against human proteins. The serum of eels contains at least 12 immunologically different antigens to rabbits. We observed most individual electrophoretic differences in the β region of the protein pattern.

1. Poulik, M. D., Smithies, O., *Biochem. J.*, 1958, v68, 636.
2. Grabar, P., Williams, C. A., Jr., *Biochim. Biophys. Acta,* 1953, v10, 193.
3. ———, *ibid.*, 1955, v17, 67.
4. Drilhon, A., Fine, J. M., Uriel, J., Le Bourdelles, F., *Compt. rend. Acad. Sci.*, 1956, v243, 1802.
5. Drilhon, A., Fine, J. M., *ibid.*, 1960, v250, 4044.
6. Fine, J. M., Drilhon, A., *ibid.*, 1960, v250, 3241.
7. ———, *ibid.*, 1961, v252, 3891.
8. Smithies, O., *Biochem. J.*, 1955, v61, 629.
9. ———, *Advances in Protein Chemistry,* Academic Press, New York, 1959.
10. Fine, J. M., Waszczenko, E., Loeb, J., Moullec, J., *Rev. Hematol.*, 1957, v12, 698.
11. Fine, J. M., Loeb, J., *ibid.*, 1958, v13, 449.
12. Poulik, M. D., *Nature,* 1957, v180, 1477.
13. Groulade, J., Fine, J. M., Ollivier, C., *ibid.*, 1961, v191, 72.
14. Scheidegger, J. J., *Inst. Arch. Allergy,* 1955, v7, 103.
15. Hirschfeld, J., *Science Tools,* 1960, v7, 18.
16. Boffa, G. A., Fine, J. M., *Rev. Franc. Etudes Clin. et Biol.*, 1962, v7, 813.
17. ———, *ibid.*, 1962, v7, 822.
18. Jacquot-Armand, Y., Boffa, G. A., Fine, J. M., *Compt. rend. Acad. Sci.*, 1962, v255, 590.
19. Engle, R. L., Jr., Woods, K. R., in *The Plasma Proteins,* F. W. Putnam, ed., Academic Press, New York, 1960, vII, p183.

Received September 3, 1963. P.S.E.B.M., 1963, v114.

Relationship Between Maximal Secretory Output and Weight of the Pancreas in the Dog.* (28760)

JACK HANSKY, OSWALDO M. TISCORNIA, DAVID A. DREILING AND HENRY D. JANOWITZ

Division of Gastroenterology, Departments of Medicine and Surgery, Mount Sinai Hospital, New York City

The maximal rate of secretion of an exocrine gland, by definition, is a function of the number of its secretory units and their rate of activity. In the dog and human stomach, a very close correlation has been established between maximal rate of acid secretion in response to histamine and number of parietal cells, the parietal cell mass(1,2).

We have recently described the maximal bicarbonate and enzyme (amylase) output of the dog pancreas in response to secretin and pancreozymin(3,4). Since the cell of origin of water and bicarbonate of pancreatic juice has not been established, in contrast to the acinar cell of origin for secreted enzymes, we attempt in this report to establish a relation between maximal bicarbonate and amylase output and weight of the pancreas in dogs.

Material and methods. Fifteen female mongrel dogs were prepared with chronic duodenal fistulae, and the maximal 15 minute volume, bicarbonate and amylase output in response to secretin and pancreozymin determined as previously described(3,4). The maximal 15 minute output was obtained with doses of secretin of 4 to 8 units/kg as single intravenous injections, or 4 to 12 units per minute as continuous infusions. The dose of pancreozymin required to produce the maximal output was 5 to 15 units/kg as a single injection or 0.5 unit/kg/minute as continuous infusion. Three of the animals then had a partial pancreatectomy with removal of from 17 to 22 g of pancreas. Following this, these dogs were again stimulated with the same maximal dose of secretin and pancreozymin, and the fluid, bicarbonate and amylase outputs determined.

All the animals were subsequently sacrificed by an overdose of Nembutal, and the pancreas carefully dissected free of surrounding tissues and weighed.

Results. The results are presented in

* Aided by a grant from NIAMD, NIH, USPHS.

TABLE I. Comparison of Weight of Pancreas, Weight of Animal, Dose of Secretin and Pancreozymin, Maximal Bicarbonate Output (MBO) and Maximal Enzyme (Amylase) Output (MEO) in 15 Intact and 3 Dogs with Partial Pancreatectomy.

Dog	Wt of dog (kg)	Wt of pancreas (g)	Secretin dose (units/min or /kg)	Pancreozymin dose (units/kg or /kg/min)	MBO (meq/15 min)	MEO (units/15 min)
			A. Intact dogs			
2732	19	33.0	12 U/min	.5 U/kg/min	2.91	474
3417	20	33.5	8 U/kg	10 U/kg	3.04	404
3924	20	32.3	4 U/min	—	1.60	—
3707	20	47.0	12 "	—	3.67	—
3734	20	30.0	4 "	—	3.49	—
3114	19.5	48.0	8 "	—	3.47	—
3923	20.2	32.0	8 "	—	1.94	—
3729	20	30.0	8 "	—	2.41	—
2953	18.5	44.5	8 "	—	3.60	—
3667	20	50.0	8 U/kg	10 U/kg	4.23	511
3308	21.5	42.5	8 "	.5 U/kg/min	3.37	327
3306	18.6	31.7	8 "	5 U/kg	2.57	306
3401	20	48.7	4 "	10 "	3.37	354
3409	22	48.8	8 "	5 "	3.49	350
3151	20.2	69.2	12 U/min	15 "	4.59	480
			B. Dogs with partial pancreatectomy (results in terms of residual pancreas)			
3401	20	31.2	4 U/kg	10 U/kg	1.62	186
3409	22	30.8	8 "	5 "	1.91	184
3151	20.2	47.7	12 U/min	15 "	2.15	310

Table I, where the weight of dog, weight of pancreas, maximal bicarbonate output and maximal amylase output in response to secretin and pancreozymin are given for 15 intact dogs; results for 3 dogs with partial pancreatectomy are given for the residual pancreas. There was a highly significant correlation between maximal bicarbonate output and weight of the pancreas ($r = +0.89$, $p < 0.01$ — Fig. 1), the line drawn representing the actual regression line calculated from the mean of the regression of x/y and y/x. In the 3 animals in whom partial pancreatectomy was performed, the maximal bicarbonate output was well correlated with the weight of residual pancreas in two. The maximal output per gram of pancreas averaged 0.08 ± 0.01 mEq/g.

The maximal amylase output, on the other hand, was poorly correlated with the weight of pancreas ($r = +0.39$, $p > 0.4$); the partial pancreatectomy dogs showing a similar pattern.

No close correlation was demonstrated between weight of pancreas and weight of the animal, nor between dose per body weight of pancreozymin and secretin and maximal bicarbonate and amylase outputs.

Discussion. The finding of a highly significant correlation between weight of the pancreas and maximal bicarbonate output in response to secretin stimulation suggests that the number of "secretory units" responsible for water and electrolyte elaboration bears a direct relationship to the mass of the gland. Unlike the stomach, the cell type responsible for water and electrolyte secretion is

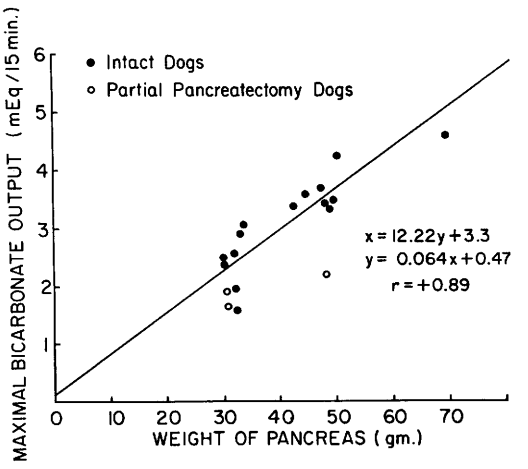

FIG. 1. Relation between weight of pancreas and maximal bicarbonate output in 15 intact dogs and 3 dogs with partial pancreatectomy ($r = +.89$, $p < .01$).

unknown, although the centro-acinar and ductular cells have been implicated in this process on fragmentary evidence(5). The situation as regards acid secretion in the stomach is more firmly established. Ragins and his co-workers(6) found a direct relationship between the weight of gastric mucosa and the 24 hour HCl secretion in dogs. Card and Marks(2) carefully correlated mucosal volume with parietal cell mass and maximal acid output of the human stomach, and Marks and co-workers(1) demonstrated a good correlation between maximal HCl response to histamine and parietal cell mass in the dog. From the bulk of evidence available, despite some contradictory data(7), as far as the stomach is concerned, there is an excellent correlation between mucosal weight, parietal cell mass and "maximum acid output." Our findings suggest that a similar relationship exists between pancreatic weight, "secretory unit" mass, and maximal bicarbonate output in response to secretin.

We observed no correlation between total body weight and pancreatic weight in our dogs. Cox(8) similarly found no constant relationship between stomach size and body size. We have attempted to compare our results in the dog with some in man, based on crude calculations. To this end we analyzed 12 randomly selected normal subjects, 6 males and 6 females, as to their response to a standard secretin test (1 unit/kg body weight). The mean peak 15 minute bicarbonate output was 6.9 (5.6-8.1) mEq in the females, and 8.2 (6.1-12.9) mEq in the males. Mean body weight was the same for both groups, 61 (46-100) kg in the females and 61 (50-75) kg in the males. Based on Schaefer's study(9), an average pancreatic weight is 85 g in the female and 90 g in the male. The calculated output per gram of pancreas was 0.08 mEq/g in the females and 0.09 mEq/g in the males. Our figure of 0.08 mEq/g for the female dog is extremely close to these estimates.

That no correlation was demonstrated between pancreatic weight and "maximal enzyme (amylase) output" is not surprising in view of the complex mechanisms involved in synthesis, storage and excretion of pancreatic enzymes. We consider that the multiplicity of steps involved is not conducive to a simple quantitative correlation.

Summary. 1. The maximal bicarbonate and amylase output of the pancreas in response to secretin and pancreozymin was determined in 15 dogs and compared with the weight of the gland. 2. A highly significant correlation was demonstrated between pancreatic weight and maximal bicarbonate output, but not between pancreatic weight and amylase output.

1. Marks, I. N., Komarov, S. A., Shay, H., *Am. J. Physiol.,* 1960, v199, 579.

2. Card, W. I., Marks, I. N., *Clin. Sci.,* 1960, v19, 147.

3. Baron, J. H., Perrier, C. V., Dreiling, D. A., Janowitz, H. D., *Am. J. Physiol.,* 1963, v204, 251.

4. Hansky, J., Tiscornia, O. M., Janowitz, H. D., Dreiling, D. A., *Am. J. Physiol.,* in press.

5. Janowitz, H. D., Dreiling, D. A., *Ciba Symposium: Exocrine Pancreas. Normal and Abnormal Functions.* J. & A. Churchill, London, p124, 1962.

6. Ragins, H., Evans, S. O., Dragstedt, L. R., II, Rigler, S. P., Dragstedt, L. R., *Arch. Surg.,* 1957, v74, 266.

7. Tongen, L. A., *Surgery,* 1950, v28, 1009.

8. Cox, A. J., *AMA Arch. Path.,* 1952, v54, 407.

9. Schaefer, J. H., *Anat. Rec.,* 1926, v32, 119.

Received September 3, 1963. P.S.E.B.M., 1963, v114.