

This Week's Citation Classic

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Borgström B, Dahlqvist A, Lundh G & Sjövall J. Studies of intestinal digestion and absorption in the human. *J. Clin. Invest.* **36**:1521-36, 1957. [Swedish Med. Res. Council, Unit for Metabolic Studies, and Dept. Physiological Chemistry, Univ. Lund, Sweden]

Intestinal content, sampled over the length of the human intestine after feeding a test meal including a nonabsorbable reference substance, was analysed for food products, bile constituents, digestive enzymes, etc., to reveal the conditions for digestion and the sites of absorption. [The SCI® indicates that this paper has been cited in over 620 publications since 1961.]

Bengt Borgström
Department of Physiological Chemistry
University of Lund
S-220 07 Lund 7
Sweden

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"My PhD thesis in 1952¹ at the University of Lund, Sweden, concerned fat absorption in the rat. In 1954, I worked as a Rockefeller Foundation Fellow at Johns Hopkins University in Baltimore in Al Lehninger's laboratory. At a lipid conference at the McCollum Pratt Institute, I met Peter Ahrens from the Rockefeller Institute for Medical Research (now Rockefeller University), New York. We had had a previous correspondence on the methodology for separating 1- and 2-mono-glycerides from intestinal content during digestion and after some discussion decided that I should come to work in his laboratory later that year. Peter had developed a technique for sampling intestinal contents over the length of the intestine in man with a thin polyvinyl tubing. I returned to Sweden with 100 feet of the tubing, convinced that man was the ideal experimental animal for digestion and absorption studies.

"Two years later I obtained a research position with the Swedish Medical Research Council for digestion studies in man. When planning the experimental approach with

two graduate students (A. Dahlqvist and G. Lundh), we realized what was desperately needed was a nonabsorbable reference substance for the test meal. Figures for concentrations, *per se* rather noninformative, could then be converted to meaningful figures for dilution, concentration, and absorption. We found such a substance in PEG-4000. Long-chain polyethylene glycols became of interest to the pharmaceutical industry in the 1940s and were shown not to be absorbed from the intestinal tract. They were used by Sperber and Hyden in Uppsala, Sweden, in 1953 to study fluid movement in ruminant digestion.²

"With these techniques at hand and the analytical skill of Jan Sjövall, the only one at that time who could determine bile salts quantitatively, we proceeded to do studies in man (the generous offer of relatives and former friends to live transintestinally intubated for weeks is in retrospect thankfully acknowledged).

"This paper, in my opinion, has been cited because it contained some 'firsts': 1) the first use in man of a nonabsorbable reference substance that allowed calculation of sites of absorption and sizes of secretions, etc.; 2) the first concentration profiles of bile salts during digestion which made possible an estimate of number of cycling of the bile salt pool and total amount of bile salt circulated per day; 3) the first indication that dietary fat undergoes considerable hydrolysis in the stomach in man; and 4) less cited but not less important were the results indicating that the major locus of action of the enzymes (disaccharidases, peptidases) formerly ascribed to the *succus entericus* is intracellular.

"This work provided the basis for future studies in man in health and disease by Dahlqvist³ and Lundh⁴ (now professors in nutrition in Lund and in surgery in Stockholm, respectively), myself,^{5,6} and many others. The importance of this work was recognized in 1979 when I was awarded the William Beaumont Prize in Gastroenterology by the American Gastroenterological Association."⁷

1. **Borgström B.** *Studies on intestinal fat absorption in the rat.* PhD thesis. Lund, Sweden: University of Lund. 1952.
2. **Sperber I, Hydén S & Ekman N J.** The use of polyethylene glycol as a reference substance in the study of ruminant digestion. *Ann. Agr. Coll. Sweden* **20**:337, 1953.
3. **Dahlqvist A & Borgström B.** Digestion and absorption of disaccharides in man. *Biochemical J.* **81**:411-18, 1961.
4. **Lundh G.** Pancreatic exocrine function in neoplastic and inflammatory disease; a simple and reliable new test. *Gastroenterology* **42**:275-80, 1962.
5. **Hoimann A F & Borgström B.** The intraluminal phase of fat digestion in man. The lipid content of the micellar and oil phases of intestinal content obtained during fat digestion and absorption. *J. Clin. Invest.* **43**:247-57, 1964.
6. **Hildebrand H, Borgström B, Békássy A, Erlanson-Albertsson C & Helin I.** Isolated co-lipase deficiency in two brothers. *Gut* **23**:243-6, 1982.
7. Presentation of the Beaumont prize to Bengt Borgström and Alan Hoimann. *Gastroenterology* **77**:948-66, 1979.