A complex and constantly changing mixture of polysaccharides enters the human colon every day. Most of these polysaccharides are plant cell wall polysaccharides. Although plant cell wall polysaccharides can be degraded to a limited extent by exposure to acid in the stomach, they are not digested at all by human small intestinal enzymes and thus reach the colon virtually intact. Also included in the mixture that enters the colon are host polysaccharides such as glycoprotein mucins secreted by goblet cells and mucopolysaccharides released during sloughing of intestinal mucosal cells. Since the rate of mucin production and mucosal cell turnover increases as the amount of fiber in the diet increases, the amount of host polysaccharide entering the colon is not constant but varies with the composition of the diet (Vahouny and Cassidy, 1986).

It is now well established that some of the starch in the diet reaches the colon (see, for example, Englyst and Cummings, 1985). Retrograded starch, which forms when starch is heated and cooled, is relatively resistant to digestion by small intestinal amylases. Also, starch in plant cells which remain intact in fragments of vegetable matter would also escape digestion in the small intestine. Microbiologists have long suspected that appreciable amounts of starch enter the colon because there are some major groups of bacteria in the colon which cannot ferment any polysaccharide except starch (Salyers et al., 1977; Salyers et al., 1978). It is unlikely that these bacteria could persist in such high numbers if their only source of carbohydrate was simple sugars lost by other colonic species which can ferment plant or host polysaccharides.

A fairly accurate estimate of the amount of plant cell wall polysaccharide which reaches the colon can be obtained from an analysis of fiber in the diet. An estimate of the amount of starch which reaches the colon could also be made based on information about the effects of various types of treatments on the starches in foods and measurements of the amount of starch which is resistant to amylase digestion. However, in the case of host glycoproteins and mucopolysaccharides, such an estimate cannot be made easily. It would be possible to
estimate the amount of host polysaccharide entering the colon by measuring the concentration in ileal fluid of sugars such as hexosamines, fucose and sialic acid which are found mainly in host products, although there are technical difficulties associated with quantitation of hexosamines and sialic acids. Also, samples of ileal fluid are difficult to obtain. So far, only one attempt has been made to measure host products in ileal fluid (Vercellotti et al., 1977). The results of this study indicated that polysaccharides containing fucose, hexosamines and sialic acids were present in concentrations comparable to those of the plant cell wall polysaccharides. However, only soluble polysaccharides were analyzed in this study, so the amount of plant cell wall material was probably underestimated.

Information about the total amounts of the various polysaccharides entering the colon is of limited utility unless the physical states of the polysaccharides are also known. Factors such as solubility or binding to protein and lignin are at least as important as structure in determining whether a polysaccharide will be fermented by colonic bacteria. The critical importance of solubility is illustrated by cellulose digestion in the human colon. Nutritional studies have shown that the cellulose in cabbage is extensively degraded in the colon (Van Soest, 1978). Thus there are clearly bacteria in the colon which can ferment the hydrated cellulosates in vegetables, although these microorganisms have not yet been identified. However, microcrystalline cellulose, a particularly insoluble form of cellulose, passes through the colons of most people without being degraded (Ehle et al., 1982). The importance of binding to nonpolysaccharide substances can be seen from studies of polysaccharide digestion by bacteria in the rumen of cattle. These studies have shown that binding of lignin to polysaccharides limits polysaccharide digestion. Accordingly, small amounts of a soluble polysaccharide which is not complexed to other materials could well have a greater impact on the colonic microflora than much larger amounts of a polysaccharide which is insoluble or in a sterically hindered complex. This could have practical significance in the case of sweeteners such as the fructo-oligosaccharides or in the case of food additives such as guar gum, both of which are soluble and rapidly digested by colonic bacteria.

MICROBIAL ECOLOGY OF THE COLON

Given the variety of complex carbohydrates entering the colon, it is not surprising that the microbial population of the colon is quite complex and consists primarily of carbohydrate fermenters (Moore et al, 1977). The genus Bacteroides, which accounts for 20% of all colon isolates, contains most of the strains which can ferment plant cell wall polysaccharides and host polysaccharides (Salyers et al., 1977). Some strains of Eubacterium, Bifidobacterium and Peptostreptococcus can also ferment plant cell wall polysaccharides (Salyers et al., 1978). However, the majority of colonic strains cannot ferment either plant cell wall polysaccharides or host polysaccharides, and it is not clear where they are obtaining the carbohydrate they need to maintain their numbers. As mentioned above, most of these bacteria can ferment starch, and enough starch may reach the colon to support them. Another possibility is that some of them may be able to ferment polysaccharides which have not been yet been tested in bacterial fermentation studies because they are not commercially available. Still another possibility is that consortia of these bacteria may be able to degrade polysaccharides which cannot be degraded by a single species.