Physical examination. Well developed and nourished. Skin clear, cheeks flushed, head negative; sclerae clear, pupils equal, regular; tongue coated, throat and tonsils negative; neck negative; chest, well developed; expansion left side greater than right; heart normal in size and position, sounds regular, good quality, no murmurs; lungs, *right chest* dull below spine of scapula almost to flatness, with râles and bronchial breathing, dull in axilla. *Left chest*, râles in lower one-half, with some bronchial respiration; spine negative, no costo-vertebral tenderness; abdomen soft and tympanitic, no masses, spasm or tenderness. Genitals negative, no hernia. Extremities, negative. Reflexes, normal. Blood, white blood corpuscles 7800; red blood corpuscles 7,296,000; 6,896,000; Hgb. 100%; stained specimen, reds normal, platelets normal, but increased. *Poly.* 78; *eosin.* 5; *mast* $\frac{1}{2}$; *lym.* $5\frac{1}{2}$; *L.M.* 11; Stools, normal; no *parasite* or *ova*. Wassermann negative. Echinococcus fixation test strongly positive.

Sputum. Specimen is mucopurulent and shows no evidence of hooklets or membrane. It is negative for T. B. and shows no characteristic bacteriological finding. Urine amber, clear, acid 1028, albumen 0, sediment 0.

X-ray by Dr. George W. Holmes. In the left chest, below the fifth rib, there is an area of increased density, 4 cm. in diameter; it is round and of even density, with sharply defined borders.

When the position of the tube is changed, overlying it there is a ring-like shadow of diminished density which changes its relation, suggesting a different plane to the dense shadow. Neither reaches the periphery. Similar slightly larger process is seen in the right lung below the fourth rib, with involvement of lung structure.

February 16, 1920. X-ray. Oxygen inflation of abdomen. Appearance in chest much the same as in previous notes.

It is possible to see distinctly the outline of the liver and spleen. They appear to be normal in size and shape; just below the lower margin of the liver there is a round, dense mass, which is apparently connected by a band of adhesions to the abdominal wall.

There is a ring-like shadow in the left kidney, having all the appearances of an echinococcus cyst.

Under the direction of Dr. George W. Holmes, from October 3, 1919, to May 15, 1920, the patient received nine x-ray treatments from two to four weeks intervals, with no improvement in the symptoms, or change in the x-ray findings, nor was there any alteration in the fixation test taken on three different occasions.

When the patient was last seen in May he still complained of an irritative cough, occasionally blood-streaked sputum, pains on both sides of the chest and left kidney region. Tried to work part of the day, but tired easily.

REMARKS.

Echinococcus cyst of the lung is one of the conditions to be thought of and ruled out in cases of pulmonary disease with bloody sputum or frank haemoptysis, especially among the immigrant classes from continental Europe and Asia Minor. The disease is common in South America, Australia, and New Zealand.

The x-ray is our chief aid in the diagnosis, especially in the closed cyst of the lung, and the complemental fixation test when positive is confirmatory, but not essential. Of course the finding of hooklets in the sputum will make the diagnosis, but the cyst will then have ruptured into a bronchus.

TREATMENT.

There is no medical treatment. X-ray treatments may be tried. It had no effect in Case 2. Salvarsan has been tried¹, with no apparent result.

Whenever possible, surgery is the treatment.

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STUDIES IN PANCREATIC FUNCTION. ENZYME CONCENTRATION OF DUODENAL CONTENTS AFTER THE INGESTION OF PURE FOODSTUFFS AND FOOD MIXTURES BY NORMAL MEN.

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THE present communication is a report of the results derived from a study of enzymatic activities of duodenal contents. The duodenal contents were obtained from normal young men after feeding pure carbohydrate, protein or fat, both alone and in various combinations, and also after the ingestion of certain food mixtures to be described later. The purpose of the study was to compare the effect of the various types of foodstuffs on the relative amounts (concentrations) of enzymes present in duodenal contents, as ascertained by estimation of the degrees of enzyme action; and by the

same method an attempt was made to determine the relative amounts (concentrations) of enzymes developed at various periods during the time the stomach was emptying itself of food.

Important studies on the rôle of the pancreas in intestinal digestion begin with the work of Claude Bernard¹ in 1856. This observer presented detailed evidence of his claim that the pancreatic juice was of great importance in the process of digestion. But the truth of Bernard's contention was not appreciated for many years, and the physiologists of his time, unable to confirm his observations, opposed the view that the pancreatic secretion played an important rôle in digestion.² The rôle of the pancreas in digestion remained unsettled until the studies of Pawlow,³ Pratt, Lamson, and Marks,⁴ and McClure and Pratt⁵; although much important work on the digestive function of the pancreas was reported by other observers between the years 1890 and 1911.⁶ Pratt, Lamson, and Marks⁴ found that excluding pancreatic secretion from the gut of dogs was immediately followed by the lack of absorption of gross amounts of fat ingested by the animal, and that this failure of absorption remained constant. These observers were able to demonstrate that technical errors accounted for contradictory results obtained by various workers. McClure and Pratt⁵ confirmed the observations of Pratt, Lamson, and Marks, and also demonstrated that depancreatized dogs absorbed from 10 to 50 per cent. of nitrogen and from 17 to 50 per cent. of the fat ingested. Further, they proved that presence of pancreatic tissue in an animal's body is not necessary for the absorption of the products of intestinal digestion, as was held by Lombroso.⁶

The rôle of the pancreas in digestion as demonstrated by the classical work of Pawlow is admirably presented in the well-known book entitled, "The Work of the Digestive Glands". Pawlow worked with dogs, in which animals he produced the fistulae which bear his name. By means of a fistula he was able to obtain pure pancreatic secretion. In this secretion, obtained after feeding meals consisting essentially of protein, fat or carbohydrate, the activities of the various types of enzymes were studied. From these studies Pawlow concluded that the kind of food eaten called forth an increase in the secretion of the enzyme specific for that particular type of food; i.e., protein food caused the secretion of a predominant amount of trypsin, carbohydrate food of amylase, etc.

In 1902, Bayliss and Starling⁷ believed they proved the presence in the intestinal mucosa of a substance called "prosecretin". This "prosecretin" is thought to be converted into "secretin" by the action of hydrochloric acid coming from the stomach. The "secretin" thus formed is believed to be carried through the blood stream to the pancreas, and after reaching that organ to excite its external secretion. But as is pointed out by von Fürth⁸, various substances, such as

cholin, are present in the duodenal mucosa, which have the same action on the pancreas as has "secretin". For this reason von Fürth concludes that until much more is found out about the chemical nature of "secretin," its actual existence remains unproved. Furthermore, nervous control of the pancreas may possibly be important in stimulating its external secretion.⁹ Therefore, it is evident that the status of the factor or factors stimulating the secretion of the pancreatic juice is not well established.

All of the work discussed in the foregoing paragraphs has been carried out on lower animals. Just how much of this work is applicable to man can only be determined by actual observations on human subjects. However, there is much pathological evidence confirming the importance of the external secretion of the pancreas in digestion in man; for example, exclusion of pancreatic juice from the intestines in man is known to be accompanied by marked disturbances in the digestion and absorption of food. But much less is known about the character of pancreatic juice secreted by the human pancreas during digestion. Various investigators have attempted to repeat Pawlow's experiments on human subjects with pancreatic fistulae. These subjects have, however, with one exception, been in such pathologic states or the pancreatic secretion obtained has been so contaminated by material from the intestines that interpretation of experimental results has been problematic. Wohlgemuth¹⁰ was fortunate enough to get pure juice from a human subject with a traumatic pancreatic fistula. Other than for the presence of the fistula, the subject was in normal physical condition. Wohlgemuth repeated the experiments on this subject which Pawlow had carried out on dogs. The results obtained are as follows: The ingestion of food consisting largely of fat brought about pancreatic secretion showing the greatest degrees of all types of enzyme action, while the secretion following a carbohydrate meal showed the least. On the other hand, carbohydrate meals were followed by the secretion of the largest amounts of pancreatic juice, while fatty food produced the least. Thus the results of Wohlgemuth's observations showed the existence of a relation between the kinds of food-stuffs ingested and the amounts of pancreatic juice secreted, and also, the degrees of enzyme action found in this juice. However, no relation was demonstrated between the type of food-stuff fed and the degree of activity of the enzyme specific for that kind of food, as was found by Pawlow in his work on dogs. In this connection it is well to emphasize that the methods for estimating the degrees of enzyme action used by Pawlow, Wohlgemuth, and others, are subject to various errors, so that interpretation of results obtained by their use are open to serious criticism; as has been discussed in a former communication.¹¹ Nevertheless, their results show that the secretion of pancreatic juice during

digestion is in some way governed by the food ingested.

The results of the work outlined in the foregoing discussion permit the following conclusions: 1. Ingestion of food is followed by the secretion of pancreatic juice; but the exact mechanism by which the secretion is stimulated is not established. 2. The external secretion of the pancreas plays a most important rôle in digestion.

While the work outlined above has yielded much of great importance, the methods used have not permitted the study of the conditions under which intestinal digestion actually occurs in living man. It is generally accepted that the end-products of intestinal digestion in man are the same as those in the lower animals; that is, carbohydrates are converted into monosaccharids, fats into soaps, and proteins into amino acids, and that these end-products are absorbed as such. But it should be noted that it was not until the comparatively recent work of Folin,¹² and of Van Slyke¹³ that the absorption from the gut of the end-products of protein digestion was established.

There are available but few studies on the physical and chemical conditions under which intestinal digestion occurs in man. In fact, many of the conditions affecting enzyme action were not established until the publication of the work of Sörensen¹⁴ as late as 1909. This investigator showed that enzyme action was dependent on the hydrogen ion and buffer conditions, as well as those of temperature, under which the enzyme was placed. Practically the only studies on the physical chemistry of intestinal digestion in the living, normal, human subject are those of McClendon *et al.*,¹⁵ and the studies of McClure, Wetmore and Reynolds.¹⁶ Hydrogen ion concentration determinations published by these investigators show that after the ingestion of a mixed diet the pH of duodenal contents of normal man varies in the immediate neighborhood of 4 to 7. McClure, Wetmore and Reynolds¹¹ have devised methods for the estimation of degrees of enzyme action of duodenal contents which conform to the present-day conception of the physical chemistry of enzyme action, and (a) have made some studies¹⁶ on the physical character and enzymatic activities of duodenal contents obtained from normal young men. The purpose of the latter studies was to devise a procedure for obtaining duodenal contents which would permit the establishment of a normal for the various types of enzyme activities, for use in certain clinical studies. Incidentally, however, it was found that the ingestion of different types of food brought about duodenal contents showing rather characteristic degrees of viscosity, varying in color and consisting very largely of liquid containing but very small amounts of the food originally eaten.

Further studies on the details of physiology of intestinal digestion in normal man were considered important; because only by such knowl-

edge can those processes of pathologic physiology of abnormal gastrointestinal conditions be ascertained which are of importance in clinical medicine. For this reason the present study of the duodenal contents of normal young men has been made.

PROCEDURE.

The subjects chosen for the study were normal young men who gave no history of gastrointestinal derangement. The subjects were instructed to eat a light supper the evening before an experiment, to drink only water during the evening and to ingest nothing after midnight. The following morning the Rehfuß gastroduodenal tube was passed on the empty stomach and without the aid of water. The metal tip was allowed to pass through the pyloric sphincter and as far as the second portion of the duodenum; its position being ascertained by means of fluoroscopic observation. The subjects then reclined on the right side and the duodenal contents were collected either (a) both before and after the ingestion of food or (b) only after the ingestion of food. The contents were siphoned off.

Enzymatic activities were estimated by the methods developed by McClure, Wetmore and Reynolds.¹¹ In these methods proteolytic activity is estimated by allowing duodenal contents to act on a solution of soluble casein. The casein not affected by the proteolytic enzyme is precipitated by means of metaphosphoric acid solution. The index of proteolytic activity is taken to be the number of milligrams of nitrogen not precipitated by the metaphosphoric acid. This nitrogen is determined by an adaptation of the method of Folin and Wu for the determination of nonprotein nitrogen in the blood. Amylolytic activity is estimated as the number of milligrams of glucose developed by the action of duodenal contents on a solution of soluble starch. The index of amylolytic activity is taken to be the total number of milligrams of glucose developed, as determined by the method of Folin and Wu for the determination of sugar in the blood. Lipolytic activity is estimated by allowing duodenal contents to act on a true emulsion of cottonseed oil and determining the amount of acidity developed by titrating with tenth normal NaOH solution. The total number of c.c. of N/10 NaOH necessary to neutralize the acidity developed is used as the index of lipolytic activity. The duodenal contents and the reagents used must be controlled for the presence of nitrogen not precipitated by metaphosphoric acid, for copper reducing bodies and for acidity.

The pure foodstuffs used were arrowroot starch, edestin,* casein and olive oil. The food mixtures were (a) 300 c.c. of a mixture of milk, water, and cottage cheese and (b) 300 c.c. of 20 per cent. cream. The food mixtures were mixed with 40 gms. barium sulphate, which allowed

* The preparation of edestin was furnished by the Arlington Chemical Company, Yonkers, N. Y., whom we thank for their cooperation.

their behavior in the stomach and duodenum to be observed through the fluoroscope.

Duodenal contents may be obtained by means of the duodenal tube, either with or without the use of aspiration. For purposes of description the collection of contents without the use of aspiration is called siphonage. By either method the flow of duodenal contents through the tube was found to be intermittent, issuing in jets at intervals varying from a few seconds to several minutes. By means of the fluoroscope it was determined that the jets occurred coincidentally with the presence of peristalsis in the duodenum, while in the absence of peristalsis only a few drops or no fluid at all were obtained. These observations indicate that the flow of duodenal contents is dependent on an increase in intraduodenal pressure; and for this reason aspiration has no advantage over siphonage. In the work here reported duodenal contents were collected by siphonage.

The enzymatic activities of 20 specimens of fasting duodenal contents were studied. These specimens were collected from six subjects over periods of thirty minutes. The results obtained, together with the quantities and physical character of the duodenal contents, are outlined in the following table (Table I).

Study of the table shows that proteolytic activity varied from 1.2 to 5.0 mgms. of nonprotein nitrogen, lipolytic activity from 0.0 to 2.7 c.c. of N/10 NaOH, and amylolytic activity from 0.3 to 6.7 mgms. glucose. The quantities obtained were from 15 c.c. to 58 c.c. in 15 specimens; while in two specimens 2 c.c. and in one 135 c.c. were collected. All the specimens were of very slight viscosity, and lightly stained some shade of yellow by the presence of bile, except three. Of the three exceptions noted, two were more deeply bile-colored and moderately viscid, and one was fairly viscid and partly light yellow and partly dark yellow in color.

After the ingestion of food substances in volumes of 50 c.c., collection of duodenal contents was divided into three stages, as follows:

1. From immediately after the ingestion of the food substance up to the time the duodenal contents became markedly darker in color (due to bile); *the first stage of collection.*
2. Then over the period of the succeeding hour; *the second stage of collection.*
3. Then over the period of a second hour; *the third stage of collection.*

Study was made of duodenal contents ob-

TABLE I.
Enzymatic activities, amounts and physical character of fasting duodenal contents collected over 30-minute periods.

Subject.	Enzymatic activity.			Amt. in c.c.	Color.	Viscosity.
	Proteolytic in mgm. NPN.	Lipolytic in c.c. N/10 NaOH.	Amylolytic in mgm. glucose.			
Cush	2.1	0.0	0.3	20	Pale yellow	Slight
	3.7	0.7	3.7	20	Pale yellowish green	Slight
	2.7	1.8	2.3	20	Pale greenish yellow	Slight
Ought	2.4	2.7	1.4	50	Pale greenish yellow	Slight
	1.2	0.4	0.6	135	Light brown	Moderate
	1.6	0.5	0.3	15	Lemon yellow	Slight
	1.8	0.5	0.3	15	Lemon yellow	Slight
	4.3	1.8	0.8	60	Lemon yellow	Moderate
White	4.6	0.8	3.9	25	Greenish brown	Moderate
	3.7	1.0	0.8	2	Lemon yellow	Slight
	3.7	1.0	0.8	2	Lemon yellow	Slight
	5.0	0.8	2.4	37	Dark greenish brown	Moderate
	3.0	0.2	2.3	20	Pale yellow	Slight
	3.0	0.8	2.9	40		
	2.4	0.4	3.2	17		
	5.0	1.1	6.7	10	15 min. light yellow 15 min. dark yellow	Moderate
MoQ	2.5	0.4	1.6	58	Pale yellow	Slight
	1.4	0.6	2.1	48	Pale yellowish green	Slight
Brown	3.0	1.1	0.8	39	Pale yellow	Slight
Desj	3.0	0.5	2.0	60	Deep golden yellow	Moderate

TABLE II.
Enzymatic activities, amounts and physical characters of duodenal contents obtained during the first stage of collection.

Subject	Enzymatic activity			Amt. in c.c.	Per-iod of col-lection in min-utes	Color	Viscosity	Pres-nce of food	Kind of food ingested
	Pro-teo-ly-tic in mgm. NPN.	Lip-oly-tic in c.c. N/10 NaOH	Amy-lo-ly-tic in mgm. glu-cose						
Ought	3.9	2.3	1.4	30	9	Pale yel-lowish green	slight	none	casein
	0.0	0.2	0.0	50	24	light yellow		some	
White	4.2	1.6	2.0	23	14	brownish yellow	slight	none	casein
Cush	3.5	0.2	3.1		23	yellowish			casein --
Cush	0.9	0.3	1.1	40	32	Pale yel-lowish green	slight	10 c.c.	olive oil
McQ	0.8	0.3	1.2	38	12	Pale yel-low	slight	some	olive oil
Brown	2.1	2.2	2.7	60	17	Pale yel-low	slight	some	olive oil
Desj	1.9	1.0	1.4	60	17	Pale yel-low	slight	none	olive oil
Desj	3.4	1.8	2.5	30	11	Lemon yel-low	slight	some	olive oil
Brown	1.3	0.5	0.0	67	13	Deep yel-low	Moderate	some	edestin
Brown	2.2	1.0	1.9	30	32	Colorless	slight		arrowroot starch
Brown	1.9	0.0	0.4	30	15	Lemon yellow	slight	some	5 c.c. oil 5 gm. edestin
Desj	2.8	0.7	2.3	15	11	Lemon yellow	slight	some	5 c.c. oil 5 gm. starch

TABLE III.
Enzymatic activities, amounts and physical character of duodenal contents obtained during the third stage of collection.

Subject	Enzymatic activity			Amt. in c.c.	Color	Viscosity	Presence of food	Kind of food ingested
	Pro-teo-ly-tic in mgm. NPN.	Lip-oly-tic in c.c. N/10 NaOH	Amy-lo-ly-tic in mgm. glu-cose					
Cush	4.0	0.6	3.1		Pale yellow		none	casein
Ought	3.8	2.7	0.9	285	dark brown	moderate	none	casein
White	4.0	2.6	0.2	100	greenish yellow	slight	none	olive oil
McQ	1.2	0.6	0.1	240	pale yellow	slight	none	olive oil
Cush	5.5	4.3	4.3	115	dark greenish brown	moderate	2 c.c. oil	olive oil
Desj	1.5	0.6	2.9	200	golden yel-low	moderate	none	olive oil
"	3.5	1.4	2.1	255	yellowish brown	" "	5 c.c. oil	olive oil
Brown	1.9	1.6	3.4	140	golden yel-low	moderate	small amount	olive oil
Brown	2.3	2.7	2.6	178	brownish yellow	moderate	none	10 gm. edestin
Desj	2.8	1.2	2.0	87	lemon yel-low	moderate	none	10 gm. edestin
Desj	3.2	1.5	3.2	75	brownish yellow	moderate	none	10 gm. arrow root starch
Brown	3.1	3.0	3.5	35	lemon yel-low	moderate	none	10 gm. arrowroot starch
Desj	3.7	2.4	3.9	95	yellowish brown	moderate	none	5 c.c. olive oil 5 gm. arrowroot starch
Brown	3.6	0.4	3.1	9	pale yellow	slight	none	5 c.c. olive oil 5 gm. arrowroot starch

tained during the *first stage of collection*. A total of thirteen duodenal contents from six subjects was studied and the findings outlined (Table II).

The findings outlined in the above table show that immediately after the ingestion of pure food substances in volumes of 50 c.c., the color and viscosity of the duodenal contents remained similar to those of the fasting contents. But after the lapse of periods varying from 9 to 32 minutes, and 45 minutes in one subject not noted in the table, an abrupt change to a markedly deeper bile color occurred. Before this change in color took place, if casein, edestin or oil had been ingested, food appeared in the duodenal contents. The presence of food was noted either immediately after its ingestion or within a period of 20 minutes, but the change in the color of the bile did not occur for from 7 to 32 minutes after the initial appearance of this food in the duodenal contents. As far as can be judged, there was no increase in the quantities collected over those obtained from the fasting duodenum. The proteolytic activity varied from 0.8 to 4.3 mgms., the lipolytic from 0.0 to 2.2 c.c., and the amylolytic from 0.0 to 3.1 mgms. These variations are comparable to those found in the fasting contents. So that the duodenal contents collected from immediately after the ingestion of food up until the abrupt change to a deep bile color, and those obtained from the fasting duodenum are comparable except for the presence of food in the former.

Studies were next made on duodenal contents collected during the second hour after the change from pale yellow to a deep bile color occurred; *i.e.*, the *third stage of collection*. The results obtained are outlined (Table III).

Study of the table shows that the specimens were some shade of light yellow, with the exception of two specimens which were dark brown. All specimens were moderately viscid but three, which were slightly so. Food was present in three of the specimens. Proteolytic activity varied from 1.2 to 5.5 mgms., lipolytic from 0.6 to 3.0 c.c., and amylolytic from 0.1 to 4.3 mgms. These findings are comparable to those obtained in the fasting duodenal contents, and in those collected immediately after the ingestion of food, except for the increase in viscosity, and the occasional presence of food. (The findings will be discussed later.)

The collection of duodenal contents for the first hour after the abrupt change to dark-colored bile occurred is called the *second stage of collection*, or the first hourly specimen. The enzymatic activities, physical character and quantities of duodenal contents obtained during this second stage of collection are outlined in the following table (Table IV).

All duodenal contents outlined in the above table were deeply bile colored, in which respect they differed from the great majority of duodenal contents previously described in Tables I, II, and III. The viscosity was much greater than was found in contents derived from the fasting duodenum or collected immediately after the ingestion of food, but not more so than was usually found in specimens obtained during the third stage of collection. The amounts of duodenal contents collected varied from 42 c.c. to 270 c.c. Proteolytic activity varied from 2.7 to 5.7 mgms., lipolytic from 1.0 to 4.4 c.c., and amylolytic from 2.5 to 4.5 mgms. of glucose. Comparison of the figures with those represent-

TABLE IV.
Enzymatic activities, amounts and physical character of duodenal contents obtained during the second stage of collection.

Subject	Enzymatic activity			Amt. in c.c.	Color	Viscosity	Kind of food ingested
	Pro- teo- ly- tic in mgm. NPN.	Lip- oly- tic in c.c. N/10 NaOH	Amy- lo- ly- tic in mgm. glu- cose				
Desj	3.2	1.8	3.6	270	very dark brown	Moderate	10 c.c. olive oil
Brown	3.8	2.4	4.5	125	very dark brown	" "	10 c.c. olive oil
Desj	2.7	1.5	2.5	140	deep brownish	" "	10 gm. edestin
Brown	3.3	1.8	2.4	105	deep brownish yellow	" "	10 gm. edestin
Desj	3.0	1.0	3.3	100	light brownish yellow	" "	10 gm. arrow root starch
Brown	2.4	1.4	2.5	100	light brownish yellow	" "	10 gm. arrow root starch
Brown	4.7	2.0	3.5	95	deep yellowish brown	" "	5 gm. edestin, 5 gm. arrow root starch
White	4.3	1.2	2.0	42	blackish	" "	25 c.c. olive oil
Cush	3.5	3.3	4.3	90	" " "	" "	" " " " " "
McQ	5.6	4.4	3.0	80	" " "	" "	" " " " " "
Ought	5.7	3.5	2.6	135	" " "	" "	" " " " " "
Desj	4.0	1.8	2.6	200	" " "	" "	" " " " " "

ing the minimum and maximum enzymatic activities of the fasting duodenal contents (Table I), and of those obtained during the first and

third stages of collection (Tables II and III) are given in the following table (Table V).

TABLE V.
Minimum and maximum degrees of enzymatic activities of fasting duodenal contents and of contents obtained during the first, third and second stages of collection.

Time of collection of duodenal contents	Enzymatic activity					
	Proteolytic in mgm. NPN.		Lipolytic in c.c. N/10 NaOH		Amylolytic in mgm. glucose	
	Min- imum	Max- imum	Min- imum	Max- imum	Min- imum	Max- imum
Fasting duodenum	1.2	5.0	0.0	2.7	0.3	6.7
First stage collection	0.8	4.3	0.0	2.2	0.0	3.1
Third stage collection	1.2	5.5	0.6	3.0	0.1	4.3
Second stage collection	2.7	5.7	1.0	4.4	2.5	4.5

The figures in the above table, representing the maximum degrees of enzyme action, show that considerable degrees of activities may be present in duodenal contents collected at any period; while those for minimum action show that activity may or may not be manifested. But the degrees of enzyme activity shown by the figures for minimum action of the various types of enzymes in the duodenal contents obtained during the second stage of collection are much greater than those shown for the minimum action in specimens collected at other periods. The significance of this finding will be discussed later.

Observations were made in order to determine the relative enzymatic activities of fractions of the duodenal contents obtained during the second stage of collection. For this purpose three subjects were fed a mixture consisting of 25 gms. casein and 25 c.c. water. After the dark colored bile appeared the first fractions of duodenal contents were collected over periods of 7 minutes, 15 minutes and 16 minutes; the next over periods of 33, 34 and 15 minutes, and of 45 minutes in one. The results obtained are outlined in the following table (Table VI).

TABLE VI.
Enzymatic activities of fractions of duodenal contents obtained during the second stage of collection after the ingestion of casein.

Subject.	Enzymatic activity			Amt. in c.c.	Period of col- lection in min- utes.
	Pro- teo- ly- tic in mgm. NPN	Lip- oly- tic in c.c. N/10 NaOH	Amy- lo- ly- tic in mgm. glu- cose		
Ought.	5.5	4.0	1.0	55	15
	4.2	2.0	1.0	165	33
White.	4.7	3.2	1.9	35	16
	4.9	3.2	1.4	50	34
Cush.	3.7	1.8	2.0		7
	3.4	1.7	1.0		15
	3.5	1.4	3.5		45

Study of the table (Table VI) shows that, in the different fractions of duodenal contents collected from the same subject, the degrees of action of the same type of enzyme did not vary widely, except in the two following instances. The lipolytic activity of the first fraction obtained from subject Ought is twice that of the second fraction; and the amylolytic activity of the third fraction from subject Cush is much larger than those of the first two fractions. None of the figures fall below those given for minimum enzymatic activities of duodenal contents obtained during the second stage of collection as outlined in Table IV. It will be recalled that the second stage of collection began with the appearance of dark-colored bile; therefore, the increase in the flow of enzymes into the duodenum and the beginning of the flow of bile were about coincident.

A synopsis of the results of the foregoing observations is given as follows: Duodenal contents obtained from the fasting duodenum, and during the first and third stages of collection are comparable, except for the greater viscosity of the specimens of the third stage of collection. The enzymatic activities of the specimens vary from little or no activity to considerable degrees of activity. When compared with these specimens, those obtained during the second stage of collection were much darker in color, and the minimum degrees of enzyme action were all much greater. The fractions of duodenal contents collected during the second stage from the same subject showed fairly uniform degrees of activity for each type of enzyme. An increase in the flow of enzymes and bile into the duodenum occurred approximately at the same time.

Pure food substances were used in the study to determine the effects of various foods on the relative concentrations of enzymes present in the duodenal contents, as estimated by degrees of enzyme action. The pure substances were edestin, arrowroot starch and olive oil. When fed singly, 10 gms. of each substance were used; when given in combinations of twos, 5 gms. of each were mixed; when all three were mixed,

3 1/3 gms. of each were used. To each preparation fed enough water was added to make a bulk of 50 c.c. The arrowroot starch was dissolved in hot water, forming a gelatinous paste, before it was fed. The results are given in the following table (Table VII).

TABLE VII.
Enzymatic activities, amounts and physical character of duodenal contents derived from pure food substances, fed singly and in combinations.

Subject	Enzymatic activity			Amt. in c.c.	Color	Viscosity	Kind of food ingested
	Pro- teo- ly- tic in mgm. NPN.	Lip- oly- tic in c.c.o. N/10 NaOH	Amy- lo- ly- tic in mgm. glu- cose				
Brown	3.9	2.4	4.5	125	very dark brown	Moderate	10 c.c. olive oil
	3.3	1.6	2.4	105	dark brownish yellow	Moderate	10 gm. edestin
	2.4	1.4	2.5	100	brownish yellow	" "	10 gm. arrow root starch
	4.7	2.0	3.5	95	dark yellow brown	" "	5 c.c. olive oil and 5 gm. edestin
	5.0	0.7	2.9	85	yellowish brown	" "	5 1/3 c.c. olive oil, 3 1/3 gm. edestin, 3 1/3 gm. starch
Desj.	3.2	1.8	5.6	270	very dark brown	Moderate	10 c.c. olive oil
	3.4	1.5	3.6	140	dark brownish yellow	" "	10 gm. edestin
	3.0	1.0	3.3	100	yellowish brown	" "	10 gm. arrow root starch
	5.4	1.2	3.1	110	yellowish brown	" "	5 gm. arrow root starch, 5 c.c. olive oil
	6.5 2.1	0.0 0.8	3.7 3.1	90	brownish yellow	" "	5 gm. arrow root starch, 5 gm. edestin

As outlined in the above table, the viscosity of the various specimens was about the same. After the ingestion of oil the duodenal contents were very dark green in color, after edestin brownish yellow and after starch yellowish brown. Thus, each pure food substance gave rise to a characteristic color in the duodenal contents. The mixtures of those foods which contained oil gave rise to duodenal contents of yellowish brown color, while the contents from the starch and edestin mixture were brownish yellow. The largest quantities of duodenal contents were collected from the oil, the next largest from the edestin, less from the starch and the smallest amounts from the food mixtures. Lipolytic activity was greatest in duodenal contents derived from the oil, next greatest in those from edestin and least in those from the starch; while in the contents from the mixtures of oil and starch and of oil and edestin lipolytic activity was of average amount. Thus, in these two subjects the ingestion of oil was followed by the greatest degree of action of the enzyme specific for fat. But this specific relation did not hold for the proteolytic and amylolytic activities after the ingestion of the edestin and starch. In general the figures representing proteolytic and amylolytic activity are comparable in the different specimens of duodenal contents derived from the two subjects. After the ingestion of the mixtures of olive oil, edestin and starch and of

starch and edestin lipolytic activity was reduced, and on one occasion absent.

Further comparative studies of enzymatic activities of duodenal contents were made on three subjects after the ingestion of olive oil and of casein. For this purpose the subjects were fed a mixture of 25 c.c. olive oil and 25 c.c. tap water and a mixture of 25 c.c. bulk of casein and 25 c.c. tap water. The results obtained are outlined in the following table (Table VIII).

TABLE VIII.
Enzymatic activities of duodenal contents derived from olive oil and from casein during the second stage of collection.

Subject.	Enzymatic activity.			Kind of food ingested.
	Pro- teo- lytic in mgm. NPN.	Lip- oly- tic in c.c.o. N/10 NaOH.	Amy- lo- ly- tic in mgm. glu- cose.	
Ought	4.2	2.0	1.0	Casein
	5.7	3.5	2.6	Olive oil
White	4.9	3.2	1.4	Casein
	6.0	4.8	4.3	Olive oil
Cush	3.5	1.4	3.5	Casein
	3.5	3.3	4.3	Olive oil

Study of Table VIII shows that duodenal contents derived from oil presented greater degrees of lipolytic action than those derived from casein. These findings confirm those discussed above (Table VII) which show that lipolytic activity is greater in duodenal contents derived from olive oil than in contents derived from casein, edestin and starch meals.

Comparative studies of the degrees of enzymatic action were made in duodenal contents derived from the fasting duodenum, after the ingestion of tap water and after drinking cornstarch solution. For this purpose the fasting contents were collected over periods of thirty minutes, then 50 c.c. of tap water were given and the contents collected over periods of 40 to 60 minutes, and after this 50 c.c. of 0.5 per cent.

cornstarch solution were ingested by two of the subjects and the duodenal contents collected for one hour. After the ingestion of water, by the three subjects to whom no cornstarch was given, the duodenal contents were collected for two hours; in fractions of one hour each. The enzymatic activities of the two fractions were similar. The results obtained from this comparative study are outlined in the following table (Table IX). To the table are added the figures representing the enzymatic activities of duodenal contents collected after the ingestion of a mixture of olive oil and tap water. The experiments with the oil feedings were made on days different from those with the fasting duodenum and tap water feedings.

TABLE IX.
Enzymatic activities and amounts of duodenal contents collected from the fasting duodenum and after the ingestion of tap water, or of corn starch solution or of olive oil.

Subject.	Enzymatic activity.			Amt. in c.c.	Period of collection in minutes.	Kind of food ingested.
	Proteolytic in mgm. NPN.	Lipolytic in c.c. N/10 NaOH.	Amylolytic in mgm. glucoase.			
McQ	2.5	0.4	1.6	58	30	Fasting duodenum
	3.8	2.8	1.1	97	60	50 c.c. tap water
	5.6	4.4	3.0	80	48	25 c.c. olive oil and 25 c.c. tap water.
Ought	1.8	0.5	0.3	15	30	Fasting duodenum
	1.5	0.1	0.0	52	45	50 c.c. tap water
	2.7	0.0	0.0	120	60	50 c.c. 0.5% cornstarch
	5.7	3.5	2.4	100	60	25 c.c. olive oil and 25 c.c. tap water.
White	3.7	1.0	0.8	2	30	Fasting duodenum
	2.0	0.1	0.0	105	40	50 c.c. tap water
	3.3	1.4	0.2	80	60	50 c.c. 0.5% cornstarch
	6.0	4.0	4.3	100	60	25 c.c. olive oil and 25 c.c. tap water.
Brown	5.9	0.5	1.9	18	30	Fasting duodenum
	3.0	1.1	0.8	39	60	50 c.c. tap water, 5 gm. barium sulphate.
	3.9	2.4	4.5	120	55	10 c.c. olive oil and 40 c.c. tap water.
Desjar	1.2	1.1	1.6	25	30	Fasting duodenum
	3.0	0.5	2.0	60	60	50 c.c. tap water, 5 gm. barium sulphate.
	3.2	1.8	3.6	270	63	10 c.c. olive oil, 40 c.c. tap water.

In the above table (Table IX) comparison of enzymatic activities of the contents of the fasting duodenum and after drinking water shows that proteolytic activity was diminished in three and increased in two; lipolytic activity was decreased in two; amylolytic activity was diminished in four and slightly increased in one. In duodenal contents derived from cornstarch proteolytic activity was increased in one and decreased in one and the same held true for lipolytic activity. Thus, after the ingestion of water or weak cornstarch solution the degrees of action

of the various enzymes present in the duodenal contents may be diminished or increased, as compared with the activity of those present in the fasting contents. However, after the ingestion of olive oil degrees of action of all these various enzymes were increased in the contents of each subject. These findings are portrayed in the following table (Table X). To the table are added the minimum and maximum figures for enzymatic activities after the ingestion of casein or edestin by four of the subjects.

The findings in Table X show: 1, that the en-

TABLE X.

Minimum and maximum enzymatic activities of fasting duodenal contents and of contents derived from water, from 0.5 per cent. corn starch solution and from olive oil.

Kind of food ingested.	Enzymatic activity					
	Proteolytic in mgm. NPN.		Lipolytic in c.c. N/10 NaOH		Amylolytic in mgm. glucose.	
	Min-imum	Max-imum	Min-imum	Max-imum	Min-imum	Max-imum
Fasting duodenum	1.2	5.0	0.0	2.7	0.3	6.7
Water (50 c.c.)	1.5	5.8	0.1	2.8	0.0	1.1
Cornstarch (50 c.c.)	2.7	3.3	0.0	1.4	0.0	0.2
Olive oil and water (50 c.c.)	5.2	5.7	1.8	4.8	2.0	4.5
Casein or Edestin (50 c.c. bulk)	3.3	4.9	1.4	3.2	1.0	3.6

zymatic activities of duodenal contents derived from water or cornstarch solution are comparable to those present in the fasting contents; and 2, that much greater minimum degrees of enzyme action were present in duodenal contents collected after the ingestion of olive oil, of casein and of edestin.

A study of the enzymatic activities and hydrogen ion concentrations* of duodenal contents

collected over hourly, and in some instances 15 minute periods, was made. The collections were carried out for four hours with each subject. For the purpose of this study five subjects were fed a mixture of milk, cottage cheese and 40 gms. barium sulphate, and two subjects 20 per cent. cream and 40 gms. barium sulphate. Each meal consisted of a volume of 300 c.c. The minimum emptying time of the stomach was about four hours, so that each specimen of duodenal contents was collected while food was passing out of the stomach. Within a few minutes after a subject had ingested a meal, deeply bile colored duodenal contents were returned through the tube; and these contents contained barium and food in easily demonstrable amounts. More or less food and barium were obtained in all the duodenal contents collected after the ingestion of these meals. In three subjects the contents collected during the first hour were fractioned into four parts, each part covering a period of 15 minutes. The results obtained in this series of experiments are outlined in the following table (Table XI).

Study of Table XI shows that the enzymatic activities were generally comparable to those in duodenal contents obtained during the second

TABLE XI.

Enzymatic activities and pH of duodenal contents collected over periods of 15 minutes and one hour, after the ingestion of milk and cottage cheese and of cream in volumes of 300 c.c.

Sub-ject	Proteolytic activity expressed in mgm. nonprotein nitrogen in specimen collected during				Lipolytic activity expressed in c.c. of N/10 NaOH in specimen collected during				Amylolytic activity expressed in mgm. of glucose in specimen collected during				pH of specimens collected during				Kind of food ingested
	1st hr	2nd hr	3rd hr	4th hr	1st hr	2nd hr	3rd hr	4th hr	1st hr	2nd hr	3rd hr	4th hr	1st hr	2nd hr	3rd hr	4th hr	
	1st hr	2nd hr	3rd hr	4th hr	1st hr	2nd hr	3rd hr	4th hr	1st hr	2nd hr	3rd hr	4th hr	1st hr	2nd hr	3rd hr	4th hr	
A	3.9*				2.6*				2.7*				5.1				Milk, water and cottage cheese
	2.9*				1.5*				1.6*				4.5				
	1.0*				0.0*				0.6*				4.1				
	2.4*	3.4*	2.3	2.4	1.4*	2.5	1.8	1.4	1.4*	2.1	0.5	1.2		4.3	5.0	5.6	
B	3.0*				1.8*				1.8*								" " "
	3.4*				2.0*				1.0*								
	1.7*				0.6*				0.7*								
	3.0*	4.2	5.2	5.2	1.6*	2.4	1.7	1.8	1.5*	1.1	1.6	2.3		6.4	7.1	7.0	
C	4.8*				2.4*				5.4*								" " "
	3.0*				2.8*				2.7*								
	3.0*				3.0*				3.4*								
	5.1*	4.0	4.2	4.7	2.8*	2.1	1.4	1.8	3.4*	2.0	0.9	1.6					
D	3.9	2.7	5.1	5.7	2.0	1.0	1.8	1.6	1.7	0.8	1.8	1.6	5.1	4.5		4.0	" " "
E	2.5	5.2	4.4	5.5	1.9	1.7	2.0	2.9	1.1	1.9	1.4	1.6					
F	3.4	3.0	3.0	3.5	3.0	2.5	2.8	2.2	1.9	1.9	2.4	2.4	5.1	5.1	5.5	5.2	20 per cent cream
G	4.5	4.1	2.8	3.5	3.9	3.0	2.5	2.9	3.6	3.0	2.2	2.6					

* Specimens collected over 15 minute periods.

stage of collection, after feeding the pure food substances (see Table IV). The enzymatic activities of the 15-minute specimens were comparable to those of the succeeding hourly collections, except for the third 15-minute specimens in subjects A and B. These two specimens were grayish instead of yellow in color, which showed a considerable dilution with material from the stomach; and this undue dilution explains the

low degrees of enzyme action present in the specimens. The same type of enzyme varied moderately in the degrees of its action in the different hourly specimens of duodenal contents from the same subject, but there was no regular manner in which the variations occurred; that is, there was no systematic increase in the enzymatic activities from the first to the fourth hours, except for the proteolytic activity in subjects B, and E.

The findings discussed in Table XI show that the enzymatic activities of duodenal contents, as

* Hydrogen ion concentrations were determined by a potentiometer constructed by the authors under the direction of Dr. Boye, of the Harvard Cancer Commission. Dr. Boye's quadrant electrometer was used.

estimated under the experimental conditions used, remain relatively constant for each type of enzyme as long as the stomach is in the process of emptying itself of food. From this finding it is inferred that the amounts (concentrations) of the enzymes remained relatively constant.

The hydrogen ion concentration determinations demonstrate that no relation existed between the degrees of acidity of the duodenal contents and the degrees of enzyme action.

DISCUSSION.

Enzymes present in duodenal contents may be derived from the pancreas, from the stomach, possibly from saliva and perhaps from duodenal mucosa. However, the methods used in the work here reported, when applied to the study of enzymatic activities of duodenal contents derived from patients,* show that all but very small degrees of enzyme action are absent when diseased processes have excluded pancreatic secretion from the duodenum. Thus, the enzymes demonstrated by these methods probably originate almost exclusively, if not entirely, in the pancreas. For this reason demonstration of enzymatic activity in duodenal contents indicates the presence of pancreatic secretion; and in the discussion of the work here reported it will be assumed that the various enzymatic activities demonstrated represent the action of enzymes secreted by the pancreas.

In patients* with complete obstruction to the common bile duct it has been found that the absence of bile does not demonstrably influence the activity of enzymes of duodenal contents as estimated by the procedures employed. Furthermore, addition of human bile to duodenal contents did not increase the activities of the enzymes, as demonstrated by the methods used. Theoretically, this is what would be expected with the methods, in view of the physical conditions under which the enzymes act. Because of these findings it is considered that the presence of different amounts of bile had a negligible influence on the activities of the various enzymes, as determined by these methods.

The term "fasting" duodenal contents designates the contents obtained from the duodenum about fifteen hours after the last ingestion of food and about nine hours after the last drink of water. But in taking the duodenal tube subjects swallowed much saliva; and it is also well known that the normal fasting stomach contains more or less acid secretion, cellular debris and mucin. Undoubtedly the stomach throws these materials over into the duodenum, so that a truly fasting state of the stomach and duodenum was not present during the course of the experiments here reported. Just what rôle the presence of these materials, or of the tube, in the duodenum played in the production of the presence of enzymes in the duodenal contents, was not deter-

mined. All that can be concluded is, that, under the experimental conditions here reported, proteolytic and amylolytic activities were always present in duodenal contents; while lipolytic activity was occasionally not demonstrable.

Enzymatic activities of duodenal contents obtained during the third stage of collection (Table III) were generally comparable to those obtained in fasting duodenal contents (Table I). It is considered that not infrequently the stomach had emptied itself of food during the second stage of collection; so that during the third stage the contents collected were often fasting contents. However, many observations* show that the normal stomach empties at different rates in different persons; and it was demonstrated that the stomach, during the experiments here reported, was not always empty at the time of the third stage of collection. Thus, at times the duodenal contents collected during the third stage represented the same conditions as were present during the second stage of collection; and under these conditions the enzymatic activities of the third and second stages were always found to be comparable.

It will be noted that the fasting duodenal contents at times showed degree of enzyme action comparable to those found in duodenal contents obtained during the second stage of collection or after the ingestion of food mixtures of 300 c.c. volume (compare maximum figures of Table V and figures of Table XI with those of Table I). But the fasting contents were relatively undiluted, while those collected after the ingestion of food were diluted with bile and gastric chyme. Amounts of the latter were particularly large after the ingestion of meals of 300 c.c. volume, as judged both by the quantities of duodenal contents collected and the amounts of barium seen to be ejected from the stomach into the duodenum when observed through the fluoroscope. For this reason the enzymatic activities found in duodenal contents during the time the stomach was emptying itself of food represented greater concentration of enzymes than was present in the fasting duodenal contents.

During the second stage of collection the stomach was emptying itself of food, and duodenal contents obtained during this stage showed minimum degrees of enzyme action much greater than minimum degrees demonstrated in duodenal contents collected over other periods (Table V). From this it is concluded: 1, that during the second stage of collection increased concentration of enzymes was present in the duodenal contents; and 2, that during this stage the effect of the ingestion of food on pancreatic activity is shown. In other words, the findings show that the presence of food in the stomach and intestines in some way brings about the stimulation of the secretion of pancreatic juice.

Evidence of pancreatic stimulation was much less pronounced after the ingestion of water or

* Unpublished observations.

* Unpublished observations.

weak cornstarch solution than after the ingestion of foodstuffs (see Table X). Water¹⁷ and cornstarch solution stimulate the secretion of acid gastric juice; so that after their ingestion acid fluid was ejected from the stomach into the duodenum. Because of this it is concluded that something more than the mere ejection of acid gastric contents into the duodenum is necessary to stimulate materially pancreatic secretion.

Not only was it demonstrated that food substances stimulate pancreatic secretion, but it was also demonstrated that lipolytic activity was greatest after the ingestion of olive oil, less after protein and least after carbohydrate (Tables VII and VIII). Furthermore, duodenal contents obtained after the ingestion of oil showed greater degrees of all types of enzymatic activity than did contents derived from protein. This last statement holds true for duodenal contents derived from four of the five subjects on whom these experiments were carried out (Tables VII and VIII). In the fifth subject the duodenal contents showed the greatest degree of lipolytic activity after the ingestion of oil, but proteolytic and amylolytic activities were comparable to those derived from a meal of edestin. Nevertheless, the findings show the existence of a relation between the degrees of enzyme action and the kind of food ingested.

It was found that lipolytic activity was diminished or absent after the ingestion of certain mixtures of the pure foodstuffs (Table IV). There is no reason to doubt that these mixtures called forth secretion of HCl in the stomachs of the subjects. At any rate, it was proved that the food mixtures were ejected from the stomach into the duodenum; and the acid fluid normally present in the fasting stomach would necessarily, also, be thrown over into the duodenum. If HCl were the principal factor in bringing about the secretion of pancreatic juice, it seems strange that at times it would fail to do so in normal persons. On the other hand, it is conceivable that the physical state of foodstuffs mixed with a gelatinous substance like arrowroot starch paste might be such as to render their digestion very slow. As a result little or no pancreatic secretion might be stimulated and only the activity of enzymes already present in the fasting duodenal contents would then be demonstrable. This may be the true explanation of the findings in the duodenal contents derived from the mixture of arrowroot starch, edestin and olive oil and from the mixture of arrowroot starch and edestin (see Table IV).

The findings in Table XI demonstrate: (1) that the enzymatic activities of duodenal contents did not show systematic increase as digestion progressed; from this it is inferred that the relative concentration of enzymes present did not increase proportionately. (2) the findings also show that no relation existed between hydrogen ion concentration (degrees of acidity in the

duodenum) and the concentration of active enzymes in the duodenal contents.

It was found, after the ingestion of pure foodstuffs and the appearance of the latter in the duodenal contents, that from seven to forty-five minutes elapsed before an increase in enzyme action was noted. This observation is most easily made after the ingestion of olive oil and tap water. The oil will be collected constantly over periods varying from ten to forty-five minutes before an increase in enzymatic activities and the change to the dark bile occur. These observations show: (1) that after the appearance of pure foodstuffs in the duodenum there is a latent period before the flow of enzymes and bile is stimulated; while (2) the finding that the flow of bile and enzymes was coincident suggests a common stimulating factor.

During the period of latency four phenomena were probably occurring: (1) an increase in the hydrochloric acid concentration of the stomach contents; (2) the actions of gastric and salivary enzymes on foodstuffs present in the stomach; (3) the action of duodenal enzymes on foodstuffs ejected from the stomach into the duodenum; and (4) the absorption of the products of digestion. What effect increase in gastric acidity, which occurs as digestion progresses, had on duodenal acidity, was determined after the ingestion of milk and cottage cheese and after cream. No effect was found (Table XI). The significance of the absorption of products of food digestion will be discussed later.

The findings: (1) that something more than the mere ejection of acid gastric contents into duodenum was necessary to stimulate demonstrably the secretion of pancreatic juice, and (2) that no relation existed between the degrees of acidity (hydrogen ion concentrations) and the action of enzymes in duodenal contents are evidence that the acidity of duodenal contents was not the essential factor in bringing about the stimulation of the secretion of pancreatic juice. On the other hand, the findings: (1) that food in some way stimulated the secretion of pancreatic juice; (2) that a relation existed between the degrees of enzyme action and the kinds of food ingested; (3) that a latent period existed in which foodstuffs could be digested and absorbed; and (4) that water was a much less potent pancreatic stimulant than food, although water stimulates a normal gastric acidity, present evidence that the products of food digestion are an essential factor in stimulating the secretion of pancreatic juice.

The above interpretation of the findings in the experimental work here reported do not agree with the view of Pawlow, except for lipolytic activity. They do not uphold either the secretin theory of Bayliss and Starling or the hypothesis of a nervous mechanism as the most potent factors in the stimulation of the secretion of pancreatic juice. The remaining most probable possibility is that the products of the digestion of

food are the most important factor in stimulating the pancreas to secretory activity.

The disagreement with Pawlow's contentions may possibly be more apparent than real. In the first place Pawlow worked on dogs; and a pancreatic regulatory apparatus may exist in dogs which is different from that of man. In the methods used by Pawlow for demonstrating enzymatic activity the substrates acted upon by enzymes were placed directly into pancreatic juice. The hydrogen ion and buffer conditions of the various specimens of pancreatic juice may have been such as to give results justifying Pawlow's conclusions. But the physical chemistry of Pawlow's methods is so grossly erroneous that an interpretation of results obtained by them is well-nigh impossible.

The experiments of Bayliss and Starling consisted of intravenous injection into animals of hydrochloric acid extracts of duodenal mucosa. In this way pancreatic secretion was stimulated. But the work of von Fürth clearly demonstrates that it is not necessary to assume the existence of "secretin" to explain this stimulation. This investigator, among others, has demonstrated that various well-known chemical substances normally present in duodenal mucosa will produce such a stimulation. Furthermore, the maceration of duodenal mucosa and its extraction with hydrochloric acid might very well form compounds (due to decomposition of proteins, etc.) similar to those occurring during digestion; such compounds may play a rôle in the stimulation of pancreatic juice when injected into the blood stream of an animal. In other words, the chemistry of the work of Bayliss and Starling was such as not to justify the drawing of far-reaching conclusions from their observations.

Experiments have been repeatedly carried out by the present authors in which water, N/20-HCl, glucose solutions and olive oil have been introduced directly into the duodenum of men. The results were the same as those obtained after the ingestion of these substances by mouth. Certainly these substances were introduced into the duodenum in an inert chemical state, except the N/20HCl. This contradicts the often-quoted statement that such substances do not stimulate pancreatic secretion. From these experiments it was concluded that whenever any harmless liquid is introduced into the duodenum of man intestinal digestion and absorption begin.

The absorption of materials present in the duodenal contents and those coming into the duodenum from the stomach (for in man the introduction of fluid into the duodenum always starts up the ejection of stomach contents into the duodenum, as the authors have repeatedly demonstrated) could explain the often-quoted experiment of Popielski.¹⁸ In this experiment hydrochloric acid solution was placed in the duodenum of one dog, whose blood supply was connected to that of another dog; as a result pancreatic juice was secreted by the latter. The contamination of the original duodenal material

with gastric contents introduces an element of uncertainty, as digestible material thus present would give rise to products analogous to those produced by food digestion. In fact, all the work supporting the "secretin" theory furnishes only indirect evidence of the correctness of that theory; while phenomena urged in its support can all be explained in other ways by using well established facts as a basis.

This discussion is not intended to belittle the excellent work of two such competent experimenters as Drs. Bayliss and Starling. But the purpose is to emphasize that "secretin" remains a hypothetical substance. Furthermore, it should be emphasized that the work on "secretin" has all been carried out on the lower animals, and whether or not the same experimental results would be obtained in man has not been determined.

The principal conclusions reached in the above discussion may be summarized as follows:

1. The findings showed that the presence of food in the human intestines in some way stimulated the activity of the external secretory function of the pancreas. They indicate that the principal factor in producing this stimulation was the absorption of the products of digestion rather than the acidity of the gastric chyme.

2. Lipolytic activity of duodenal contents was always, while proteolytic and amylolytic activities were almost always, greater after the ingestion of olive oil than after the ingestion of protein or carbohydrate food. From this it is inferred that olive oil was a more powerful stimulant to the activity of the external secretory function of the pancreas than were the other types of food.

3. Water was a less potent stimulant of external pancreatic secretion than were food substances.

4. After the appearance of food substances in the duodenum there was a latent period before the flow of enzymes and bile began.

6. The time coincident of the onset of the flow of bile and pancreatic juice suggests a common stimulant.

7. Under the experimental conditions employed the fasting duodenal contents contained both enzymes and bile pigments.

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Suffolk District Medical Society.

MEETING ON "REHABILITATION."

The Suffolk District Medical Society held a meeting on "Rehabilitation" at the Boston Medical Library on November 22, 1922. The program was arranged by Dr. Hilbert F. Day, and the following speakers took part:

DR. F. J. COTTON, Boston: Reconstruction or rehabilitation, which was brought into prominence by the war, is being carried over into civil life and industry. It is a field the importance of which is just beginning to be recognized and its scope broadened. The problems are similar to those encountered in the war, namely to save the derelicts of industry. Everybody dealing with the subject from the surgical side is impressed with the fact that the cases are due to bad surgery and are avoidable. What we ought to have is a better type of surgery which will make correcting the mistakes of others unnecessary. For instance, cases of fracture of the os calcis which go through the ordinary routine and are crippled, are picked up in the reconstruction work and brought back to normal. Then there are cases of Colles' fracture which often have a permanent partial or total disability. We can handle those cases late and straighten them out very well, although it should be unnecessary. Of course, results obtained late are not comparable to results at the time of injury.

An important part of the work of rehabilitation is bridging the patient over from the time of injury to his return to the pay-roll. The average surgical case receives surgical treatment only and is discharged unfit to go back to work. The medical man should be called in, also the orthopedist, the physiotherapist and the man who knows occupational therapy. We need team work. Take, for example, a man of fifty with a fractured femur or any case requiring a long period of treatment. Such cases are not cases for surgical reconstruction alone but cases for team work rehabilitation. The success of rehabilitation depends on proper team work. This is purely a team work proposition. My own feeling is that we are going

to have institutions for this sort of thing where a man can be taken care of during the period of convalescence with a view to his rehabilitation to industry.

THE STATE INSTITUTIONS.

DR. JOHN H. NICHOLS: In the Industrial Departments of the State Institutions we have the inmates engaged in carpentry, basket making, weaving, mending, farming, etc. The work is assigned; hours of work are fixed. Industrial employers hire men who are 75 percent plus efficient, but men who are only 50 percent efficient are outcasts. It seems to me that the problem of finding a market for their wares is harder than finding work for the inmates.

I would present two viewpoints: The first, the more difficult, is to promote successfully a "back to the country," "back to the farm" movement. Even the cripple insists on going back to the city. On the farm there is always something that the cripple can do and be self-supporting. But now the unfortunates and crippled can scarcely earn a livelihood on the farms in this Commonwealth. Movements for small farms and gardens should be promoted and reclamation of waste land. The physicians could then send patients out on farms for rehabilitation where they could help to raise farm products. We might call them "heliotherapy" farms.

The second viewpoint which especially bears on the problem is a city problem. Why not erect a building in the city for these cripples who are loafing or selling pencils on the street? Call it a service shop or accommodation shop where cripples can go and do repair work and mending and all sorts of light work. Have a building centrally located which could serve as an employment office and as a clearing house for the sale of articles made by cripples.

CERTAIN LEGAL ASPECTS.

JOSEPH A. PARKS, Esq.: Rehabilitation is the biggest problem under the Workmen's Compensation Act, bigger than the matter of compensation. I want to take up the problem of the cripple after he has left the hands of the doctor. He has got stale. Take the case of a man who has lost an arm, a hand or fingers—how are you going to get such a man back into industry? You can't unless you have the whole-hearted support of the employers of labor in this Commonwealth. Few employers are kind enough to employ such men. The result is that the cripple drifts about from job to job, his physical condition getting worse. Employers should coöperate with the Board and with the doctors. The sum of \$7,000,000 is paid out every year for compensation insurance and for doctors' bills, and there is no reason why \$1,000,000 cannot be clipped off that sum by the proper coöperation on the part of employ-