! Why Rods and Cocci

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Bacteria exhibit a wide variety of shapes but the commonly studied species of bacteria are generally either spherical in shape which are called *cocci* (singular coccus) or have a cylindrical shape and are called *rods* or *bacilli* (singular bacillus). In reality rods and cocci are the ends of a continuum. Some of the cocci are slightly elongated and some of the rods are so short that they look almost like cocci. Sometimes a term coccobacillus is used to describe them.

Why did bacteria get different shapes? Why aren't all of them spherical or all rod shaped? Different shapes are likely to give different selective advantages. A rod shaped cell has a streamlined body which would be advantageous in swimming, just like the slender body of a fish, a boat or a plane. A spherical body will experience greater frictional resistance. This hypothesis is supported by the fact that among the flagellated motile bacteria almost all are rod shaped. Only exceptionally few cocci are motile. This hypothesis, however, is not adequate since a large number of species of bacteria are non-motile.

A rod shape can confer another advantage, that of having a large surface area per unit volume. Intake of nutrients takes place through the cell surface. The rate of bacterial growth depends largely on the rate of intake of nutrients. Therefore having a large surface area can confer great selective advantage whenever there is competition for nutrients.

The obvious question that follows is that if a rod shape confers many advantages, then why did spherical cells evolve at all? Among all possible shapes, a sphere has the minimum surface area per unit volume. Having a larger surface area might be good for intake of nutrients, but it may prove detrimental under some other conditions such as desiccation or osmotic shocks. If a cell

is exposed to desiccation or to a hypertonic environment, it will lose water through its surface. Bacteria have mechanisms to resist desiccation. However, more the surface area more difficult will it be to resist desiccation. In environments where osmotic shocks or desiccation is likely to be faced more frequently, a spherical shape is more likely to evolve.

These are speculations, and mere speculations don't make science. The speculations should lead to testable predictions, which should be tested through observations or experiments. The tests may either reject or support a hypothesis. We can make the following testable predictions from the speculations we have made.

a. Bacteria with the fastest growth rates should be rod shaped and not cocci, since greater rate of nutrient uptake will allow faster growth.

b. In environments such as perennial fresh water lakes or the inside of the gut of animals, where osmotic conditions are fairly constant, one should find a greater proportion of rods as compared to environments such as soil where large osmotic fluctuations and prolonged periods of desiccation are common.

c. Since rod shaped organisms are more susceptible to desiccation, they may need additional sophisticated mechanisms of resistance such as spore formation. The prediction of the hypothesis is that rod shaped bacteria should show a greater proportion of spore formers than cocci.

d. Clustering of cells reduces the surface exposed to the environment. Rod shaped cells should not show a tendency to form clusters since clustering will defeat the purpose of being rod shaped while cocci should show profound tendencies of clustering in all dimensions since it further reduces the surface area.

Exercise: In order to test the above predictions, students can do the following simple exercises:

1. Find out from text-book literature, the names of bacteria having the smallest doubling time. Find out whether they are rods or cocci.

2. Find out the names of bacterial species in human gut. How many of the species are rod shaped and how many are cocci? Similarly find out the names of bacterial species found in soil. How many are rods and how many cocci?

3. Plate out fresh fecal sample and garden soil. Randomly pick up any 30–40 colonies from each and observe the morphological characters. What is the proportion of rods and cocci in both the samples? Furthermore, in which of the environments do you expect cocci to be in three dimensional clusters and in which environment more in linear chains? Remember that less surface is exposed by clustering in three dimensions compared to forming a linear chain.

4. Expose a plate to air. In air do you expect more rods or cocci? Confirm by randomly picking 30–40 colonies.

5. Find out from the literature, among the spore forming bacteria, how many are rods and how many cocci. In addition find out how many rod shaped bacteria are found isolated, how many form chains and how many form clusters. Similarly how many species of cocci are isolated, how many form chains and how many form clusters.

Do the results of your exercises support the hypothesis? Do the predictions turn out to be correct?