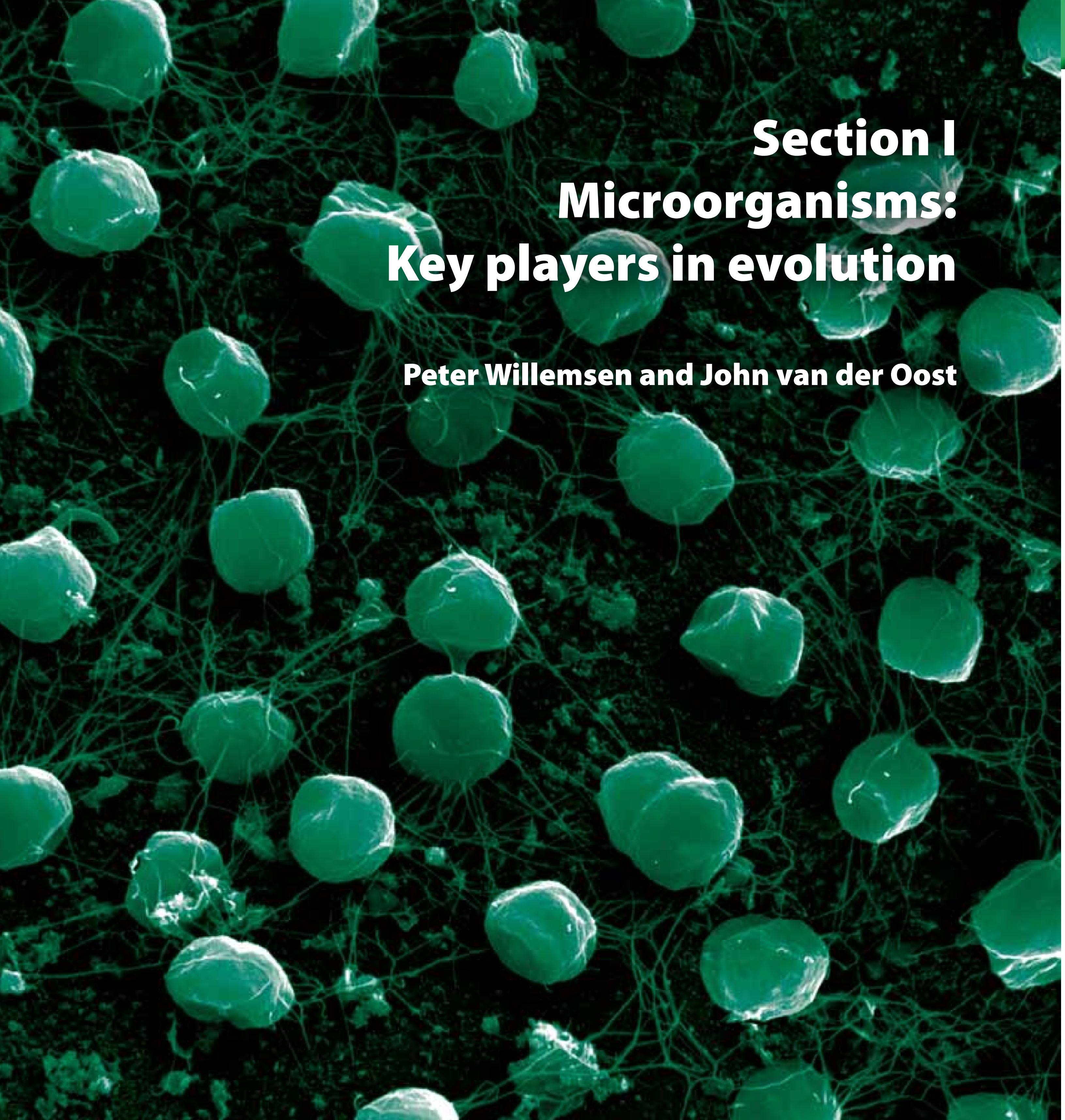


Section I
Microorganisms: Key players in evolution

Peter Willemsen and John van der Oost

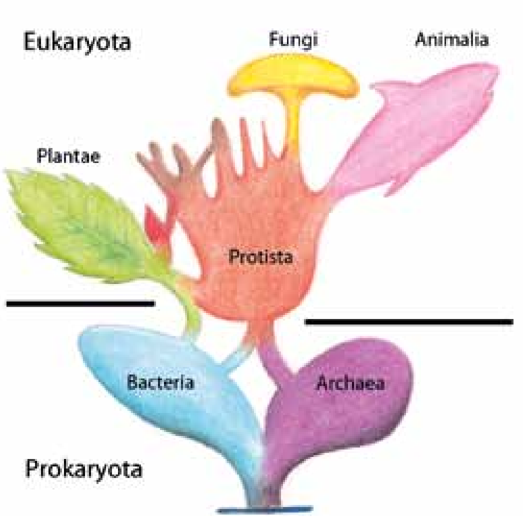
Microorganisms are, by definition, the smallest living organisms on Earth. They were the first inhabitants of our planet and, compared to their multicellular descendants, occur in massive numbers and incredible diversity. This quantitative and qualitative superiority reflects their prominent role in evolution as we know it. If we consider the 4.5 billion years of the Earth's existence in terms of a single calendar year, then the first microorganisms appeared by the end of February. More complex multicellular organisms such as worms only appeared in the middle of November. In late November, land plants appeared and the first mammals evolved by the middle of December. On December 31, just one second before midnight, our human ancestors arrived on the scene.

The relatively minor contribution of multicellular organisms to the total number of living organisms is reflected by the structure of the evolutionary tree of life. There are three domains: the Bacteria, the Archaea and the Eukarya. The first two domains are made up of distinct types of prokaryotes, generally unicellular microorganisms without intracellular compartmentation (no nucleus, no mitochondria). The eukaryotes evolved intracellular compartments (nucleus, mitochondria), but the vast majority are still single-celled microorganisms (yeast, algae, protozoa). Multicellular organisms such as plants and animals only form a minor branch on this phylogenetic tree.

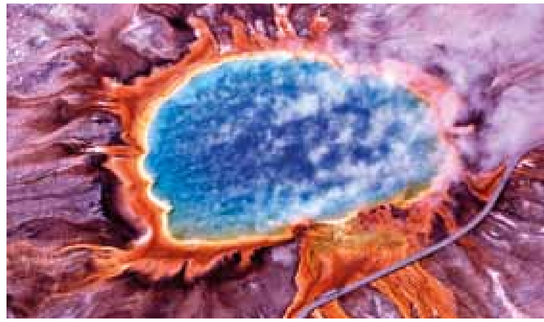
This first Section of *Mighty Microbes* describes a number of important, fundamental topics in microbiology. First of all, how did the first living cells evolve? Obviously, despite spectacular scientific progress over the past 50 years, there are still many gaps in our knowledge of that intriguing beginning.

It is important to realize that all of the microorganisms that have been studied in any detail since the discovery of microorganisms by pioneers such as Antoni van Leeuwenhoek just make up the tip of the iceberg. An important step in our understanding of microbial diversity became possible after the development of molecular biology techniques in the 1970s. A ground-breaking discovery revealed that the Archaea actually formed a second prokaryotic domain containing organisms very different from the Bacteria. Advances in molecular detection have since allowed the ongoing discovery of huge numbers of different microorganisms. At least in part due to rapidly advancing DNA-sequencing techniques, major progress has also recently been made in understanding the evolution of more complex organisms, the eukaryotes. In recent decades, it has become clear that billions of years of evolution have produced an amazing diversity of microorganisms.

Many bacteria and archaea have been shown to have unique features that allow their survival, and even growth, in a wide range of environments with major variations in physical and chemical conditions including temperature, pressure, acidity/alkalinity, and nutrition. Some microbial properties, especially when combined with enormous amounts of microbial biomass, can have a major impact on life, locally or even on a global scale. For example, many of the more complex eukaryotes, including humans, rely on the oxygen in the atmosphere that is mainly generated by microorganisms. As further examples, this section will showcase the role of microorganisms in the nitrogen and carbon cycles on Earth. The take-home message of these introductory chapters is that, despite their size, microorganisms are great!



Artistic impression of the tree of life.



The colours around this hot spring in Yellowstone National Park in the USA are the result of microbial mats.

Emiliania huxleyi, a unicellular, eukaryotic alga, can form massive blooms