Total Score: ___/30

Name _____
Section Number _____

Homework 3
Due April 24th at the beginning of lecture

Instructions:

You are welcome to discuss concepts with your classmates but must compose your own answers. If you are unsure of the honor code for this course, please ask or look at the course website. http://www.its.caltech.edu/~bi1/Bi1__Micro-_to_Macro-Biology/Policies.html
The goal of this assignment is to help you understand a dense research paper. Many of the questions do not have a single correct answer. You will be given full credit as long as your answer is reasonable.
The answers must be legible and should not extend past the allotted space. Keep in mind that a few well-written sentences can give a higher score than a whole page of text.
Remember to write your full name and section number on each page.

Part A:

Microbes profoundly impact their physical, chemical, and biological environments. This week's homework paper is an example of the interactions between three species: the parasite *Toxoplasma gondii,* its rat host, and cats.

Read the paper carefully and answer the following questions.

Berdoy, M, et al. (2000) "Fatal attraction in rats infected with *Toxoplasma gondii." Proc. R. Soc. Lond.* B. 267: 1591-1594

1. What is the hypothesis being tested? (1-2 sentences) (3 points)
   Toxoplasmosa changes the behavior of the intermediate host (the rat) to increase its chances of predation by the cat, so the protozoan can replicate in the definitive host (the cat).

2. Describe the results of the experiment in your own words. (2-3 sentences) (4 points)
Rats infected with *Toxoplasmosa* made a greater number of visits to areas sprayed with cat urine than uninfected individuals as well as exhibiting a preference over time to cat areas over rabbit areas. The infected rats and uninfected rats showed the same behavior for rabbit and their own scents.

3. What is the significance of the experiment? (1-2 sentences) (3 points)
   A parasite infection can radically change the behavior of infected intermediate hosts to increase the parasite's fitness to the detriment of the intermediate host. Importantly, this was mediated through cognitive processing rather than direct sensing, which may have significance for humans infected with *Toxoplasmosa*.

4. Up to a third of farm animals may be infected with *Toxoplasma gondii*.[1] Considering these organisms are dead-end hosts for the parasite, why do you think this might be the case? (There is no 'correct' answer for this – just give a reasonable hypothesis).[2] (1-2 sentences) (3 points)
   E.G. Increases resistance for those animals to other infections. Cats are common on farms and their feces may come in contact with the fields animals feed on.

[1] http://www.aaem.pl/pdf/17125.htm
[2] If you're interested in reading about the effects that some scientists think *Toxoplasma gondii* has on humans, take a look at the article "How Your Cat is Making You Crazy" from *The Atlantic*'s March 2012 issue!

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Part B:
From the lecture reading, you know that an *Escherichia coli* bacterium can vary the tumbling frequency based on the attractant and repellant concentration gradients. A sensed change in the concentration in one of these affects the rotation of the bacterium's flagella motors via the bacterial chemotaxis protein circuit.

Read the paper carefully and answer the following questions.
Alon, U (2007) "Robustness of protein circuits: The example of bacterial chemotaxis." In: *An Introduction to Systems Biology*, Chapman & Hall/CRC. 137-159.

1. Briefly describe what feedback loops and exact adaptation are, and how they relate to the chemotaxis circuit discussed. (4-5 sentences) (5 points)

   Feedback loop – can be either positive by amplifying a signal (often by an end-product) or negative where it quickly suppresses activity as more of the signal is generated. For example, the methylation of the receptors increases the rate of CheY phosphorylation to increase tumbling and make receptors sensitive to gradients in a large concentration range.

   Exact adaptation – eventual return to original state (of tumbling frequency) independent of level of attractant

2. What is the major difference between the two toy models of exact adaptation? (1-2 sentences) (2 points)

   Major difference – Fine-Tuned Model "depends on a precise balance of different biochemical parameters" (p. 145), whereas the other model reflects robustness and occurs for a large range of biochemical parameters (independent of absolute concentration).

3. The diagram in Figure 7.6 describes the signal transduction network. Using this figure and the text, what would you expect to happen to the tumbling frequency and the concentrations of the chemotaxis proteins <u>initially</u> if the bacterium is an environment (10 points)

	tumbling frequency	~~CheA~~ X	~~CheA-P~~ X*	CheY	CheY-P	CheZ	CheR	CheB
a. at steady-state	Same	Same	Same	Same	Same	Same	Same	Same
b. where the concentration of attractant is increasing	Down	Up	Down	Up Phosphor-ylated at slower rate	Down	Same	Same	Same
c. where the concentration of repellent is increasing	Up	Down	Up	Down	Up	Same	Same	Same

d. How does this differ in the long run?

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(Adaptation) Negative feedback loop:
Attractants: less CheB phosphorylation, reduced demethylation by CheB (while constant methylation by CheR)
Repellants: more CheB phosphorylation, …
Most important: **adaptation**
Grade *leniently* on this part