

and was easily detachable, leaving a bleeding surface. On the evening of the fourth day there was slight delirium, which became more severe on the following day, and finally the sixth day found the patient again rational. On March 16, the seventh day of the disease, the membrane disappeared, the temperature was normal and a marked amelioration was apparent. From this time convalescence was rapid. The treatment consisted in the administration of trional, ice-packs to the head, and an antiseptic gargle.

A swab was taken from the throat on the third day of the disease and a culture on blood serum, prepared in the usual manner, showed a profuse growth, the cover-slips from which contained moderate-sized, oval cocci arranged almost entirely as tetrads and taking the aniline gentian violet and Loeffler's methylene blue stains evenly and deeply. A few diplococci of similar size could be made out. Treated with Gram's solution, the cocci retained their stain.

Agar and gelatin plates made from the blood-serum culture contained pure growths of a coccus which behaved on media as follows:

Agar slant: profuse, gray, moist, slimy growths slightly raised above the surface of the medium.

Blood-serum: a growth similar in character to that on agar.

Potato: thick, slimy, white growth.

Gelatin stab: white growth along the line of inoculation, and in three or four days a round, raised, white, button-like growth on surface; no liquefaction of the gelatin.

Faintly alkaline bouillon: very slight turbidity of the medium and a thick gray or white viscid deposit in the bottom.

Litmus milk: slight acidity but no coagulation of milk.

Dunham's solution: growth similar to that in bouillon; no indol formation.

Lactose, glucose and saccharose media: no evidences of gas production.

Hanging drop: preparations showed no motility and cover-slips from various media exhibited a variable morphology—sometimes diplococci, less often tetrads. The organism stained by Gram's method.

A full-grown guinea-pig, subcutaneously inoculated with 2 c.c. of a 24-hour-old bouillon culture, died in four days, with abscess formation at the point of inoculation. The inoculated coccus was recovered from the abscess, blood and viscera. Four c.c. injected into one of the auricular veins of a three-quarter-grown rabbit produced stupor, and death in eighty-seven hours. The organism was recovered from the blood; cover-slips from the viscera, pus from abscess in guinea-pig, and the sections of tissue from the animals experimented on contained tetrad cocci in abundance.

The bacteriologic diagnosis was micrococcus tetragenus (Gaffky).

The appearance of the throat, it has been thought by Dieulafoy⁸ in some cases, is to be regarded to some extent as a characteristic of this class of infection: "*Ils donnaient l'apparence d'une gorge qui aurait été saupoudrée de grains de sable,*" to which French observers give the name "*angine sableuse.*"

We are constrained, however, from our experience, based on four cases of tetragenous infection, to regard the throat picture as variable in presentation, sometimes simulating the supposedly, until lately, charac-

teristic appearance of diphtheria; at other times resembling tonsillitis in its common forms. The phenomena of a general systemic nature in the cases thus far studied have been in a general way similar to those common in acute tonsillitis. The case reported in this paper was one accompanied by profound disturbances, but the cerebral symptoms are, perhaps, to be regarded in this case more of the nature of a susceptibility on the part of the patient, since in all diseases a more or less marked tendency toward cerebral derangement has been manifest.

The frequency of the localization of processes, due to infection with this organism, to the mouth and about the jaws, has already been noted by Karlinsky.⁹ An explanation of this may be found in the fact that the micrococcus tetragenus is commonly found in the mouths of perfectly healthy individuals, as we have repeatedly observed.

EXPERIMENTS IN GASTRIC DIGESTION.*

A PRELIMINARY REPORT.

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The experimental study of gastric digestion of proteids has been extensively made from a chemico standpoint. Test-tube digestion by the aid of ferments has created a large literature in this branch of physiologic chemistry. Kuhne and Chittenden's classification of digestive products or Neumeister's nomenclature are most generally adopted, and in the absence of a knowledge of the albumin molecule, serve at least for a temporary classification. Kossel's work has not led to any more definite conclusion and it may be stated that the slight differences found in the chemico reaction or the physical properties of the albumoses have not been so characteristic as to allow these compounds to be regarded as separate bodies.

The object of digestion appears to be to reduce the food to such a condition that the cells lining the walls of the intestine may take it up, change and transfer it to the blood in the form of circulating albumins. This process is very much influenced by certain mechanic or motor functions of the gastro-intestinal tract. If this function of motility is hindered or obstructed the process of digestion is very much retarded or ceases altogether.

The methods of investigation which the author has the honor of presenting before this association have for their object the observation of the influence of mechanic or motor effects on the process of gastric digestion by the use of artificially devised stomachs, made from rubber of different degrees of elasticity. These artificial stomachs are caused to imitate in some degree the movements of the normal stomach contents, the churning process by which the food is forced from one end of the stomach to the other and back again.

The artificial stomach apparatus consists of thin rubber bags suspended from an arm which moves in a half circle, so that the contents of the bags are thrown from one end to the other. These bags are placed in an incubator at the usual temperature. When thick bags, with strong elastic resistance are employed, the process is very marked, but when thin rubber bags are used in which the resistance is very

⁸ Apert: Soc. de Biologie, 1896.

⁹ Karlinsky: Centralt. f. Bakteriologie, 1890, vii, p. 113.

*Read before the American Gastro-Enterological Association, May, '99.

slight, the bag stretches or dilates and the contents gravitate to the bottom of the sacculated portion which hangs like a hammock. Consequently the contents are not so much disturbed by each movement of the arm or beam from which the bag is suspended and the mechanic part of the digestion is rendered less active.

The mechanism by which the bags are made to move is placed in the ordinary incubator, in which the usual temperature is maintained. In the experiments, an opening is made in the back of the incubator and through this a shaft is passed attached to a wheel which is connected on its eccentric with the shaft running to the beam. The shaft is actuated by a small electric motor.

As before stated, the bags are made of rubber possessing different degrees of thickness and consequently elasticity. Some of the bags are divided into chambers or compartments—a duodenal portion and a gastric portion—by a small constricting ring through which fluids, but not solids, can pass. One chamber is intended to represent the gastric portion and the other the duodenal portion. In the latter a small lead ball is placed which acts as a ball-valve and is so arranged as to allow the escape of a part of the fluid products of proteolysis at each movement or half rotation of the beam and thus relieve the contents of the stomach-bag of the excess of peptones which would otherwise accumulate and might retard, or put a stop to, the digestive process. As the process of digestion thus progresses, small quantities of HCl and pepsin are allowed to flow at intervals from a bag reservoir into the bag which contains the food undergoing digestion, thus simulating as much as possible the secretion of the gastric juice.

Chopped meat, either cooked or raw, is weighed and placed in the bag, to be digested. This is mixed with a small quantity of dilute hydrochloric acid and pepsin, also weighed. Sometimes eggs are added, either boiled or raw, and the weight recorded. The bag is then placed in the incubator. After a period of digestion has elapsed the fluid matters are strained off and the solids remaining are weighed to determine the amount of the mass that has undergone digestion.

It is more practical to estimate the residue of undigested food than to attempt to estimate the amount of the albumoses formed. For instance, a known quantity of egg-albumin was placed in the bag and after experimental digestion, the coagulated residue was estimated. When using chopped meat the advantage gained by the ease with which the remainder or residuum can be observed is plainly to be seen, and especially so when the microscope is used to demonstrate the condition of the muscle fibers.

Bag A consists of: 1. A gastric apartment or cavity for the introduction of the chopped meat, eggs, broth or other food substances to be used in the experiment. 2. A secretory chamber containing an amount of dilute HCl and pepsin estimated in accordance with the weight of the food to be digested. 3. Duodenal or intestinal chamber. The material of which the bag is composed is of such thickness that it will sustain a given weight of from 200 to 500 grams of food, that is, meat and water. This portion is marked A 1.

Bag A 2 is arranged similarly to bag A 1, but the walls of the bag are thinner and therefore less resistant to the weight of its contents. As will be seen, the movements are not so great nor are the contents so thoroughly acted on by the energy of its move-

ments, and consequently less commotion or churning is observed in this bag than in bag A 1. As a result the process of digestion is retarded in the second bag and a greater residuum of undigested proteid is observed.

Bag B 1 contains no outlet for the escape of the products of digestion from the albumoses and peptones, but the HCl and pepsin are allowed to pass into the gastric cavity at regular intervals.

Bag B 2 is similar to bag B 1, excepting that the walls are thinner and resemble in distensibility those of bag A 2.

As there is no provision for the escape of the fluid or peptones formed, and as the artificial gastric juice is added, the combined weight of the latter and the food causes the bag to become more and more sacculated. The excursion of the food from one end of the bag to the other, which occurs in the thicker bag, is thus prevented and retarded or diminished digestion results.

A marked difference is observed in the mechanic effects, not only as regards the results of the more intimate relation between the ferments, HCl and food particles brought about in the mixing process, but also as regards the actual friction between food particles which causes them to be more readily separated, more finely divided and more easily acted upon by the ferments.

I have, by means of the motion alone, without the use of any ferments, reduced the food-stuffs to a condition resembling pulpy chyme ready for intestinal digestion, and on the addition of hard, coarse particles, such as bran, to this mass, the process of digestion was much accelerated. I have already called attention to this fact in a previous communication.

The following series of experiments has been, and is still being, carried out by the writer to observe the mechanic effects of motion alone on the food contents of these improvised stomachs.

Series 1, in which bag A 1 was used, had for its purpose the creation of a standard degree of digestion which was necessarily arbitrary, although it conformed as nearly as possible to the natural conditions.

In the creation of this standard the chief considerations observed in bag A 1 were the following: 1. Character of food. 2. Water. 3. HCl and pepsin. 4. Weight and bulk. 5. Resistance of bag. 6. Number of movements in a given time. 7. Time required for digestion. 8. Character of the residuum of undigested food, weight, bulk, appearance, etc. 9. Observation of the products of digestion. 10. Chemic analysis. 11. Toxicity when injected into animals.

Series 2 was carried out in a similar manner to Series 1, but much thinner bags were used, similar to bag A 2. As this bag had less resistant walls, the mass was not thrown from end to end of the bag, and the elasticity of this thinner bag was greater and the energy exerted upon its contents consequently less than in the case of bag A 1. The food mass in bag A 2 was therefore not subjected to as great mechanic disturbance, churning, sub-division, and the like, as was the contents of bag A 1. The results of this series of experiments demonstrate that a longer time was required for the digestive process, and that a greater amount of residuum remained thereafter.

Series 3 was intended to determine the effects of motion on food-stuffs without the addition of HCl or ferments. In this series the reduction of the food to a soft, pulpy mass depended exclusively on the sol-

vent action of the warm fluid, and on the effect of motion and consequent friction on the particles of food. The time required for this reduction depended on the nature of the food and the fineness of division of the food particles used in the experiment. It was especially noteworthy that when large particles, 3 to 5 c.c. in weight, were used and kept in a quiescent state, the particles remained intact, but were swollen and slightly softened, and consequently rather larger than before. If motion was kept up for the same length of time (six to ten hours), the particles were reduced to a smaller size and the mass assumed a pulpy consistency resembling chyme.

In Series 4, bags were employed which were made from parchment instead of rubber. Proteids and ferments were placed in these bags, which were kept in motion under running water at the regular temperature. For these experiments a water-tight tank was used which contained two large wheels, the axles of which passed through the sides of the tank. The bags were suspended from the circumference of the wheel to the axle, so that with each revolution the contents of the bag was thrown from one end to the other. The rate of digestion was not materially increased through the action of dialysis of the peptones.

In all the foregoing experiments, carbohydrates and proteids were used both together and separately, and it was found that the degree of motion, as well as the character of the motion, produced marked increase in the products of artificial digestion, both as to the chemic products and the physical appearance. The influence of motion on digestion is a most interesting fact and one that would appear to be an all-important factor in the study of digestive processes, both experimentally and clinically.

In Series 5 experiments were made with a method of motion intended to simulate the contraction of the pyloric end of the stomach by which the stomach contents are forced back toward the cardiac end of this organ. By the repetition of this process the contents are churned and reduced to a substance resembling chyme. The apparatus in this series of experiments consists of rubber bags placed on an incline. The lower end of the bag, corresponding with the pyloric end of the stomach, was compressed, forcing the contents into the upper portion of the bag, which corresponds to the cardiac end of the stomach. This distends the upper portion of the bag and on the release of the pressure the contents descend by gravity to the lower or pyloric end. This process was repeated until the stomach contents had been thoroughly mixed and churned.

However valuable the observation of artificial gastric digestion, especially the purely physical processes may be, the researches on animals must necessarily be of greater importance. The observations of Cahn and Von Mering have added much to our present knowledge, but these observers neglected to investigate the motility of the stomach and conditions under which mixed foods, consisting of liquids and solids, are mixed, churned and forced out of the stomach.

It is true that Schuele¹ made some investigations in this direction, but in his experiments on dogs a duodenal fistula was formed and the cardia was temporarily and partially closed by an inflated rubber bag.

The writer has made experiments on the stomachs of dogs by isolating the stomach suspended in the abdominal cavity. A loop of jejunum was first united by an anastomosis with the cardia and the stomach

closed below this point after curettage of the mucous membrane. The walls of the stomach were then sutured together. A duodeno-jejunosomy was next made to direct the flow of the biliary and pancreatic secretion below the loop. The abdomen was then closed and two weeks later a duodenal fistula was made at the pylorus, closing off the pyloric end of the duodenum. The stomach was thus switched off completely from the intestinal tract, but the blood and nerve supply was not interfered with.

The animal was then fed for a month, the food, instead of passing into the stomach, going directly into the jejunum. The operation for this purpose would better be performed in two stages, because experience has demonstrated that when the operation was completed at one sitting the animals invariably died from shock soon after.

The stomach is then used for observation of the mechanic as well as the proteolytic action and bacteriologic observations also made on its contents. After the second week it was found that the stomach resumed its functions, but to a lesser degree.

It is the writer's intention to report these experiments later on, as well as to give a more detailed description of the results thus obtained from the study of artificial digestion, together with other observations which he hopes to present in the near future.

THE DIPHTHERIA BACILLUS.*

ITS PERSISTENCE IN MOUTHS OF CONVALESCENTS.

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Since the introduction of more thorough and scientific methods for the diagnosis of diphtheria produced by the inroads of the Klebs-Loeffler organism, it has been known that this germ often persisted in the throats of convalescents for considerable periods of time. The cases which I have to offer here are not markedly peculiar, except that they show a persistence somewhat prolonged, although there are a considerable number of cases in which the time period has been found to be longer than in these cases. Another point of interest is from the fact that frequent cultures were taken, and also the virulence of the disease germ determined after the recovery of the case.

The cases reported are taken from some of the control work that is carried on in my laboratory, under my direction, by my assistants, Mr. Frost and Mr. Bassett.

HISTORY OF THREE CASES OF BACTERIOLOGICALLY CONTROLLED DIPHTHERIA.

Case 1.—R. J. Madison, male, 8 years of age, was taken sick Nov. 27, 1897; diagnosed, clinically, as diphtheria; antitoxin administered November 28; rather mild type of the disease. After application of antitoxin, the case at once improved.

November 30, nearly pure culture of Klebs-Loeffler bacillus found in swab from the throat by means of Loeffler's serum mixture.

December 4, mixed culture developed from swab.

December 15, typical Klebs-Loeffler bacillus found; quarantine raised by city health department and house disinfected with formaldehyde.

December 17, few organisms found.

December 21, diphtheria bacillus found on two different serum cultures.

December 22, ditto.

December 29, ditto.

¹ Zeits. f. Klin. Med., xxviii, p. 87.

* Read before the Central Wisconsin Medical Society, March 29, 1899.