appropriate controls the concentration of each amino acid could be established. The absence of glycylysproline (<0.5 mm) from the samples was established by t.l.c. From each of two to six animals a minimum of four sacs were prepared from the ileum. Examination of sacs after incubation by light-microscopy failed to show any disruption caused by the experimental procedure.

Fig. 1(a) shows the glycine and proline concentrations of sac contents (serosal fluid) expressed as percentages of those in sacs from uninfected control animals (n = 15). Control values were 4.17 ± 0.13 mm for glycine and 3.55 ± 0.10 mm for proline. Less amino acid appeared in sacs as the infection progressed, with only a slight return towards normal within 21 days. Weight gain in infected animals was less than in controls, with a maximum difference on day 8. This correlates with the life-cycle of the parasite, which, after invading epithelial cells of the small intestine within hours of inoculation, leaves the animal around day 9 in the form of oocysts that can be detected in faeces. The extent to which the epithelial layer had recovered by day 21 is not yet known, but reports from chickens suggest that it is exceptional for macroscopic lesions to persist beyond day 12 (Turk, 1978).

Absorption of amino acids from the human buccal cavity

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Absorption of drugs across the mucosa of the human mouth (buccal cavity) has been investigated extensively (reviewed by Beckett & Hossie, 1971). Subsequently the buccal absorption of some nutrients has been studied, e.g., sugars and vitamins.

Manning & Evered (1976) found that buccal absorption of D-glucose and L-arabinose was stereospecific. The buccal absorption of D-glucose, D-galactose and 3-O-methyl-d-glucose was thought to implicate carrier-mediated transport (Manning & Evered, 1976), as in small intestine (McMichael, 1971). The absorption mechanism for a poorly absorbed disaccharide, lactulose, was thought to be passive diffusion across the mucosa of both buccal cavity and small intestine (Sadoogh-Abasian & Evered, 1979).

The present study was designed to compare the absorption of mixtures of amino acids from the buccal cavity with that found for the small intestine.

The technique for buccal absorption was a modification (Manning & Evered, 1976) of the method of Beckett & Triggs (1967). Amino acids were determined after deproteinization, by using an automatic analyser (Locarte Scientific Instruments Co.) with D-norleucine as an internal standard. Incubation studies with amino acid mixtures suggested that losses by bacterial metabolism were negligible.

Our results show that buccal absorption of amino acids was also stereospecific. The absorption of a mixture of D-amino acids (Fig. 1) at 2 mm concentration was significantly lower (P < 0.01 to P < 0.005) compared with a mixture of L-amino acids (Fig. 1, II). Similar results were found with loops of rat small intestine (Gibson & Wiseman, 1951). By contrast, D-tyrosine and D-phenylalanine did not participate in the active transport of L-amino acids across hamster intestine (Lin et al., 1962).

Buccal absorption of L-amino acid mixtures at initial concentrations of 2 mm and 8 mm revealed that the uptake of long-chain neutral amino acids was most rapid compared with other amino acids (Fig. 1, II and III). A similar pattern was noted with three different subjects. Tasaki & Takahashi (1966) perfused equimolar mixtures of 18 L-amino acids through chicken intestine. They too found high absorption rates with amino acids with large non-polar side chains, whereas glycine and amino acids with polar side chains were absorbed slowly.

With L-amino acids the human intestine showed rapid absorption of isoleucine, leucine, methionine and arginine, but slow absorption of threonine, histidine, glycine and glutamic acid (Orten, 1963). Similarly, Adibi et al. (1967) showed that methionine, isoleucine, leucine and valine were absorbed rapidly from amino acid mixtures by human intestine, whereas acidic amino acids were absorbed slowly. By comparison, we found that buccal mucosa absorbed rapidly the L-isomers of the following amino acids: phenylalanine, arginine, methionine, isoleucine and leucine (Fig. 1). Glutamic acid and threonine were poorly absorbed. In contrast with the present work, a cyclic amino acid, D- or L-cycloserine, was absorbed poorly across the mucosa of the mouth, the colon (Sprake & Evered, 1979) and the small intestine (Wass & Evered, 1971). In summary, the present investigation supports the hypothesis that certain nutrients are absorbed across the mucosa of the buccal cavity by processes similar to those in the small intestine. As well as the sugars mentioned above, this hypothesis now includes L-amino acids and some vitamins: ascorbic acid (Sadoogh-Abasian & Evered, 1979), lactulose (Evered & Sadoogh-Abasian, 1979), nicotinamide and nicotinic acid (Sadoogh-Abasian & Evered, 1980; Evered et al., 1980).
Further proof awaits the isolation of carrier molecules from these mucosae.

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### Table 1. Effect of aspirin on the absorption of 10 mm-D-glucose across human buccal mucosa

Mean values are shown, ± S.E.M. for six experiments. The subject was a 22-year-old male Caucasian, and informed consent was first obtained. Statistical significance was determined by Student’s t-test.

<table>
<thead>
<tr>
<th>Aspirin concn. (mm)</th>
<th>Glucose absorbed (μmol/5 min)</th>
<th>Statistical significance</th>
<th>Inhibition (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 (control)</td>
<td>68.1 ± 0.2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>20</td>
<td>48.0 ± 1.1</td>
<td>P &lt; 0.005</td>
<td>30</td>
</tr>
<tr>
<td>15</td>
<td>68.5 ± 0.4</td>
<td>P &lt; 0.005</td>
<td>18</td>
</tr>
</tbody>
</table>

Aspirin inhibition of glucose absorption from the human mouth

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Aspirin inhibited glucose absorption from the gastrointestinal tract of the human in vivo (Arvanitakis et al., 1977) and the rat in vitro (Cooke et al., 1979). Glucose was absorbed from the human mouth apparently by a Na+-dependent carrier-mediated process (Manning & Evered, 1976). The aim of the present study was to investigate whether aspirin also inhibited glucose transport across buccal mucosa.

Absorption of D-glucose from the human mouth in vivo was studied in the absence and presence of aspirin (acetylsalicylic acid) at pH 6 by a published method (Manning & Evered, 1976). Equimolar citric acid was substituted for sodium citrate in the buffer solution and 3.5 mM-CaCl₂ was added. D-Glucose was measured enzymically (Dahlqvist, 1964). Absorption, measured as a loss from the buccal cavity, was at an initial concentration of 10 mm-glucose. This value was on the upper linear portion of absorption rate in relation to glucose concentration (Manning & Evered, 1976).

The results given in Table 1 show that aspirin inhibited glucose absorption from the buccal cavity of a male human adult aged 22 years. By comparison, aspirin at 10 and 20 mm inhibited transport of 40 mm-glucose across everted sacs of rat small intestine by 16 to 70% (Cooke et al., 1979). It is probable that buccal mucosa is permeable to aspirin, presumably in its un-ionized form. Salicylic acid and salicylamide were absorbed from the human mouth at pH 6 in vivo (Sprake, 1977).

There are two likely hypotheses to account for aspirin inhibition of glucose absorption across gastrointestinal mucosa. Firstly, aspirin uncouples oxidative phosphorylation (Brodie, 1956). Buccal absorption of glucose was inhibited by salicylate (Evered et al., 1977), which also uncouples oxidative phosphorylation (Brodie, 1956). Moreover, phenobarbitone inhibited buccal absorption of glucose (Evered et al., 1977), and barbiturates too inhibited cellular respiration (Jalling et al., 1955).

Secondly, aspirin decreased significantly the net flux of Na⁺ ions across the epithelium of rat small intestine (Cooke et al., 1979). Ca²⁺ ions stimulated glucose transfer across the mucosa of the human mouth (McMullan et al., 1977) and rat small intestine (Manning et al., 1978). This effect of Ca²⁺ ions was thought to be due to a stimulation of Na⁺ fluxes. There was no such effect of Ca²⁺ ions in rat small intestine (Manning et al., 1978), which is independent of Na⁺ ions. Significantly, aspirin did not inhibit absorption of fructose across intestinal epithelium (Cooke et al., 1979).

The present experiments do not discriminate between these rival theories. However, the results provide further support for the presence of a Na⁺-dependent carrier-mediated transport process for D-glucose in human buccal mucosa, as in mammalian small intestine.


