

Prokaryots

Prokaryot is the name given to those single-cell organisms having a certain primitive cell structure. (The alternative cell structure, *eukaryotic*, is much more advanced.) The prokaryots comprise the bacteria and blue-green algae. (The latter are also known as cyanobacteria.)

Principally prokaryots lack a *nucleus* which the eukaryots possess. This is a membrane that encloses a region of the cell containing the cell's genetic material – the *chromosomes*. *Cytoplasm* is the name given to the material inside the cell but outside the nucleus in the case of eukaryotic cells. Thus in a prokaryotic cell the genetic material occurs in the cytoplasm along with the other cellular machinery only loosely localized near the center of the cell. The chromosome itself occurs as a single ring of *DNA*. In addition there may be smaller rings of DNA called *plasmids* scattered about the cytoplasm.

DNA, or *deoxyribonucleic acid*, is the genetic molecule responsible for storing, templating, and propagating all the instructions on how to make the organism itself. The DNA within a chromosome is organized into segments called *genes* which work together to effect specific characteristics or structures or processes within the cell. We will have much more to say about this later on.

More generally, the prokaryotic cell lacks any internal organization at all except for the *plasma membrane*. This is a structure to which the cell's *ribosomes* are attached providing the required stability for the ribosomes to carry out their task – protein synthesis.

Bacteria come in 3 basic shapes: rod (*bacillus*), round (*coccus*), and spiral (*spirillum*).

Reproduction in prokaryots is *asexual* meaning no genetic material is exchanged with another organism. Therefore the result of the reproduction is an exact duplicate, in terms of DNA, of the original, that is a *clone*. Reproduction is by *binary fission*. The cell wall pinches off near the middle of the cell thus forming two cells of half the size. The chromosome is duplicated prior to the separation with both halves getting a copy.

If not in reproduction the DNA complement of a prokaryot can nevertheless be changed in several ways thus forming an organism with new properties. First by *mutation*. This a direct modification of the DNA either by injury or by replication error. Another is by *conjugation*, bacteria can exchange DNA upon physical contact; this is especially so with respect to their plasmids. The other bacterium in the exchange need not be of the same species. (Thus drug resistance which may occur by mutation in one species of harmful bacteria can be passed to another, for example in hospitals.) A living bacteria can pick up DNA from a dead one, a process called *transformation*. And finally, in a process called *transduction*, bacteria can acquire DNA from an infecting virus (bacteriophage). (A *virus* is a living thing(?) even more primitive than a prokaryot in that it does not have any metabolic machinery or even a cell at all; it infects a living cell, injects its own DNA and coops the cell into making more virus particles.)

Under favorable conditions, bacteria reproduce approximately every 20 minutes.

Prokaryotes are *haploid* meaning they do not have paired chromosomes as do most eukaryotes. Paired chromosomes, called *homologs*, are two chromosomes both containing the genes responsible for the same characteristics in the cell. (But the genes themselves need not be the same.)

In times of stress, some bacteria form *endospores* – a portion of the cytoplasm and a copy of the chromosome walls itself off from the rest of the cell with a thick cell wall. Endospores are resistant to extremes in, for example, temperature, desiccation, and chemicals.

One reason for prokaryote reproduction has to do with the cell's ability to continue living: its *surface to volume ratio*. The *metabolism* of a cell is carried out within the volume of the cell. Metabolism describes the processes by which the cell takes in food and energy and turns them into everything the cell needs to live. But the exchange of materials with the outside world takes place across the surface of the cell.

Letting ℓ denote some characteristic length measurement of the cell (for example its radius for an approximately spherical cell), then the volume of the cell is proportional to ℓ^3 while the surface area is proportional to ℓ^2 . (For a spherical cell $V = \frac{4}{3}\pi\ell^3$ and $S = 4\pi\ell^2$.) Therefore the surface area per unit volume is

$$\frac{S}{V} = \frac{k}{\ell}$$

for some constant k . As the cell increases in size (volume) it has less and less surface in relation through which to take in food and expell wastes. It can dramatically increase this by dividing in half.