Two other substances used in solution with the sodium taurocholate were cholesterin and sodium bicarbonate. Cholesterin showed no change in the dilution at which reaction of the pneumococcus on inulin took place when sodium taurocholate alone was used. Sodium bicarbonate even in the higher dilutions of 1:65,600 prevented a change in the inulin which was due, in all probability, to its alkalinity. This change was out of proportion to the slight protective effect it exerted on the white mouse.

Pneumococcus II of our stock was run as a comparison and was found to possess no virulence and to show no reaction on inulin.

Pneumococcus III, as stated previously, did not lose its ability to ferment inulin in the presence of bile dilutions in proportion to its loss of virulence. An interesting point, however, presented itself with regard to its coagulation in that it started in the bottom of the tube while that of pneumococcus I started in the top of the tube. In this type of pneumococcus sodium citrate in sodium taurocholate also shifted the reaction to the next higher dilution.

In summarizing the results, it appears that the ability of pneumococcus I to ferment inulin, especially when the bile salt dilution is added, varies with its virulence for the white mouse and its numbers, while that of pneumococcus III maintains its ability to ferment inulin on loss of virulence to a much greater degree than type I. There is also demonstrated an inhibiting effect on pneumococcus inulin fermentation, if the sodium citrate is added to the sodium taurocholate solution which is in accordance with the increased toxicity of this solution for the white mouse.

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A Comparative X-Ray Study of Passage of Foodstuffs Through Gastro-intestinal Tract of Rats.

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(Introduced by J. H. Musser.)

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For many years previous to the discovery of the Roentgen ray, studies of the emptying time of various foodstuffs by the stomach and intestines were made by many investigators. These early investigations were usually conducted on animals with artificial fistulas. It was impossible at that time to visualize the viscera of these animals except by operation, and this was undesirable as the process of digestion was thereby interfered with.

Cannon[1] was the first to employ the Roentgen ray in such a study. His observations were made on healthy animals, principally cats. The Roentgen ray afforded him the opportunity to visualize and study the digestive tract of these animals uninfluenced by any artificial conditions which could disturb their digestion. His studies were undertaken a few years after the discovery of the Roentgen ray when little was known of the normal motility of the gastro-intestinal tract.

It occurred to us that such a study at this time, using improved Roentgen ray technic and the modern powerful apparatus together with the present day knowledge in this field relative to the gastro-intestinal tract would yield more satisfactory results. For this reason, we undertook the study of the passage of carbohydrate, protein and fatty foodstuffs through the gastro-intestinal tract of rats in order that the findings of the earlier investigators may be compared with the results obtained through the employment of present modern facilities.

In our experiments, 39 healthy rats were used. These rats before being examined were fasted for 48 hours and deprived of water for 24 hours. The animals were placed in the same environment and handled in the same manner as reported by us[2] in our observations upon rachitic rats.

Two separate sets of carbohydrate and protein fed rats and one set of fat rats were employed. There were 14 rats in the first carbohydrate group and one in the second group. This rat was used as a check on the rats of the first group as it was not found necessary to use more inasmuch as the emptying times of the gastro-intestinal tract of the first group were in accordance with the findings of other observers. The rats of both groups were fed 7½ gm. of starch and 2½ gm. of barium sulphate for 20 minutes. They were immediately fluoroscoped in loose cotton sacks to ascertain if the stomach was full and at the same time to observe if any of the food was passing through the pylorus. Careful fluoroscopic observations were made every 15 minutes thereafter until it was definitely demonstrated that the food column was entering the cecum.

In the instance of the rats fed with protein our findings were in variance with other investigators and for this reason we ran 2

[1] Cannon, W. B., *Am. J. Physiol.*, 1904, xl, 416.

[2] Menville, L. J., Blackberg, S. N., and Ané, J. N., PROC. SOC. EXP. BIOL. AND MED., 1929, xxvi, 758.

groups, the second serving as a check on the first group. In the first protein group we used 10 rats to which we fed 7½ gm. of casein and 2½ gm. of barium sulphate. In the second group we used 8 rats, giving them the same food in the same quantity as in those of the first group. Both groups were permitted to feed for 20 minutes and were fluoroscoped in the same manner as those of the carbohydrate groups.

Six rats composed the fat group and they were fed 7½ gm. of pure cream mixed with 2½ gm. of barium sulphate and permitted to feed for 20 minutes and examined radiologically as in the carbohydrate and protein groups.

The various foodstuffs ingested by all of the rats were of approximately the same general consistency.

TABLE I.
General Averages of Series No. 1.

Food	Wt. Gm.	Ate Gm.	Cecum Appearance Time		Stomach Emptying Time		Small Intestine Emptying Time		Colon Emptying Time	Rats No.
			hr.	min.	hr.	min.	hr.	min.	hr.	
Carbohydrates	204.4	5.2	5	4	6	56	10	11	53	14
Proteins	275.2	7.56	4	12	11	58	14	06	63.4	10
Fats	235.8	5.3	8	35	16	44	29	10	61.3	6

TABLE II.
General Averages of Series No. 2.

Food	Wt. Gm.	Ate Gm.	Cecum Appearance Time		Stomach Emptying Time		Small Intestine Emptying Time		Colon Emptying Time	Rats No.
			hr.	min.	hr.	min.	hr.	min.	hr.	
Carbohydrate	200	6	5	23	9	8	13	30	....	1
Protein	207.5	6	4	42	14	32	16	10	....	8

TABLE III.
Compiled Averages of Series No. 1 and No. 2.

Food	Wt. Gm.	Ate Gm.	Cecum Appearance Time		Stomach Emptying Time		Small Intestine Emptying Time		Colon Emptying Time	Rats No.
			hr.	min.	hr.	min.	hr.	min.	hr.	
Carbohydrate	204.1	5.3	5	05	7	05	10	24	53	15
Protein	245.1	6.8	4	26	13	09	15	01	63.4	18
Fats	235.8	5.3	8	35	16	44	29	10	61.3	6

The first fluoroscopic observations were made on the rats of all groups immediately after the completion of the feeding time and in every instance the stomach was found filled and some of the food had already passed through the pylorus. This finding is in accord with that of McClure, Reynolds and Schwartz.[3] Careful fluoroscopic observations were then made every 15 minutes until the food column was visualized in the cecum and the stomach and small intestine was found empty. Skiagraphs were made of representative rats of the various groups, so that they may serve as records of the results. The fluoroscopic examinations of the emptying time of the colon were made at longer intervals which varied from one hour to several hours. The results obtained in all of these observations are recorded in our tables.

As shown in Table No. I, the average emptying time of the stomach of the carbohydrate group was the most rapid, the protein next, while the fat was the slowest of all. The cecum appearance time of the food column of the protein group was the fastest, next the carbohydrate and last the fat group. The small intestine emptying time of the carbohydrate group was the fastest, next the protein and last the fats. The colon emptying time of the carbohydrate group was the fastest of all and with a slight difference between the protein and fat groups. These observations on the colon are not as accurate as those of the stomach and small intestine because this organ empties itself very slowly of the various foodstuffs used and for this reason the fluoroscopic examinations were of longer intervals.

Table II represents a check on the group as shown in Table I and it is seen that the findings in Table II check closely with those in Table I.

Conclusions. These experiments demonstrate that carbohydrates in the form of starch, protein in the form of casein, and fat in the form of pure cream all leave the stomach of rats at approximately the same time. The rate of emptying time of stomach, small intestine and colon corresponds closely to those found by other observers. Although the emptying times observed by us were approximately the same as those of previous workers, marked differences were noted for the rates of passage of the various foodstuffs in our experiments as compared with others.

The passage of protein through the small intestine of rats is much faster in every instance than fat and only slightly faster than carbohydrate. This is at variance with the findings of the earlier investigators, who stated that proteins pass through the small intestine slowly, fats a little faster and carbohydrates fastest of all.

We believe that the rate of the food column of the different foodstuffs through the small intestine is probably due to the muscular

[3] McClure, C. W., Reynolds, L., Schwartz, C. O., *Arch. Int. Med.*, 1920, xxvi, 410.

response of this organ. The rate of the emptying time of the stomach seems a negligible factor as it was demonstrated that some of the meal of the different foodstuffs passed through the pylorus at about the same time.

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Is the Cystic Bile Resorbed in Toto?

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Notwithstanding the great body of evidence accumulated during the last 7 years tending to show that the gall bladder discharges the bulk of its contents after meals, it has lately been reaffirmed that the primary function of this organ is to resorb the cystic bile *in toto* for the purpose of returning it to the general circulation, and that "under normal conditions, whatever passes into the gall bladder through the cystic duct, never passes out again through the cystic duct."

Although this hypothesis has had the effect of stimulating research in a difficult field, it owes its existence largely to teleological reasoning. Thus, to one investigator it offers the best theory for explaining the formation of gall stones and the occurrence of hydrops of the gall bladder[1]; to another, it is justified by the assertion that no one has explained why a biliary reservoir is necessary for digestion[2]; to a third the interpretations of the results of cholecystography are easier and the manifestations less contradictory if it is assumed that the bile enters the gall bladder not to be stored there and in time expelled, but to be resorbed *in toto* by the gall bladder mucosa.[3]

Yet it is to be questioned whether, in the 7 years that have elapsed since this theory was first promulgated, any proof that the cystic bile is resorbed *in toto* has ever been advanced. Believing that this theory is susceptible to proof or disproof we have undertaken to block the cystic duct in cats in such a way as to avoid trauma to the gall bladder or interference with its vascular drainage—a method successfully employed by both Sweet and Halpert in their experiments. With the outlet blocked it is reasonable to expect that the gall blad-

[1] Halpert, Bela, *Arch. Surg.*, 1929, xix, 1037.

[2] Sweet, Joshua, *Annals Surg.*, 1929, xc, 939.

[3] Blond, Kasper, *Arch. f. klin. Chir.*, 1928, cxlix, 662.