Introducing the prokaryotic cell

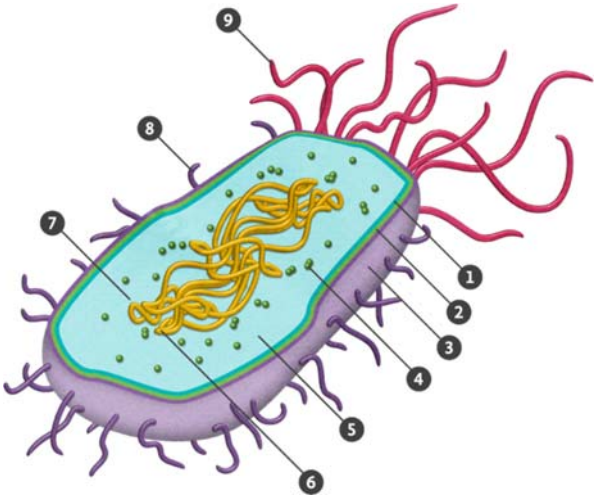

Illustration by Bret Syfert for 'Big Picture'

Prokaryotes, meaning 'before nucleus' (from the Greek 'pro' and 'karyon'), are structurally simpler and smaller than eukaryotic cells. As suggested by their name, they lack a nucleus or any other membrane-bound organelles (including mitochondria, endoplasmic reticulum and Golgi apparatus), yet share some of the features seen in the eukaryotic cell.

1. Plasma (or cell) membrane: Just like in eukaryotic cells, the plasma membrane acts as a physical barrier – controlling what can move into or out of the cell – and enables the cell to communicate with its neighbours and surroundings. It is made up of phospholipids, carbohydrates and proteins, some of which are involved in bacterial infections of the human body.

2. Cell wall: The cell wall, which is thicker than the plasma membrane, is mainly made of peptidoglycan (also called murein). In bacteria, the cell wall can also contain other proteins, depending on whether they are Gram-positive or Gram-negative (named for their response to the Gram stain, a technique used to classify bacteria). The cell wall provides strength and rigidity to the cell structure and is permeable to solutes to allow transport. Like plants, bacteria have both a cell membrane and a cell wall – animal cells have only a cell membrane.

3. Capsule (or slime capsule): The outmost layer of the prokaryotic cell. This structure is made up of thick polysaccharide, making it highly organised and not easily removed. It is the cause of some bacterial diseases, as the capsule helps the bacteria stick to human cells and can prevent phagocytes engulfing and destroying them.

4. Ribosomes: Similar to but smaller than those found in eukaryotes, these structures are made of protein and ribosomal RNA (rRNA). They are involved in the process of translation, in which proteins are synthesised from mRNA. Unlike in eukaryotic cells, they are found only in the cytoplasm.

5. Cytoplasm: As in eukaryotes, the cytoplasm is made up of water, proteins, and organic and inorganic molecules, and is the store for all the cell's chemicals and the site of many chemical reactions.

6. Circular DNA: These circular chromosomes contain the genomic DNA of the cell. Bacteria can also have plasmid structures (not shown) that are separate from the chromosome and are often gained from plasmid exchange with other bacteria. These plasmid structures often contain genes for antibiotic resistance.

7. Nucleoid region: describes the region of the cytoplasm that contains the circular DNA. This region can often be visualised under electron microscopy.

8. Flagella: Long, ‘whip-like’, rigid tails that rotate to help the cell move in its surroundings. Unlike the flagella structures found in eukaryotic cells, these are not surrounded by the cell membrane and are made up of flagellin proteins (rather than tubulin).

9. Pili: Pili, which are appendages that are shorter than flagella, can ‘fix’ the cell to a surface and can aid the exchange of genetic information between cells.

At a glance, there are some obvious structural differences between prokaryotic and eukaryotic cells. But at a more functional level, how do these differences affect how the two cell types work?

Some aspects of their life cycle might not seem too different. Both use their genetic material – DNA – as a template to create mRNA through transcription, and then convert this mRNA into protein, through translation, using ribosomes. However, because the eukaryotic cell keeps its DNA locked up in the nucleus, it has to complete each stage of this process separately and move the mRNA from the nucleus out to the cytoplasm – or rER – to be translated. Prokaryotes, by contrast, don’t face this obstacle and perform both transcription and translation in a ‘coupled’ manner – allowing protein synthesis to happen faster.

Another aspect that is different between the two cell types is how they multiply. Eukaryotic cells divide through a complex mechanism called mitosis. Prokaryotic division follows some similar concepts but, thanks to prokaryotic cells’ relative simplicity, they can divide much faster as they don’t have to remove and remake the nuclear envelope or replicate membrane-bound organelles. Their division – known as binary fission – starts with copying the circular DNA plasmid, and as the cell elongates these plasmids are moved to either end of the cell. The cell then pulls apart into two new cells, each with one copy of the DNA, ensuring that each copy is genetically identical.