and regularity than the other vegetative processes, such as general assimilation, circulation and respiration.

Influence of the Nervous System on the Stomach.—It is well known that mental emotions frequently have a marked influence on digestion, and this, of course, can take place only through the nervous system. Of the two nerves which are distributed to the stomach, the pneumogastric has been the more carefully studied, experiments upon the sympathetic being more difficult. Although the complete history of the influence of the pneumogastrics upon digestion belongs to the physiology of the nervous system, it will be useful in this connection to consider briefly some of the facts which have been ascertained with regard to the influence which these nerves exert upon the stomach.

The experiments of Bernard and others have shown that the vascular mechanism of the mucous membrane is to a great extent under the influence of the pneumogastrics. If these nerves be divided while gastric digestion is at its height, the mucous membrane immediately becomes pale, and the secretion of gastric juice is nearly if not quite arrested. It has been found, however, that gastric juice may be secreted in small quantity under the stimulus of food, even when both pneumogastrics and the sympathetic nerves going to the stomach have been divided (Heidenhain).

Section of both pneumogastrics, while it does not entirely paralyze the muscular coat of the stomach, renders its contractions irregular and feeble. It is stated that section of these nerves is followed by "a short temporary contraction of the cardiac aperture" (Stirling).

Movements of the Stomach.—As the articles of food are passed into the stomach by the acts of deglutition, the organ gradually changes its form, size and position. When the stomach is empty, the opposite surfaces of its lining membrane are in contact in many parts and are thrown into longitudinal folds. As the organ is distended, these folds are effaced, the stomach itself becoming more rounded, and as the two ends, with the lesser curvature are comparatively immovable, the whole organ undergoes a movement of rotation, by which the anterior face becomes superior and is applied to the diaphragm. At this time the great pouch has nearly filled the left hypochondriac region; the greater curvature presents anteriorly and comes in contact with the abdominal walls. Aside from these changes, which are merely due to the distention, the stomach undergoes important movements, which continue until its contents have been dissolved and absorbed or have passed out at the pylorus; but while these movements are taking place, the two orifices are guarded, so that the food shall remain for the proper time exposed to the action of the gastric juice. By the rhythmical contractions of the lower extremity of the œsophagus, regurgitation of food is prevented; and the circular fibres, which form a thick ring at the pylorus, are constantly contracted, so that—at least during the first periods of digestion—only liquids and that portion of food which has been reduced to a pultaceous consistence can pass into the small intestine. It is well known that this resistance at the pylorus does not endure indefinitely, for indigestible articles

of considerable size, such as stones, have been passed by the anus after having been introduced into the stomach; but observations have shown that masses of digestible matter are passed by the movements of the stomach to the pylorus, over and over again, and that they do not find their way into the intestine until they have become softened and more or less disintegrated.

The contractions of the walls of the stomach are of the kind characteristic of the non-striated muscular fibres. If the finger be introduced into the stomach of a living animal during digestion, it is gently but rather firmly grasped by a contraction, which is slow and gradual, enduring for a few seconds and as slowly and gradually relaxing and extending to another part of the organ. The movements during digestion present certain differences in different animals; but there can be no doubt that the phenomenon is universal. In dogs, when the abdomen is opened soon after the ingestion of food, the stomach appears pretty firmly contracted on its contents. In a case reported by Todd and Bowman, in the human subject, in which the stomach was very much hypertrophied and the walls of the abdomen were very thin, the vermicular movements could be distinctly seen. These movements were active, resembling the peristaltic movements of the intestines, for which, indeed, they were mistaken, as the nature of the case was not recognized during life. No argument, therefore, seems necessary to show that during digestion, the stomach is the seat of tolerably active movements.

A peculiarity in the movements of the stomach, which has been repeatedly observed in the lower animals, particularly dogs and cats, and in certain cases has been confirmed in the human subject, is that at about the junction of the cardiac two-thirds with the pyloric third, there is frequently a transverse band of fibres so firmly contracted as to divide the cavity into two almost distinct compartments. It has also been noted that the contractions in the cardiac division are much less vigorous than near the pylorus; the stomach seeming simply to adapt itself to the food by a gentle pressure as it remains in the great pouch, while in the pyloric portion, divided off as it is by the hour-glass contraction above mentioned, the movements are more frequent, vigorous and expulsive.

As the result chiefly of the observations of Beaumont, the following may be stated as a summary of the physiological movements of the stomach in digestion:

The stomach normally undergoes no movements until food is passed into its cavity. When food is received, at the same time that the mucous membrane becomes congested and the secretion of gastric juice begins, contractions of the muscular coat occur, which are at first slow and irregular, but become more vigorous and regular as the process of digestion advances. After digestion has become fully established, the stomach is generally divided, by the firm and almost constant contraction of an oblique band of fibres, into a cardiac and a pyloric portion; the former occupying about two-thirds, and the latter, one-third of the length of the organ. The contractions of the cardiac division of the stomach are uniform and rather gentle; while in the pyloric division, they are intermittent and more expulsive. The effect of the

contractions of the stomach upon the food contained in its cavity is to subject it to a tolerably uniform pressure in the cardiac portion, the general tendency of the movement being toward the pylorus, along the greater curvature, and back from the pylorus toward the great pouch, along the lesser curvature. At the constricted part which separates the cardiac from the pyloric portion, there is an obstruction to the passage of the food until it has been sufficiently acted upon by the secretions in the cardiac division to have become reduced to a pultaceous consistence. The alimentary mass then passes into the pyloric division, and by a more powerful contraction than occurs in other parts of the stomach, it is passed into the small intestine.

The revolutions of the alimentary mass, thus accomplished, take place slowly, by gentle and persistent contractions of the muscular coat; the food occupying two or three minutes in its passage entirely around the stomach. Every time that a revolution is accomplished, the contents of the stomach are somewhat diminished in quantity; probably, in a slight degree, from absorption of digested matter by the stomach itself, but chiefly by the gradual passage of the softened and disintegrated mass into the small intestine. This process continues until the stomach is emptied, lasting between two and four hours; after which, the movements of the stomach cease until food is again introduced.

Regurgitation of food by contractions of the muscular coats of the stomach, eructation, or the expulsion of gas, and vomiting are not physiological acts. It has been shown that vomiting is produced by contractions of the abdominal muscles and the diaphragm, compressing the stomach, which is passive, except that the pyloric opening is firmly closed, the cardiac opening being relaxed. Eructation, although usually involuntary, is sometimes under the control of the will. When it occurs, while it is difficult or impossible to prevent the discharge of the gas, the accompanying sound may be readily suppressed. Eructation frequently becomes a habit, which in many persons is so developed by practice that the act may be performed voluntarily at any time. The gaseous contents of the stomach during digestion are composed of oxygen, carbon dioxide, hydrogen and nitrogen, in proportions that are very variable.

CHAPTER IX.

INTESTINAL DIGESTION.

Physiological anatomy of the small intestine—Glands of Brunner—Intestinal tubules, or follicles of Lieberkühn—Intestinal villi—Solitary glands, or follicles, and patches of Peyer—Intestinal juice—Action of the intestinal juice in digestion—Pancreatic juice—Action of the pancreatic juice upon starches and sugars—Action upon nitrogenized substances—Action upon fats—Action of the bile in digestion—Biliary fistula—Variations in the flow of bile—Movements of the small intestine—Peristaltic and antiperistaltic movements—Uses of the gases in the small intestine—Physiological anatomy of the large intestine—Processes of fermentation in the intestinal canal—Contents of the large intestine—Composition of the fæces—Excretine and excretoleic acid—Stercorine—Indol, skatol, phenol etc.—Movements of the large intestine—Defæcation—Gases found in the alimentary canal.

Physiological Anatomy of the Small Intestine.

The small intestine, extending from the pyloric extremity of the stomach to the ileo-cæcal valve, is loosely held to the spinal column by a double fold of serous membrane, called the mesentery. As the peritoneum which lines the cavity of the abdomen passes from either side to the spinal column, it comes together in a double fold just in front of the great vessels along the spine, and passing forward, it divides again into two layers, which become continuous with each other and enclose the intestine, forming its external coat. The width of the mesentery is usually three to four inches (7·62 to 10·16 centimetres); but at the beginning and at the termination of the small intestine, it suddenly becomes shorter, binding the duodenum and that portion of the intestine which opens into the caput coli closely to the subjacent parts. The mesentery thus keeps the intestine in place, but it allows a certain degree of motion, so that the tube may become convoluted, accommodating itself to the size and form of the abdominal cavity. The form of these convolutions is irregular and is continually changing. The length of the small intestine, according to Gray, is about twenty feet (6·1 metres); but the canal is very distensible, and its dimensions are subject to frequent variations. Its average diameter is about an inch and a quarter (3·18 centimetres).

The small intestine has been divided into three portions, which present anatomical and physiological peculiarities, more or less marked. These are the duodenum, the jejunum and the ileum.

The duodenum has received its name from the fact that it is about the length of the breadth of twelve fingers, or eight to ten inches (20·32 to 25·4 centimetres). This portion of the intestine is considerably wider than the constricted pyloric end of the stomach, with which it is continuous, and is also much wider than the jejunum.

The coats of the duodenum, like those of the other divisions of the intestinal tube, are three in number. The external is the serous, or peritoneal coat, which has already been described. The middle, or muscular coat is composed of non-striated muscular fibres, such as exist in the stomach, arranged in two layers. The external, longitudinal layer is not very thick, and the direction of its fibres can be made out easily only at the outer portions of the tube, opposite the attachment of the mesentery. Near the mesenteric border the outlines of the fibres are very faint. This is true throughout the