Preface

The *Encyclopaedia Britannia* defines biotechnology simply as the use of biology to solve problems and make useful products. The term biotechnology was coined in the 1960–1970s when the techniques in cellular and molecular biology were developed. It became obvious that basic research could lead to useful products and processes in the medical and industrial field, such as to produce therapeutic substances or to refine industrial processes by producing useful substances like vitamins and enzymes. In the early days, the most common technique used in biotechnology was genetic engineering. The aim was to introduce genes coding for useful compounds into a "production cell" to enable a large scale production of the desired compound (e.g. insulin). However, with the advancement of basic research in cellular and molecular biology, the development of new powerful instruments, advanced computer technology, and the discovery of extremophilic organisms with astonishing capabilities, a plethora of new applications has emerged in all kinds of scientific fields. It goes without saying that many developments in biotechnology would in fact not have been possible without the extremophiles. The most well-known example is the *Taq* polymerase, which is used today worldwide in the polymerase chain reaction (PCR). This enzyme was initially isolated from a thermophilic microbe in a hot spring in 1966. Since the late 1970s, the techniques of biotechnology have shifted toward more refined and advanced applications, such as developing preventive measures of diseases, making a process more efficient and sustainable with regard to energy usage or reduced negative impact on the climate, or to even boost up an organism's survival capabilities. The intention of this volume is to present a survey of the current state of the art and the further potential of biotechnological applications based on different extremophilic or extremotolerant organisms. The contents have been sorted by application field, starting with industrial and medical biotechnology (Chapters 1–5), which is then followed by environmental biotechnology (Chapters 6–9), geobiotechnology (Chapters 10–11), and the emerging new field, astrobiotechnology (Chapters 12–14).

In Chapter 1, Kaul and Abouhmad present a survey on how different extremophiles can serve as a source of different novel natural products, while Stennett et al. present in Chapter 2 the amazing pharmacy sources from different extremophiles. In Chapter 3, Karlsson et al. present cutting-edge technology in metabolic engineering of thermophiles, which also includes CRISPR/cas9-based technology. Espina et al., representing an international biotech company, present in Chapter 4 how extremozymes can be screened and used to produce novel substances. In Chapter 5, Kunte et al. demonstrate a new application field, namely how to use ectoine, a compatible solute from halophiles, to support biological material to survive extreme osmotic stress and other stressful conditions, such as freezing and radiation.

The applications within environmental biotechnology start with a survey in Chapter 6 by Haruta on how energy is produced and converted in thermophilic

https://doi.org/10.1515/9783110424331-202

photosynthesizing systems and how this can be harnessed based on synthetic ecology. Ferro et al. describe in Chapter 7 how cold-adapted algae can be used to transform wastewater into clean water, air, energy, and useful biosubstances. In Chapter 8, Adeleke et al. describe how microbes can adapt to hazardous substances, such as polycyclic aromatic hydrocarbons, while Þorsteinsdóttir and Vilhelmsson describe in Chapter 9 the potential of bioremediation in cold desert environments.

The geobiotechnology section is introduced by Chapter 10, where Stan-Lotter takes us deep down to the subsurface to explore how microbes there can support a safe storage of nuclear waste. Marrero et al. show in Chapter 11 how microbes can be useful for a cost-efficient solution to recover different types of heavy metals from ores and other metal-containing solutions.

Last but certainly not least when it comes to amazing novel applications of extremophiles is the new field of astrobiotechnology. Each of the last three chapters deal with a specific group of organisms of great interest for both applications on Earth, as well as in space related research. In Chapter 12, Verseux elaborates how cyanobacteria can be employed on space missions for different purposes, and how lessons learned from this could benefit Earth-based technologies. Vandewalle-Capo et al. reveal in Chapter 13 how even yeast, which was once thought to be just an ordinary mesophile, harbors an impressive potential of tolerance under different extreme conditions. Yeast is therefore not only interesting for different kinds of biotechnological applications, but has also become an interesting model species in astrobiology. The last chapter (14, by Rehamnia et al.) deals with remarkable microscopic animals, the tardigrades – known for their impressive capabilities to survive extreme conditions by morphological adaptations. The biotechnological potential of the tardigrades was actually suggested over 50 years ago, but it is only today, thanks to recent advanced research, that the biotechnological applications of tardigrades have just about started to become truly apparent.

More than ever, Louis Pasteur's statement on the difference between basic research and applied research has shown to be the key solution to all advance in science, in particular in biotechnology: "There does not exist a category of science to which one can give the name applied science. There are science and the applications of science, bound together as the fruit of the tree which bears it."

Umeå, April 8, 2020, Natuschka Lee

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