Introductory Preface

General Aspects
Living organisms are able to synthesize an overwhelming variety of polymers which can be distinguished into eight major classes according to their chemical structure: (1) nucleic acids, (2) proteins and other polyamides, (3) polysaccharides, (4) polyoxoesters (polyhydroxalkanoic acids), (5) polythioesters, (6) polyanhydrides (polyphosphate), (7) polyisoprenoids, and (8) lignin. These biopolymers accomplish quite different essential or beneficial functions for the organisms. Microorganisms are capable of synthesizing biopolymers belonging to classes 1–6, whereas eukaryotes synthesize mainly biopolymers belonging to classes 1–3 and 6–8. Among the biopolymers produced are many used for various applications in industry. Biotechnological production of polymers is at present mostly achieved by fermentation of microorganisms in stirred tank bioreactors, and the biopolymers can be obtained as extracellular or intracellular compounds. Alternatively, biopolymers can also be produced by enzymatic in vitro processes. However, by far the largest amounts of biopolymers are still extracted from plant and animal sources or from algae.

Biopolymers exhibit fascinating properties and play a major role in the food industry for processing food and modifying food texture and properties. Among the various biopolymers, polysaccharides and polyamides are the most important in the food industry.

Polysaccharides
Polysaccharides are per se renewable resources or are produced from renewable resources, and they offer a wide variety of potentially useful products to human life. They comprise a distinct class of biopolymers, produced universally by living organisms including microorganisms, plants, and animals. They exhibit a large variety of unique and in most cases rather complex chemical structures, different physiological functions, and a wide range of potential applications, particularly for foodstuff. For instance, a number of plant polysaccharides such as starch have been widely used in food for a very long time. More recently, other plant or microbial polysaccharides such as levan, inulin, curdlan, and pullulan have also found use in the food industry. Similarly, marine algae have yielded such useful products as agar, alginate, and carrageenan. Cellulose and its derivatives have also found many uses as food additives because of their easy availability and cheapness. While cellulose, chitin, and some other polysaccharides are insoluble, many other polysaccharides are water-soluble and are capable of significantly altering the rheology of aqueous-based solutions and find a wide range of application in the food industry.
Proteins, Proteinaceous Materials, and Poly(Amino Acids)

Proteins are biopolymers composed of amino acids and are essential components of every biological system. They are catalysts of diverse capability, agents of molecular recognition, mediators of self-assembly, transducers of energy and information, media of communication, producers of directed motion, and librarians of the genetic program. The specific amino acids used and the sequence of amino acids in a protein polymer chain as well as the length of the polymer chain are determined by the corresponding DNA and RNA templates, respectively. Therefore, ribosomal protein biosynthesis yields principally monodisperse products which a clearly defined chemical structure. Proteinaceous materials provided by nature have been exploited by human technology for millennia. Silks, furs, leather, bone, horn, feathers, all have been—and many still remain, despite modern chemistry—essential materials for all human cultures. In addition, organisms and in particular microorganisms are capable of synthesizing other biopolymers also consisting of amino acids; they are referred to as poly(amino acids) or polyamides. Polyamides are in contrast to proteins synthesized by soluble synthetases, which use free amino acids as substrates in ATP-dependent reactions. Since synthesis is not directed by a template, the products are polydisperse. In addition, the specificities of these synthetases are also not restricted to their “natural” substrates, and they are therefore not strictly specific. Moreover, R-stereoisomers of amino acids and linkage types not found in proteins occur in poly(amino acids). One of these poly(amino acids) is cyanophycin, which is a copolymer of aspartic acid and arginine. In addition to cyanophycin, microorganisms synthesize poly(glutamic acid) and poly(lysine) in a similar way by template-independent mechanisms. Whereas cyanophycin is a storage compound for nitrogen, carbon, and energy, and occurs as insoluble cytoplasmic inclusions in many bacteria, poly(glutamic acid) and poly(lysine) are only synthesized by a few microorganisms and the polymers occur as extracellular polymers.

Many proteins and poly(amino acids) are of commercial interest because of their catalytic or physicochemical properties. The advances in recombinant DNA technology have presented new approaches and opportunities for design and biosynthesis of protein materials. In addition, many traditional proteins prepared by extraction of animal (e.g., collagen) or plant (e.g., soy or zein from corn) tissue are being chemically or physically modified for new applications in biotechnology and in the food industry.

Scope of this Book

Taking the importance and the applications of biopolymers in the food industry as our guide, we carefully selected from Volumes 5–8 of the ten-volume work *Biopolymers* 19 chapters all dealing with polysaccharides, proteins, proteinaceous materials, and poly(amino acids). The present two-volume spin-off product covers 13 different types of polysaccharides in Volume 1 and six different polyamides in Volume 2. The polymers from these selected chapters are successfully being used as key food additives, e.g., for gelling, viscosifying, stabilizing, and stiffening of food products. They include bacterial cellulose, curdlan, xanthan, dextran, levan, exopolysaccharides of lactic acid bacteria, pullulan, alginites from algae, carrageenan, pectins, starch, inulin, chitin, and chitosan from animal sources of polysaccharides. Enzymes for technical applications, collagen and gelatins, sweet-tasting proteins, and the seed storage proteins vicilin and legumin are also included. Poly(ε-1-lysine) and poly(γ-glutamic acid) represent the poly(amino acids) relevant for the subject of this volume. Each
polymeric substance is treated similarly, covering properties, production, patents, and applications, which range from traditional uses, e.g., of starch and pectins, to novel applications such as sweet-tasting proteins.

In compiling this handbook, it has been our intention to provide the scientific and industrial community with a comprehensive view of the current state of knowledge on polysaccharides and polyamides. This handbook attempts to review what is currently known about these fascinating biopolymers in terms of their discovery, occurrence, chemical and physical properties, analysis, biosynthesis, molecular genetics, physiological role, fermentative production, isolation, purification, and applications. With the title more focused and at a price more affordable than that of the complete Biopolymers series, this two-volume handbook will be of interest in particular to medium-sized laboratories that are interested or active in this area, and to libraries.

We consider it a strength of this collection that the individual chapters are diverse in style and in purpose. Some paint an area in broad, conceptual strokes, others in fine technical detail. Some present information, others arguments or interpretation. Some summarize past accomplishments; others point to future possibilities. We are convinced that each is in some way appropriate to its topic. As broad as this field is, there is of course no hope of completeness. We have attempted to sample broadly, but key omissions are inevitable and we readily acknowledge them. We will feel this handbook has been successful if some of these chapters stimulate readers to become interested in and solve specific problems, or make the field more accessible to newcomers.

Acknowledgments
Whatever is accomplished is of course the achievement of the authors. We are most grateful to all of them for devoting so much of their valuable time to this endeavor and for sharing their knowledge and insights so generously. We are also particularly grateful to the authors of the selected chapters for allowing the contents of their Biopolymers contributions to be included in this new title.

Last but not least, we would like to thank Wiley-VCH for publishing this new handbook with their customary professionalism and excellence and for their outstanding help throughout the gestation and birth of this handbook. Special thanks are due to Mrs. Karin Dembowsky, who initiated the Biopolymers series, to Dr. Andreas Sendtko, who continued and finalized it, and to many others at Wiley-VCH for their initiative, constant efforts, helpful suggestions, constructive criticism, and wonderful ideas.

Alexander Steinbuechel
Münster and Seoul
Sang Ki Rhee
May 2005