16
Carbohydrates

Mark D. Maloney
Spelman College, Atlanta, Georgia, U.S.A

I. INTRODUCTION

A. Carbohydrates

Their importance as nutrients has historically been the focus of research on carbohydrates. The importance of carbohydrate moieties as components of glycoconjugates—glycoproteins, glycolipids, mucins, and structural polymers—has become increasingly apparent. Examples include carbohydrate moieties as critical determinants of protein transport within cells and of cell homing within tissues of the body. The carbohydrate components of glycoproteins influence protein function, conformation, stability, and half-life in vitro and in vivo and function as important components of receptors in signal transduction pathways. Glycolipids and carbohydrate matrix components are important in a variety of biological systems such as the nervous system with regard to myelin formation and directed neuronal growth and in B cells and other types of cells as regulatory components of signal transduction pathways (epidermal growth factor, interferon-alpha, apoptosis, and antiviral pathways), cell adhesion pathways (selectin systems, CD19–CD77 interaction), and potentially other immune functions such as antigen presentation.

Carbohydrates are widely distributed in organisms. They usually have the general formula $C_n(H_2O)_n$, where five units (pentoses) or six units (hexoses) form the basic cyclic structures. This large family of natural products includes monomers of basic structures called simple sugars or monosaccharides, their dimers or disaccharides, polymers of a few basic structures known as oligosaccharides, and complex polymers called polysaccharides. Most simple sugars are either polyhydroxyaldehydes (aldoses, e.g., glucose) or polyhydroxyketones (ketoses, e.g., fructose). However, there are some that have at least one —OH group replaced by some other substituent. The two most common groups that replace the —OH group in these monosaccharides are —H and —NH2. Deoxy sugars (2-deoxy-D-ribose, etc.) have a CH_2 group in place of the α-CH(OH) group. Amino sugars (D-glucosamine, D-galactosamine) have an α-$CH(NH_2)$ group in place of the α-CH(OH) group.

Even though monosaccharides exist largely as cyclic hemiacetals or hemiketals, the pressure of carbonyl-containing compounds necessitates consideration of both acyclic and cyclic structures in sugar reactions. Common monosaccharides can be reduced to alkanepolyols (D-manitol, sorbitol) or oxidized to aldaric, aldonic, or uronic acids.

Because carbohydrates are present in various forms and there are many isomers and analogs, separation of these compounds often involves more difficult problems than the separation of other very abundant natural products. Difficulties are also encountered in detection owing to the lack of chromophores or fluorophores.