Total Score: ___/50

Name _____

Homework 1

Due April 10th before 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.
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 on each page.

Part A:
Read Komeili et al., (2006) Magnetosomes Are Cell Membrane Invaginations Organized by the Actin-Like Protein MamK. *Science.* 311: 242-245

1) *Science* papers don't follow the traditional paper organization discussed in recitation section with headers for each section of the paper. Instead, the papers contain all of the requisite information, but the sections blend one into the next. As you read through Komeili *et al.*, pay attention to how it is organized and mark the transitions from one section to the next. In the table below, write the first line of each section. (5 points)

Abstract:	[1 point] "Magnetosomes are membranous bacterial organelles sharing…"
Introduction:	[1 point] "Prokaryotes are highly organized cells with many ultrastructural similarities
Materials and Methods:	[1 point] "Electron cryotomography (ECT) is an emerging technology…" or "To image magnetotactic bacteria by ECT…" ; both accepted
Results:	[1 point] "A slice through the middle.." or "Of greatest interest, however, were the…"
Discussion:	[1 point] "These results have important implications for the mechanism…"

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2) **In one or two sentences**, answer the questions below in the left column. In the right column note which section of the paper (following your division above in Question 2) contained the relevant information. Some answers may be found in multiple sections, but you only need to list one. (20 points)
2 points for each part

	Which section?
What was the scientific goal or hypothesis of this paper? investigate mechanisms of magnetosome localization	
What is a magnetosome composed of? magnetite Fe_3O_4	
What do magnetosomes help the cell accomplish? magnetotaxis (orientation in magnetic field to find microaerophilic environment)	
How did the authors determine the localization of the magnetosomes? they used electron cryotomography create 3d-reconstructions of whole cells and map out spatial localization of intracellular components (including magnetosomes)	
Where are magnetosomes located? Do the results of this paper agree or disagree with previous results using other techniques? magnetosomes are located in inner membrane invaginations – disagree with previous studies, which suggested they were in membrane vesicles	
The authors saw that intracellular filaments were associated with magnetosome chains (Figure 2). What other observation led them to investigate the role of cytoskeleton-like proteins in magnetosome localization? Genetic mutants missing the *mamAB* gene cluster are non-magnetic and also do not form filaments. The *mamAB* cluster contains a gene for MamK, which was predicted to form filaments based on its similarity to actin-like proteins (which are known to form filaments). 1 point for only mentioning the linearity of magnetosome chains. This is the observation that led the authors to investigate structural constraints, but it does not deal specifically with cytoskeleton-like proteins.	
What is MamK? MamK is a homolog of the actin-like protein MreB, which is known to form filaments within the cell.	

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Full credit for mentioning similarity to MreB or that it forms filaments.	
How did the authors investigate the localization of MamK? The authors used a GFP fusion to MamK. 1 point if a fusion was not mentioned specfically—GFP alone doesn't provide information on localization.	
What happens to magnetosome positioning in cells without the protein MamK? What does this suggest about the role of MamK? Without MamK, magnetosomes are no longer organized into linear chains within the cell. This suggests that MamK plays a role in determining the organization of magnetosomes. For full credit, both questions should be answered explicitly.	
Why are the results of this research significant? Showing that magnetosomes are membrane invaginations suggests a mechanism for the synthesis of magnetite. More importantly (for full credit), the organization by MamK suggests similarities between bacterial and eukaryotic organelles and raises new evolutionary questions.	

3) Propose an experiment to test if other proteins affect MamK localization. **(6 sentences maximum)** (5 points)

A simple experiment would involve deleting various other genes and monitoring the resulting changes in MamK localization, either with GFP-tagged MamK or with electron cryotomography. Alternatively, proteins could be added instead of deleted to see if those proteins perturb MamK localization. A functional assay could be used (directly testing the ability of the bacteria to align in a magnetic field), but MamK should be observed directly at some point.

Notes:

- This question is asking about **MamK** localization, not magnetosome localization.
- There is no requirement to limit the search to just genes in the *mamAB* cluster.
- Answers should highlight how MamK will be visualized.
- If it turned out that MamK does not *directly* control magnetosome localization, then it might be possible to get MamK filaments without having ordered magnetosome chains, or vice versa. Answers should be explicit about monitoring MamK and not just the magnetosomes.
- The best answers should be specific about their intent. For example, it is not sufficient to say you will use a protein—you should describe what specifically you will do with it.

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4) Is there any evidence **in this paper** that bacteria sense magnetic fields? If so, where is this information located in the paper? If not, where might you find it? (2 points)
No. Although the paper says that bacteria can sense magnetic fields, it does not provide any evidence. Instead, this paper cites other works that provide the evidence. The authors show no data that demonstrate magnetotaxis.

1 point partial credit for citing the relevant sentence in the introduction.

5) This question can be answered by thinking critically about the environment in relation to magnetic fields. However, feel free to use additional outside sources to supplement your answer. If you do use outside sources, please cite them in your answer. (8 points)

- The authors state that magnetotaxis helps bacteria "search for their preferred microaerophilic environments". What information does Earth's magnetic field provide that might help bacteria find different concentrations of oxygen? **(4 sentences maximum)**
  The oxygen concentration in a water column depends on the distance from the surface. Earth's magnetic field provides information about which way is up and down, which the bacteria can use to swim towards or away from the surface of the water.

  Notes:
  - Although oxygen is paramagnetic, the influence of Earth's magnetic field is negligible compared to diffusion through the atmosphere or water.
  - Bacteria are very small and swim slowly on a planetary scale. It is unlikely that they could swim vast geographical distances towards or away from the poles, especially if they have to compete against ocean currents.

- Based on your answer to a, what regions of the planet would you **not** expect to have magnetotactic bacteria, and why? **(4 sentences maximum)**
  This question was graded based on each answer to a, so answers very greatly. Note that the best answers deal more with the relative direction of the magnetic field and not with the strength of the field.

  If bacteria are using the vertical component of the magnetic field, then you would not expect to find magnetotactic bacteria at the equator (where the magnetic field is parallel to the surface).

  If your answer to (a) involved the horizontal component of the magnetic field, then you would not expect to find magnetotactic bacteria at the poles.

  Lots of other answers received partial credit (the amount depends on how well they relate to the answer in a). For example, you might not expect to find magnetotactic bacteria in an iron-limited environment.

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While it's true that oxygen dissolves more readily in cold water, the question states that these bacteria prefer microaerophilic environments (ie, low oxygen concentrations). If your hypothesis delt with temperature-dependent oxygen concentrations then you would not expect to find magnetotactic bacteria at the poles.

6) Magnetosomes are an active area of research and there been many developments since this paper was published. Finding related research is an important skill regardless of your field. Answer the following questions using Web of Knowledge (http://apps.webofknowledge.com/) **(no sentences needed)** (10 points)

a) How many times has this paper (Komeili *et al.* 2006) been cited?
[2 points]; 209 (all databases); 194 (Web of Science); accept both answers

b) What is the most recent paper that cites Komeili *et al.*?

[2 points]; Title: **Growth and Localization of Polyhydroxybutyrate Granules in Ralstonia eutropha**
Author(s): Beeby Morgan; Cho Mimi; Stubbe JoAnne; et al.

c) What is the most cited paper that cites Komeili *et al.*?

[2 points]; Title: **Controlling Mineral Morphologies and Structures in Biological and Synthetic Systems**
Author(s): Meldrum Fiona C.; Coelfen Helmut

d) What is the title of one review that cites Komeili *et al.*?

[2 points];
http://apps.webofknowledge.com/summary.do?SID=1FdipHEEdBl62NpcbG2&product=UA&qid=21&search_mode=Refine&last_prod=WOS&highlighted_tab=UA&cacheurl=no

e) How many times has Grant Jensen cited Komeili*et al.*?
[2 points]; 17