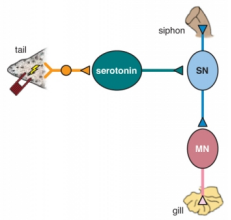
30

protein	location	diffusion rate	fold slower
GFP	water	87.0 ± 2.0	n.a.
GFP	cytoplasm *E. coli*	8.0 ± 2.3	~10 X
GFP over produced	cytoplasm *E. coli*	3.6 ± 0.7	~24 X
GFP + sugar-binded protein	cytoplasm *E. coli*	2.5 ± 0.6	~35 X
GFP	periplasm *E. coli*	2.6 ± 1.2	~33 X
GFP + membrane protein	membrane *E. coli*	0.13 ± 0.03	~669 X

31

description	green alga	bacterium	diatom	yeast, fungus	red alga	flowering weed
species	*O. tauri*	*E. coli*	*T. pseudonana*	*S. cerevisiae*	*C. merole*	*A. thaliana*
cell length	1 μm	2 μm	5 μm	5 μm	2 μm	multicellular
genome size	12.5 Mbp	4.6 Mbp	34 Mbp	12 Mbp	16.5 Mbp	140 Mbp
number of chromosomes	20	1	24	16	20	5
number of genes (rounded)	8,200	4,300	11,200	6,600	5,300	27,200

32



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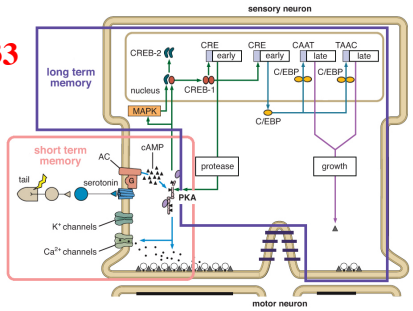

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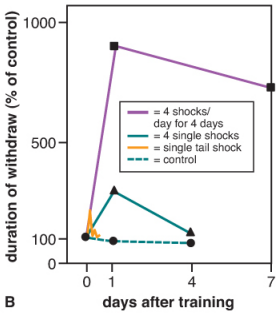

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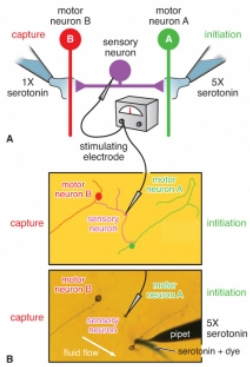

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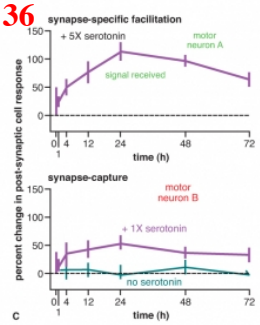

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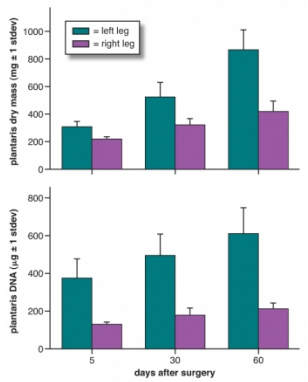

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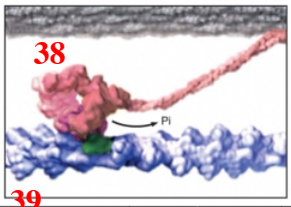

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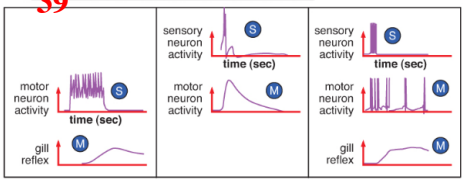

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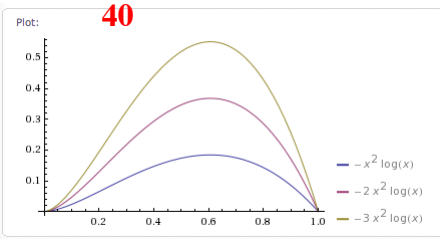

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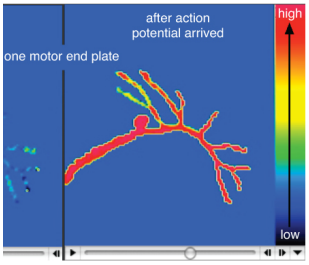

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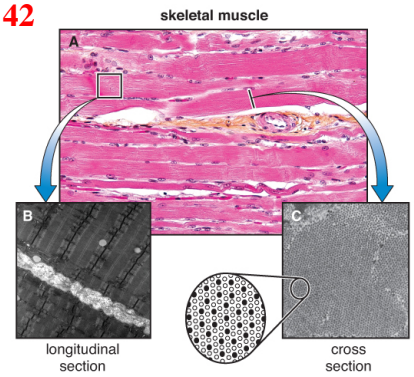

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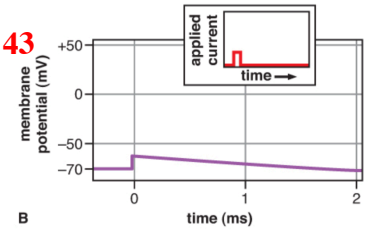

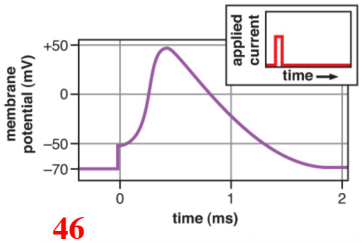

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ion	intracellular concentration	extracellular concentration
K^+	155 mM	4 mM
Na^+	12 mM	145 mM
Ca^{2+}	0.0001 mM	1.5 mM
Cl^-	4 mM	120 mM

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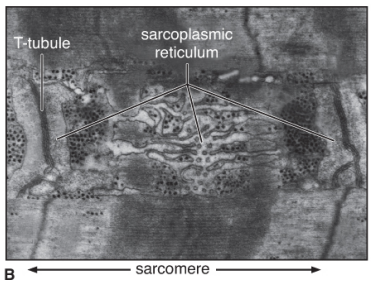

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