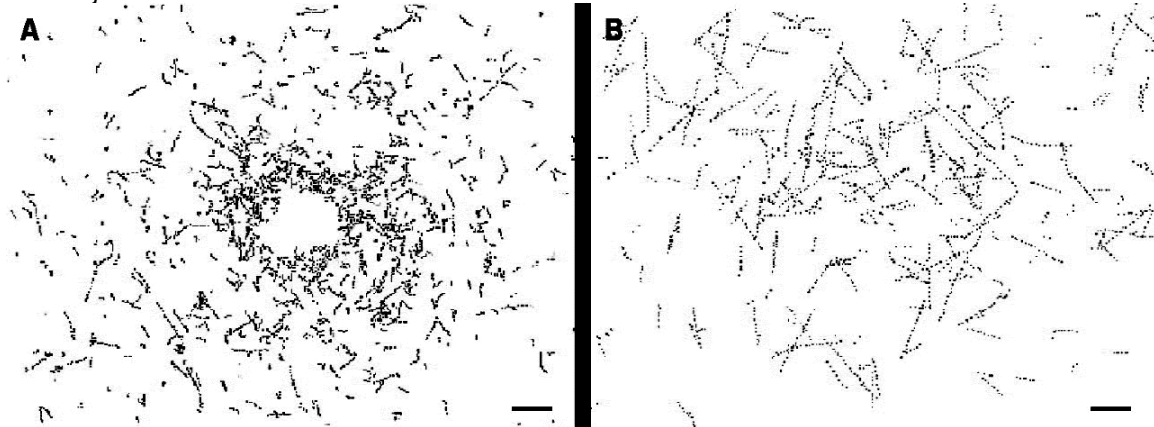


Be sure to write your name above. Read the question carefully, think, then write your answer in the lined space (front and back of this page). When finished, please hand your answer in, separate from your exam booklet.

QUESTION: The figure below has been modified from a recent publication¹ in which the authors report on bacterial feeding on nutrient patches in planktonic² habitats in seawater. The diagram on the left (A) shows bacterial tracks surrounding a lysed ciliate³ (the ciliate cell is the empty space in the center of the panel). The diagram on the right (B) shows bacterial tracking in a diffuse cloud of nutrient broth. The locations of the bacteria were marked at equal intervals. The duration of the measurements is about 2 seconds; the bars are 50 μm .



Explain the difference in the tracking, on the basis of your biophysical knowledge of bacterial motility.

KEY:

Bacteria search for food by switching between runs and tumbles (5 points). Runs result in a unidirectional motility, similar to the tracks shown in Figure B, in which the nutrient concentration is uniformly distributed throughout the medium (2 points). Tumbles are caused by a change in the rotation of the flagella: The bacterium changes its swimming direction during the next run after a tumble. When nutrients are present, the bacteria will tend to tumble less. If the nutrient is removed, the frequency of tumbling increases, as the bacteria 'searches' for nutrients (2 points). Runs and tumbles are well described by a Poisson probability distribution that implies the transitions occur at random, albeit at different frequencies (1 point). In Figure A, the nutrients are present as a localized source, such that a gradient of nutrients extends outward some short distance from the lysed ciliate. Far away from the lysed ciliate, the bacteria appear to change direction more frequently. That is, they exhibit a higher frequency of tumbles (2 points), 'searching' for a source of nutrients. Near the lysed ciliate, the bacteria neither run nor tumble, but exhibit a low swimming speed (1 points). In contrast, in the absence of a gradient of nutrients (Figure B), the bacteria do not undergo tumbles, and swim at a fast rate through the medium (1 points).

Total points: 14 points.

¹ Blackburn, N, T Fenchel, J Mitchell (1998) Microscale nutrient patches in planktonic habitats shown by chemotactic bacteria. *Science* 282:2254–2256.

² Planktonic: The small and microscopic organisms drifting or floating in the sea (or fresh water); mostly of diatoms, protozoans, small crustaceans, and the eggs and larval stages of larger animals. Many animals are adapted to feed on plankton.

³ Ciliate: A single celled protist, normally heterotrophic, whose motility depends upon their cilia (small flagella that move in an 'oar-like' fashion). Cell sizes vary, but 20–40 μm is not uncommon.