NOTE ON THE HYDROGEN ION CONCENTRATION OF
THE HUMAN DUODENUM.

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It has long been known that the stomach is acid in comparison to the ileum, and it follows from this that the reaction of the duodenum must be influenced by the opening of the pylorus. According to Cannon, the opening of the pylorus is controlled by the acidity of this region, but it has been shown by a number of workers, most recently by Luckhardt, Phillips, and Carlson, that the motor phenomena of the stomach have a great influence on the passage of its contents through the pylorus. Perhaps the following description is nearly correct: Acid influences the tone of the pylorus but whenever this is less than the tone of the stomach or duodenum the passage of fluid may occur. The passage must necessarily be toward the region of lesser tone and is not always in the same direction, as shown by the fact, known for a long time, that the stomach contents may occasionally be bile-stained. Since the chyme is acid and the pancreatic juice alkaline, the relative rate of the flow of these two into the duodenum must influence its reaction.

In 1915 Dr. John P. Schneider gave one of us two samples of human duodenal contents which were found to be of pH 1.5 and 7.61. He had been removing the duodenal contents from many of his patients with an Einhorn duodenal tube in order to estimate the bile pigments. He allowed the duodenal contents to syphon out of the tube and found that the flow was intermittent. Sometimes the fluid spurted out and it was then acid to litmus whereas otherwise it was not acid to litmus (paper). It was shown by McClendon that the duodenum of the infant, although always acid, was very variable, the reaction sometimes approach-
Reaction of the Human Duodenum

ing neutrality (pH = 6.3). Long and Fenger, using the duodenal tube, observed great variation in the adult duodenum (pH = 3.80 to 7.81). The technique used in the present paper differs from theirs only in the use of the hydrogen electrode described by McClendon and Magoon.

The Einhorn duodenal tube was swallowed by one of us (F.J.M.) and allowed to descend to the first mark, then carefully lowered to the second mark. The subject was then placed on his right side on a couch, with his hips elevated. An average of about 3.5 hours was required before the end of the tube with the lead

<table>
<thead>
<tr>
<th>Meal.</th>
<th>Food taken</th>
<th>pH</th>
</tr>
</thead>
<tbody>
<tr>
<td>Breakfast.</td>
<td>Hot cakes, toast, coffee.</td>
<td>3.80</td>
</tr>
<tr>
<td>&quot;</td>
<td>Bacon, rice, coffee.</td>
<td>3.20</td>
</tr>
<tr>
<td>&quot;</td>
<td>Corn flakes and cream, eggs, toast.</td>
<td>6.98</td>
</tr>
<tr>
<td>Luncheon.</td>
<td>Beef, potatoes, tomatoes, pie.</td>
<td>4.60</td>
</tr>
<tr>
<td>&quot;</td>
<td>Pork, eggplant, cake.</td>
<td>5.00</td>
</tr>
<tr>
<td>Breakfast.</td>
<td>Hot cakes, pineapple sauce, coffee.</td>
<td>7.21</td>
</tr>
<tr>
<td>&quot;</td>
<td>Toast, raspberry sauce,</td>
<td>7.40</td>
</tr>
<tr>
<td>&quot;</td>
<td>Ham, eggs, toast, coffee.</td>
<td>7.54</td>
</tr>
<tr>
<td>Luncheon.</td>
<td>Beef, potatoes, corn, ice-cream.</td>
<td>7.00</td>
</tr>
<tr>
<td>&quot;</td>
<td>&quot; bread, melon, iced tea.</td>
<td>7.82</td>
</tr>
<tr>
<td>&quot;</td>
<td>Potatoes, carrots, pie, cake, ice-cream, milk.</td>
<td>7.60</td>
</tr>
<tr>
<td>&quot; *</td>
<td>Beef, onions, potatoes, pie, cake followed by bismuth.</td>
<td>7.54</td>
</tr>
</tbody>
</table>

* The fluoroscope was used in conjunction with bismuth and the duodenal tube after the digestion of the food was well under way.

weight seemed to be in the duodenum. The degree of traction on the tube was at first used as an index of its passage of the pylorus, but since some of the samples were acid we began to doubt that the pylorus had been passed, and confirmed this by use of the fluoroscope, for which our thanks are due the University Hospital.

In Table I the determinations that were acid and those that were alkaline are separated for comparison. We have no doubts that the acid samples came from the duodenum, since all samples were taken about 3 or 4 hours after the last meal and it has been shown by McClendon that the pH of the stomach at this time was between 1 and 2.5 in all normal individuals examined, whereas
the acid samples reported in Table I have a pH between 3.2 and 6.98.

After the position of the lead weight on the end of the duodenal tube in the duodenum was shown by means of the fluoroscope, it was drawn down toward the pylorus by traction on the tube and a photograph taken. A tracing from the x-ray plate is shown in Fig. 1. The dim edges of shadows in the plate were sharpened by free-hand drawing in making the tracing.
CONCLUSIONS.

The reaction of the duodenum between 3 and 4 hours after meals was usually found to fluctuate around the neutral point, but the extreme range on the acid side was greater than on the alkaline side, possibly due to the spurring of gastric contents into the duodenum.

BIBLIOGRAPHY.

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