Preface

The continued release of contaminants into the environment, predominantly by industrial and agricultural activities, means that there is an ongoing need to remediate sites exposed to elevated concentrations of a wide range of pollutants. A number of chemical and physical processes are currently used to encourage the degradation of, or altered mobility of pollutants in field, laboratory and bioreactor settings. However, the microbial bioremediation of troublesome contaminants is increasingly seen as being both cost-effective and reliable, and a number of approaches are in widespread commercial use. Microbial bioremediation largely capitalizes on the metabolic activities of biofilm-dwelling microorganisms which are widely accepted as being responsible for the majority of pollutant degradation in natural environments. Common methods for the *in situ* biological treatment of contaminated sites include the use of permeable reactive biobarriers in which the natural movement of water is used to direct subsurface contaminants though engineered 'walls' of enhanced biofilm microbial activity. Alternatively, contaminated media can be extracted and manipulated within biofilm bioreactors. In this way, a greater level of experimental control is provided and the fate of pollutants, as well as their degradation products may be more easily monitored. Where the biomass and activity of potential degraders in the natural community is too low, new microbial strains can also be introduced. Regardless of the approach used, it is evident that biofilm-dwelling microbial communities rather than planktonic organisms dominate the bioremediation of most pollutants. Thus, an increased understanding of the complex structure of microbial biofilms and the communication and cooperation among individual microbial cells will inevitably aid their successful use in bioremediation applications. Fortuitously, recent advances in both molecular and microscopy-based methods have revolutionized our understanding of the microbial biofilm 'mode-of-life'. The three-dimensional structure of biofilms and their coating by extracellular polymeric substances have been interrogated using a broad range of microscopy-based techniques to reveal how this mode of community organization provides microbial cells with substantial additional protection from toxic substances and mechanical stresses. Gradients in the availability of nutrients, toxicants and gases across biofilm structures have also been observed and characterized. The complex spatial organization of biofilms provides a variety of microniches to support an increased diversity of microbial life and their associated metabolic potential. Evidence of this is provided by the outputs of DNA sequencing studies, while advanced isotope labelling methodologies have permitted the accurate identification of even low-abundance taxa involved in key metabolic processes. As advances in biofilm research continue, the scientific community is finding ever more applications and ways to manipulate the degradation of pollutants by biofilms present in soils, natural waters, and on the surfaces of other organisms frequenting polluted environments, including plants and even fish!

In the first part of this book we provide an up-to-date review of the latest scientific research that has contributed to our understanding of the vital importance of microbial biofilms for the biological remediation of contaminated environments. In part two, the results of a variety of key case studies are presented to highlight the broad range of treatment approaches and applications at our disposal. Finally, as the application of biofilms in bioremediation continues to increase, we seek to predict the future trends and likely growth areas in biofilm-related research.

Gavin Lear