Summary

Carbohydrate constitutes the major contributor to energy supply in the diets of infants and children. They include mono- and disaccharides and starches, which are all digested and absorbed rapidly and efficiently. In addition to these available carbohydrates, the diet contains unavailable carbohydrates like some oligosaccharides and plant fibres. In hypolactasia, which has to be considered a normal phenomenon in adults, the amount of carbohydrate reaching the colon may increase considerably, depending on the lactose content of the diet. Several other conditions can lead to malabsorption of single carbohydrates or to generalised malabsorption. The sequelae of carbohydrate malabsorption are well known and include abdominal pain, abdominal distension, flatulence, borborygmi, and osmotic diarrhoea. Only recently it has become clear that there is a gray zone between carbohydrate "absorption" and "malabsorption". The efficacy of carbohydrate digestion and absorption depends on several factors and healthy subjects may fail to absorb up to 20% of certain carbohydrates. This fraction is considerably higher in preterm infants as far as lactose is considered. The physiological role of these events is stressed by the observation that the residential anaerobic colonic flora is predominantly saccharolytic. The preservation of the anaerobic flora requires a daily energy supply of up to 60 g of carbohydrate. This is more than can be provided by fibre alone, the more so since fibres are only fermented to a very limited extent.

The fermentation products of bacterial carbohydrate metabolism are mainly short chain fatty acids and the gases CO₂, H₂, and CH₄. H₂, which is produced exclusively by bacteria and eliminated partly by diffusion into the blood and excretion via the lungs, may be used as a probe marker of carbohydrate fermentation. This thesis deals with breath H₂ determination as a measure of the incomplete absorption of carbohydrates, and with the relation between the incomplete absorption and abdominal symptoms in healthy and diseased children.

For the measurement of H₂ in breath an existing gas chromatographic technique was improved enabling the use of very small breath samples (Appendix A). These samples were obtained using a simple device that could be operated by patients and parents. By this method DBHPs were obtained in healthy children at home on their normal diets. Two different patterns were observed. In half of the children the excretion of H₂ in the breath was similar throughout the day, whereas in the other half a sharp increase was found late in the afternoon. This confirms that in healthy subjects a significant part of the dietary carbohydrates may escape absorption.

In a subsequent study the value of the DBHP was assessed in the investigation of children with abdominal symptoms and diarrhoea (Appendix B). In a significant percentage of children (37%) the DBHP was found abnormal; about half of these showed a sharp increase in breath H₂ concentration at the moment they reported abdominal symptoms. An abnormal DBHP was particularly found in children with functional abdominal complaints or giardiasis. Contrary to the lactose breath H₂ test, the DBHP enabled the direct corre-
Carbohydrate absorption in children

Abnormal DBHPs indicating carbohydrate malabsorption are found in several gastrointestinal conditions such as cystic fibrosis, methotrexate enteropathy, and dumping syndrome. In the latter emphasis is generally laid on the abnormal glucose metabolism that results from accelerated gastric emptying. We investigated also the importance of carbohydrate malabsorption in 10 children with dumping syndrome by measuring changes in both blood glucose and breath H₂ concentrations following a glucose load (Appendix C). Hyperglycaemia and increased breath H₂ excretion were constant features. The best discrimination from the normal blood glucose profile was obtained by the difference between peak and subsequent lowest blood glucose level, the Δ glucose. In dumping syndrome, Δ glucose was >5.9 mM and breath H₂ increase >10 ppm. In 8 children with persisting dumping symptoms we studied the effect of glucomannan, a highly hygroscopic fibre. Glucose tolerance, as measured by Δ glucose, was improved, but the effect on glucose absorption was variable. Glucomannan added to the meals did not improve symptoms. According to our results, glucomannan seems to be of no value in the treatment of dumping syndrome in children.

One of the carbohydrates that might be implicated in the complaints arising from increased fermentation in the colon is fructose. We studied fructose absorption in healthy children (Appendix D) and found incomplete absorption of the test dose in 73% of 31 children. The addition of an equal amount of glucose to the fructose solution resulted in almost complete disappearance of the breath H₂ increase. This effect was dose dependent. Presumably glucose exerts its effect on fructose absorption by improving the disaccharidase related fructose transport.

The practical consequences of these findings are that foods containing fructose in excess of glucose may provoke abdominal symptoms in susceptible children. The most important of these foods in the diets of children is apple juice. This contains per liter about 64 g of fructose, 24 g of glucose, 16 g of sucrose, and 4 g of sorbitol. Sorbitol is a poorly absorbed polyol. We investigated the possible role of apple juice in chronic nonspecific diarrhea (Appendix E). Nine children with chronic diarrhea and 8 controls performed apple juice breath H₂ tests with 250 ml of apple juice. All were daily consumers of apple juice. Breath H₂ excretion was significantly higher in the diarrhea group. Addition of 10 g of glucose to the apple juice resulted in a decrease of mean H₂ excretion by 80%. Supposedly about four fifths of the breath H₂ increase is due to unabsorbed fructose and the remainder to sorbitol. Elimination of apple juice from the diets of the children with chronic diarrhea resulted in normalisation of their stool consistency and frequency.