Part C: Exam Practice Question (25 points)

The question is based on the Chen et al. paper, which was this week's assigned recitation reading.

Some species looked at in this paper went against the trend observed in terms of elevation shifts. For a large multicellular organism, describe and explain intrinsic and extrinsic factors that could contribute to its ability to ***migrate or adapt*** *in response to an environmental change. If the authors were looking at microbes instead, how would you expect the results of the paper to differ, and why?* (500 words) (0 points)

Answer:
The main theme of this question is migration versus adaptation. Every point of your answer should address this theme. The question can be divided into two. First, what are the factors? Second, how would microbes react differently? You should identify at least two intrinsic and two extrinsic factors and you should clearly explain how they would favor or inhibit adaptation or migration. If you identified and properly explained more than two, we would take that into account in your favor.

- Intrinsic factors: (8 points)
    - 2 points for mentioning the first factor
    - 2 points for explaining the first factor
    - 2 points for mentioning a second intrinsic factor
    - 2 points for explaining the second factor
    - Possible factors: mutation rate, reproduction method (sexual vs. asexual, pollination, etc.), mobility, sensitivity to temperature, etc.
    - Example explanation: *A species with a higher mutation rate has a higher probability of finding a key innovation through mutation. Under the stress of the rising temperatures it is possible that a key innovation, which allows for adaptation to the new temperatures, would arise and eventually become prevalent in the species. This process would take many generations to occur, therefore shorter generations would also be advantageous.*
- Extrinsic factors: (8 points)
    - 2 points for mentioning the first factor
    - 2 points for explaining the first factor
    - 2 points for mentioning a second intrinsic factor
    - 2 points for explaining the second factor
    - Possible factors: geographical barriers, habitat/niche availability (food source, competitors, predators), might thrive in a new habitat but actually destroy that habitat, etc.
    - Example explanations: *It may be possible that a species cannot migrate because there is no niche to thrive on at the new location. The new location may not have the food source that a species need to thrive and would thus inhibit that species from migrating into it. Similarly, it could have the food source but the incoming species might not be able to compete against an already present species. Even if the food source is present in the new location, the incoming species may find itself being predated by another already present species. All of these ecological barriers on the migration of a species would force the species to adapt to the new temperatures in order to survive.*
- Microbes: (9 points) For this section you need an adequate explanation for why microbes are worse at migration and much better at adaptation.
    - 2 points for explaining that microbes are more likely to adapt than to migrate
    - 2 points for an explanation of why they are less mobile (mostly an issue of scale)
    - 5 points for an explanation of why they can adapt faster. You would be expected to name at least 3 of this with a good explanation for each (faster chemistry, faster growth, faster adaptation through gene regulatory networks, mutation rate, more horizontal gene transfer)
    - Example explanation (would need additional examples for adaptation of course): *Microbes are much less mobile and can adapt faster. In terms of mobility, the size of microbes prevents them from purposefully moving on a geographic scale. Chemotaxis only works at a microscopic scale, so microbes could not really move in response to a general environmental change. Microbes are much better at adapting because they have a propensity for horizontal gene transfer. They achieve this by becoming naturally competent to take up DNA, exchanging plasmids, and incorporating viral DNA transferred from other bacteria. This allows microbes already suited to the environmental change to share their beneficial genes with other members of the community.*