

the addition of ethanol. *Gram-positive* cells remain purple, while *gram-negative* cells become colorless. Finally, counterstaining with safranin leaves *gram-positive* cells purple, while *gram-negative* cells are red. This ability to react with the gram stain reveals intrinsic differences in the structure of the cell envelope.

A typical *gram-negative* cell is *E. coli* (see Fig. 2.2). It has an *outer membrane* supported by a thin peptidoglycan layer. *Peptidoglycan* is a complex polysaccharide with amino acids and forms a structure somewhat analogous to a chain-link fence. A second membrane (the inner or *cytoplasmic membrane*) exists and is separated from the outer membrane by the *periplasmic space*. The cytoplasmic membrane contains about 50% protein, 30% lipids, and 20% carbohydrates. The cell envelope serves to retain important cellular compounds and to preferentially exclude undesirable compounds in the environment. Loss of membrane integrity leads to *cell lysis* (cells breaking open) and cell death. The cell envelope is crucial to the transport of selected material in and out of the cell.

A typical *gram-positive* cell is *Bacillus subtilis*. *Gram-positive* cells do not have an outer membrane. Rather they have a very thick, rigid cell wall with multiple layers of peptidoglycan. *Gram-positive* cells also contain *teichoic acids* covalently bonded to the peptidoglycan. Because *gram-positive* bacteria have only a cytoplasmic membrane, they are often much better suited to excretion of proteins. Such excretion can be technologically advantageous when the protein is a desired product.

Some bacteria are not *gram-positive* or *gram-negative*. For example, the *Mycoplasma* have no cell walls. These bacteria are important not only clinically (e.g., primary atypical pneumonia), but also because they commonly contaminate media used industrially for animal cell culture.

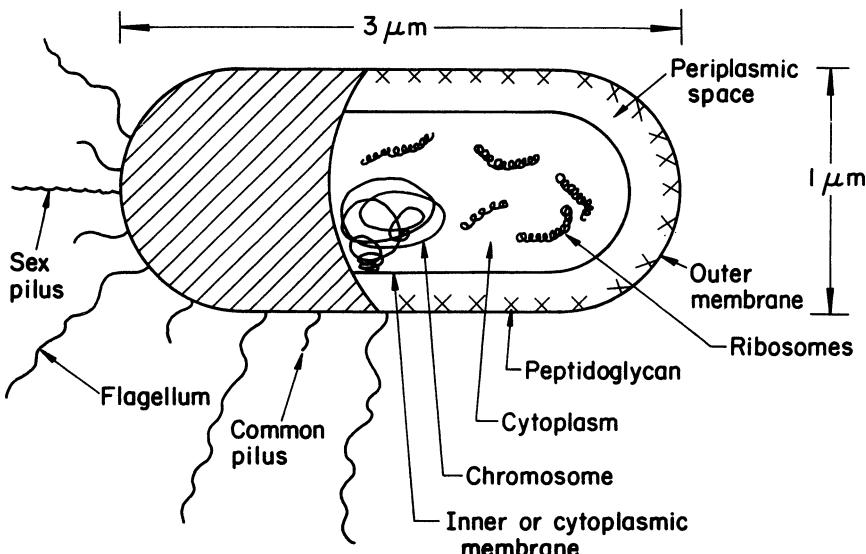


Figure 2.2. Schematic of a typical *gram-negative* bacterium (*E. coli*). A *gram-positive* cell would be similar, except that it would have no outer membrane, its peptidoglycan layer would be thicker, and the chemical composition of the cell wall would differ significantly from the outer envelope of the *gram-negative* cell.