CELL SHAPES AND ORGANIZATION

Models:

1. Rod-shaped cells. Orient the model so that the label is closest to you. On the top of the plate are two individual cells of different lengths. A chain of cells, with one of the cells in the process of dividing, is below.

2. Round cells (cocci). Orient the model so that the label is closest to you. Above, at the right, are cells of Streptococcus. These cells form linear chains. At the left are the Staphylococci. Here the cells are arranged in a three-dimensional cluster.

3. Spiral-shaped cells. The model depicts a Spirochete. You might be able to feel a small ridge running along the surface of the body. These represent axial fibrils, organs of motility which are attached to the ends of the cell.

4. Filamentous cells of Streptomyces, enlarged about 5000X. Place the flat plate of the model on a surface with the label in front. The upright part represents a cross section of soil, with the top the air-soil interface. Streptomyces mostly lies just below the surface, but aerial hyphae extend upward to expose the chains of small, bead-like spores included in the model.

The cells of each bacterial species have a characteristic shape. One of the most common of these shapes is a cylinder with rounded ends, much like a short sausage. Bacterial cells with this shape are called rods (**Model 1**). In this model, the cells are attached to a flat plate so that their spatial relationship is maintained. The cells can be found singly (top) or attached to each other as chains (bottom). The plane of cell division is perpendicular to the long axis of the rod. The middle cell in the chain is in the process of dividing. There is an indentation in the middle of the cell. This indentation will increase, constricting the cell until two separate rods are formed.

An example of a rod-shaped organism is *Escherichia coli*, which has cells about 0.0005 mm in diameter and a length four times as long, about 0.002 mm. The size is often stated in micrometers, also called microns. A micron is one millionth of a meter, so the cell would be 0.5 by 2 microns. The length is not constant, however, but increases before it divides. These bacteria and others are so small that we cannot directly detect individual cells. Just how small is this? If the cell was enlarged 1000 times, it would be 0.5 mm in diameter and 2 mm long. This is about the size of a grain of coarse sand. If it were hard like sand, you would probably be able to detect it on a smooth surface by touching.

Cells that are nearly spherical cells are also commonly found. Such cells are called cocci. The Staphylococci and Streptococci are examples (**Model 2**). Both groups contain important disease-causing species. While the individual cells appear very similar, their arrangement is different. Streptococcal cells are arranged in long chains (**Model 2,** right), whereas Staphylococcal cells are grouped in clusters (left). The difference is due to the planes of cell division. Streptococci always divide along the same plane. In **Model 2**, right side, the plane of division is perpendicular to the flat surface of the model and always oriented in the same direction. One of the cells in the chain, fourth from the right end, is in the process of dividing. You can feel a furrow between what will become the two cells formed after division. If the cells remain associated, the result after many divisions is a long chain of cells.

In contrast, the Staphylococci can divide along three planes, not just one. The first of these is identical to the plane of division for Streptococcus. The second is also perpendicular to the flat surface of the model but rotated 90 °. The last plane is parallel to the flat surface. Division along this plane would produce cells extending vertically. Remarkably, the division planes are sequential. If a cell divides along plane 1, the resulting two cells divide along plane 2 and then the cells resulting from this division along plane 3. The progression then repeats in the same order. Thus cells “remember” the plane of the previous division and this information is then used to set the plane of the next division.

Although rods and cocci are common shapes of bacterial cells, there are other shapes as well. Some bacteria are helical, much like a corkscrew (**Model 3**). An important group are the Spirochetes. Members of this group cause several significant diseases, for example syphilis. The cells are motile, propelled by rotation of the helical cell in liquid. The motion is like that of a simple corkscrew. When the corkscrew is turned it will move into the stationary cork stopper of a bottle. In the same way, Spirochete motion is like a corkscrew being driven through watery liquid, which at the scale of bacteria is viscous and resistant.

One other important kind of bacterial cell shape and organization must be described. The Streptomyces, a large group of soil and aquatic bacteria, produce a network of filaments made up of attached cells. Part of such a network is depicted by **Model 4**. Orient the model so that the base is resting on a solid surface and the label is in the front. The vertical portion of the model represents a cross section of soil, with the air-soil interface indicated by the cross-piece at the top. You can feel in the cross-section tubes extending in various directions. Some of these tubes are branching. These tubes represent the filaments that are part of the Streptomyces network of cells. The network grows by elongation at the tips of these long filaments with occasional branching, one filament becoming two as shown in the model. The filaments contain cross walls that divide it into compartments, but the individual compartments do not separate, although occasional fragmentation can occur. For Streptomyces, therefore, trying to describe the shape of a typical individual cell, or how such cells are arranged, does not make sense.

Streptomyces species also produce spores. Some filaments, called aerial hyphae, extend upward to the surface and a chain of spores is then generated from the tip (**Model 4**). The spores are very hardy and can survive adverse conditions for a long time. They are dispersed from the hyphae and then germinate at suitable locations to begin a new network.

The Streptomyces are notable for producing a wide range of chemical compounds that are not strictly required for survival. Compounds of this type are referred to as secondary metabolites. The characteristic odor of fresh, healthy soil is due to geosmins, secondary metabolites synthesized by Streptomyces. In addition, these organisms have been a major source of naturally occurring antibiotics. The first of these was discovered in the 1940’s and understandably named streptomycin.

QUESTIONS TO CHECK YOUR UNDERSTANDING

1. For a population of *E.* coli cells, short rods are sometimes called “new” cells and longer rods “old” cells. What is the reason for this?

2. Some cocci are arranged in groups of four cells. How many division planes are there in this case?

3. Streptomyces are sometimes referred to as multicellular organisms. What would be the arguments for and against this designation?