believe that it is better, especially in experimental studies, to restrict the term ulcer to defects which involve one or more muscular layers as well as the mucosa, and correspond to the acute or chronic penetrating or perforating lesions that are encountered in man.

The dog in which ulcers were found was one of 3 animals which developed jaundice, and showed marked degenerative changes in the liver at autopsy. This finding coincides with our earlier observations concerning the possible rôle played by biliary and hepatic factors in the genesis of peptic ulcers in dogs.[1] The occurrence of degenerative alterations in the liver after the prolonged deprivation of pancreatic juice has been described.[6]

In double pancreatic duct ligations, followed by atrophy of the pancreas (5 dogs), no changes in the duodenum or stomach were found, 23, 47, 53, 80, and 97 days respectively, after ligation. Ivy and Fauley[8] encountered ulcers in 6 out of 61 animals after ligation of the pancreatic ducts. We have not observed ulcers in dogs after total pancreatectomy, and others who have studied insulin treated depancreatized dogs (fed raw pancreas) over periods as long as 2½ years have not reported the occurrence of ulcers.[9]

Conclusion. The preponderance of evidence indicates that peptic ulcers develop in dogs more readily after the deprivation of bile than after the loss of pancreatic juice.

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Gastrointestinal pH in Rats as Determined by the Glass Electrode.*

IRENE EASTMAN AND EDGAR G. MILLER, JR.

From the Department of Biological Chemistry, College of Physicians and Surgeons, Columbia University.

Investigators have reported many studies on gastrointestinal pH in animals, using various methods of determination—hydrogen electrodes, quinhydrone electrode, and colorimetry. The results have all been somewhat open to question because of the possible inaccuracy of these methods in a medium such as intestinal contents. For the

[8] Ivy, A. C., and Fauley, G. B., *Am. J. Surg.*, 1931, **11**, 531.

[9] Best, C. H., and Hershey, J. M., *J. Physiol.*, 1932, **75**, 49. Chaikoff, I. L., Macleod, J. J., Simpson, W. W., and Markowitz, J., *Am. J. Physiol.*, 1926, **76**, 210.

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range of pH encountered in such work, the glass electrode seems to be the method of choice. We have used glass electrodes prepared by the methods of MacInnes and Dole[1] or Robertson.[2] The electrical apparatus developed for this work was that described by Rosebury.[3]

Four hundred and fifty-five albino rats were used. Groups were placed on various diets: (I) a "normal" diet which included corn, wheat, barley, oats, soy bean, milk, meat scrap, alfalfa, NaCl, and $CaCO_3$; (II) diet I + 10% lard; (III) diet I + 30% lard; (IV) bread; (V) potato; (VI) suet; (VII) lean beef; (VIII) McCollum's[4] rachitic diet 3143; (IX) diet VIII + 2% cod liver oil; (X) Steenbock's[5] diet 2965; (XI) diet X + 2% cod liver oil; (XII) Zucker's[6] diet 401; (XIII) diet XII + 2% cod liver oil; (XIV) diet XII + 15% cod liver oil. The rats on the last 3 and the suet diets showed consistent malnutrition.

The rats were killed by a blow on the head or by chloroform, and the abdomen opened immediately. The stomach, the small intestine in 3 approximately equal lengths, the cecum, and the colon

TABLE I.

Diet	No. Rats	Age	Stomach		Sm.Int. Upper Third		Sm.Int. Middle Third		Sm.Int. Lower Third		Cecum		Colon	
			av.	σ	av.	σ	av.	σ	av.	σ	av.	σ	av.	σ
Normal	64	1-1½ yr.	3.6	0.6	5.9	0.5	6.3	0.2	6.8	0.3	6.2	0.3	6.6	0.3
" + 10% lard	50	"	3.4	0.6	6.2	0.2	6.4	0.2	6.8	0.2	6.3	0.3	6.5	0.2
" + 30% lard	8	"	3.4	0.7	5.4	0.6	5.8	0.4	6.4	0.4	5.8	0.4	6.1	0.4
Bread	50	"	3.3	0.7	6.3	0.5	6.7	0.2	7.0	0.2	6.4	0.3	6.1	0.3
Potato	11	"	3.6	0.7	6.0	0.6	6.8	0.2	7.0	0.2	6.5	0.3	6.6	0.3
Suet	9	"	3.7	1.0	6.0	0.9	6.5	0.3	7.2	0.3	7.0	0.2	6.8	0.3
Meat	7	"	3.7	1.0	5.9	0.3	6.4	0.2	6.8	0.3	6.2	0.3	6.4	0.3
McCollum 3163	50	"	3.9	0.7	6.5	0.2	6.8	0.2	7.3	0.2	6.9	0.3	7.1	0.2
" + 2% C.L.O.	50	"	3.9	0.7	6.5	0.2	6.7	0.2	7.2	0.2	6.7	0.2	6.9	0.2
Normal	25	3 wk.	3.9	0.7	6.4	0.3	6.7	0.3	7.1	0.3	7.0	0.3	7.0	0.4
McCollum 3143	35	"	4.8	1.0	6.5	0.3	7.0	0.3	7.5	0.5	7.3	0.3	7.4	0.3
" + 2% C.L.O	23	"	4.6	0.7	6.3	0.4	6.8	0.3	7.4	0.4	7.1	0.2	7.1	0.2
Steenbock 2965	23	"	3.9	1.0	6.4	0.5	6.6	0.5	7.0	0.3	7.0	0.3	7.1	0.3
" + 2% C.L.O.	13	"	4.3	0.4	6.6	0.2	6.5	0.3	6.9	0.2	6.9	0.2	7.0	0.1
Zucker 401	17	"	4.6	0.6	6.6	0.2	6.7	0.1	7.0	0.2	7.0	0.2	7.2	0.2
" + 2% C.L.O.	13	"	4.5	0.5	6.5	0.1	6.7	0.1	6.9	0.1	6.9	0.1	7.0	0.1
" + 15% C.L.O.	7	"	4.9	0.5	7.1	0.2	7.1	0.2	7.2	0.3	7.1	0.3	7.1	0.2
Total, adult	299	1-1½ yr.	3.6	0.7	6.1	0.5	6.6	0.3	7.0	0.3	6.4	0.4	6.6	0.5
" young	156	3 wk.	4.3	0.9	6.5	0.4	6.8	0.3	7.2	0.4	7.1	0.3	7.1	0.3
" all rats	455		3.8	1.1	6.2	0.5	6.7	0.3	7.1	0.3	6.7	0.5	6.8	0.5

[1] MacInnes, D. A., and Dole, M., *J. Am. Chem. Soc.*, 1930, **52**, 29.

[2] Robertson, G. R., *J. Ind. Eng. Chem., An. Ed.*, 1931, **3**, 5.

[3] Rosebury, F., *J. Ind. Eng. Chem., An. Ed.*, 1932, **4**, 398.

[4] McCollum, E. V., *J. Biol. Chem.*, 1921, **47**, 50.

[5] Steenbock, H., *J. Biol. Chem.*, 1925, **64**, 263.

[6] Jephcott, H., and Bachrach, A. L., *Biochem. J.*, 1926, **20**, 1350.

were quickly tied off and removed and the contents gently expressed under oil. The contents were then diluted sufficiently with water and the pH determined.

Plotting histograms of the incidence of the data revealed that if calculated as pH the occurrences closely approximated the normal bell-shaped curve. We have, therefore, in using statistical formulae to describe the data, considered them in the pH form throughout rather than as C_H. The averages with their standard deviations are shown in the table.

For a given level of the tract, there is a very striking tendency to maintain a normal pH range in spite of wide variations in the nature of the diet. In general, the pH increases with descending levels to the ileocecal valve; the cecal contents are more acid than the ileum; and in the colon the pH again rises over that in the cecum. On the suet and the bread diets, the acidity of the colon was greater than that of the cecum.

The pH values for the young rats show a tendency to be slightly higher than for the adults. The individual series differences, while not surely significant statistically, nevertheless occur so consistently that the reality of a small age difference in pH becomes apparent.

The McCollum rachitogenic diet 3143 gave, in each section of the gut below the stomach, an increase of pH over the normal figures which was more than 2 times the probable error of the difference. When the consistency of the effect at all of the levels is considered, it appears that this is a real difference. The addition of cod liver oil to the diet caused a consistent though small return of the pH towards the normal.

The other diets, including the other rachitogenic diets, gave no divergences from the normal that can be interpreted as being surely significant statistically.

When the data for individual rats are studied, it appears that there is no great correlation between the recurrences of high or low pH values in consecutive levels of the tract. This implies, perhaps, that the local conditions in the gut (secretions and absorptions and bacterial flora) are more potent factors in determining the hydrogen ion concentration than is the pH of the food residues themselves as they pass down the lumen, although the question of the titratable acidity still remains to be investigated.