Protection of the Opening of the Larynx and Uses of the Epiglottis in Deglutition.—The entrance of the smallest quantity of solid or liquid foreign matter into the larynx produces a violent cough. This accident is of not infrequent occurrence, especially when an act of inspiration is inadvertently performed while solids or liquids are in the pharynx. During inspiration, the glottis is opened, and at that time only can a substance of any considerable size find its way into the respiratory passages. Respiration is interrupted, however, during each and every act of deglutition; and there can, therefore, be hardly any tendency at that time to the entrance of foreign substances into the larynx. During a regular act of swallowing, nothing can find its way into the respiratory passages, so complete is the protection of the larynx during the period when the food passes through the pharynx into the œsophagus.

It is evident, from the anatomy of the parts and the necessary results of the contractions of the muscles of deglutition, that while the food is passing through the pharynx, the larynx, by its elevation, passes under the tongue as it moves backward, and the soft base of this organ is, as it were, moulded over the glottis. With the parts removed from the human subject or from one of the inferior animals, the natural movements of the tongue and larynx can be imitated, and it is seen that they must be sufficient to protect the larynx from the entrance of solid or semi-solid particles of food, particularly when it is remembered how the alimentary particles are agglutinated by the saliva and how easy their passage becomes over the membrane coated with mucus. It is impossible, also, for the muscles of the pharynx to contract without drawing together the sides of the larynx, to which they are attached, and assisting to close the glottis. At the same time, as the movements of respiration are arrested during deglutition, the lips of the glottis fall together, as they always do except in inspiration. In addition to this passive and incomplete approximation of the vocal chords, it has repeatedly been observed that the lips of the glottis are accurately and firmly closed during each act of deglutition.

Longet justly attached great importance to the acute sensibility of the top of the larynx in preventing the entrance of foreign substances. His experiments of dividing all the nervous filaments distributed to the intrinsic muscles show that their action is not essential; but after division of the superior laryngeal—the nerve which gives sensibility to the parts—he found that liquids occasionally passed in small quantity into the trachea.

With reference to the action of the epiglottis in contributing to the protection of the larynx during the second period of deglutition, observations on the human subject only are to be relied upon. Such observations, in cases of loss of the epiglottis especially, show that this part is necessary to the complete protection of the larynx. While loss of the epiglottis may not interfere always with the perfect deglutition of solids, and even of liquids, particles of food and liquids frequently find their way into the larynx, and deglutition is often effected with difficulty, showing that complete protection of the larynx at all times, does not exist unless the epiglottis be intact.

To appreciate the mechanism by which the opening of the larynx is protected during the deglutition of solids and liquids, one has only to carefully follow the articles as they pass over the inclined plane formed by the back of the tongue and the anterior and inferior part of the pharynx. As the food is making this passage in obedience to the contraction of the muscles which carry the tongue backward, draw up the larynx and constrict the pharynx, the soft base of the tongue and the upper part of the larynx are applied to each other, with the epiglottis, which is now inclined backward, between them; at the same time the glottis is closed, in part by the action of the constrictor muscles attached to the sides of the thyroid cartilages, and in part by the action of the intrinsic muscles. If the food be tolerably consistent and in the form of a single bolus, it slips easily from the back of the tongue along the membrane covering the anterior and inferior part of the pharynx; but if it be liquid or of soft consistence, a portion takes this course, while another portion passes over the epiglottis, being directed by it into the two grooves by the side of the larynx. It is by these means, together with those by which the posterior nares are protected, that all solids and liquids are passed into the œsophagus, and the second period of deglutition is safely accomplished.

The third period of deglutition is the most simple of all. It merely involves contractions of the muscular walls of the œsophagus, by which the food is passed into the stomach. The longitudinal fibres shorten the tube and slip the mucous membrane, lubricated by its glairy secretion, above the bolus; while the circular fibres, by a progressive peristaltic contraction from above downward, propel the food into the stomach. In experiments on the lower animals, it has been observed that while the peristaltic contractions of the upper two-thirds of the tube is immediately followed by a relaxation, which continues till the next act of deglutition, the lower third remains contracted generally for about thirty seconds after the passage of the food into the stomach. During its contraction, this part of the œsophagus is hard, like a cord firmly stretched. This is followed by relaxation; and alternate contraction and relaxation continue, even when the stomach is empty, although, during digestion, the contractions are frequent in proportion to the quantity of food in the stomach. The contraction is always increased by pressing the stomach and attempting to pass some of its contents into the œsophagus (Magendie). This provision is important in preventing regurgitation of the contents of the stomach, especially when the organ is exposed to pressure, as in urination or defecation.

An approximate estimate of the duration of the acts of deglutition is given in the following quotation from Landois:

"According to Meltzer and Kronecker, the duration of deglutition in the mouth is 0·3 sec.; then the constrictors of the pharynx contract 0·9 sec.; afterward, the upper part of the œsophagus; then after 1·8 sec. the middle; and after another 3 sec. the lower constrictor. The closure of the cardia, after the entrance of the bolus into the stomach, is the final act in the total series of movements."

The entire process of deglutition, therefore, occupies about six seconds.

The muscular movements which take place during all the periods of deglutition are peculiar. The first act is generally automatic, but it is under the control of the will. The second act is involuntary when once begun, but it may be excited by the voluntary passage of solids or liquids beyond the velum pendulum palati. It is impossible to perform the second act of deglutition unless there be some article, either solid or liquid, in the pharynx. It is easy to make three or four successful efforts consecutively, in which there is elevation of the larynx, with all the other characteristic movements; but a little attention will show that with each act a small quantity of saliva is swallowed. When the efforts have been frequently repeated, the movements become impossible, until time enough has elapsed between them for the saliva to collect.

All the movements of deglutition, except those of the first period, must be regarded as reflex, depending upon an impression made upon the afferent nerves distributed to the mucous membrane of the pharynx and œsophagus.

The position of the body has little to do with the facility with which deglutition is effected. Liquids or solids may be swallowed indifferently in all postures. Bérard saw a juggler pass an entire bottle of wine from the mouth to the stomach, while standing on his head. The same feat was accomplished with apparent ease, by a juggler who drank three glasses of beer while standing on his hands in the inverted posture (Flint).

Deglutition of Air.—In his essay on the mechanism of vomiting, Magendie stated that as soon as nausea occurred the stomach began to fill with air, so that before vomiting occurred, the organ became tripled in size. Magendie showed, fathermore, that the air entered the stomach by the œsophagus, for the distention occurred when the pylorus was ligated. In a subsequent memoir, the question of the deglutition of air, aside from the small quantity which is incorporated with the food during mastication and insalivation, was farther investigated. It was found that some persons had the faculty of swallowing air, and by practice, Magendie himself was able to acquire it, although it occasioned such distress that it was discontinued. Out of a hundred students of medicine, eight or ten were found able to swallow air.

It is not very uncommon to find persons who have gradually acquired the habit of swallowing air, in order to relieve uncomfortable sensations in the stomach; and when confirmed, it occasions persistent disorder in digestion. Quite a number of cases of this kind were reported by Magendie, and in several it was carried to such an extent as to produce great distention of the abdomen. A curious case of habitual air-swallowing was observed by the late Dr. Austin Flint and is reported in his work on the Practice of Medicine.

CHAPTER VIII.

GASTRIC DIGESTION.

Physiological anatomy of the stomach—Glands of the stomach—Closed follicles—Gastric juice—Gastric fistula in the human subject in the case of St. Martin—Secretion of the gastric juice—Properties and composition of gastric juice—Action of the gastric juice in digestion—Peptones—Action of the gastric juice upon fats, sugars and amylaceous substances—Duration of gastric digestion—Conditions which influence gastric digestion—Movements of the stomach.

Physiological Anatomy of the Stomach.

The stomach serves the double purpose of a receptacle for the food and an organ in which certain important digestive processes take place. It is situated in the upper part of the abdominal cavity and is held in place by folds of the peritoneum and by the œsophagus. Its form is not easily described. It has been compared to a bagpipe, which it resembles somewhat, when moderately distended. When empty, it is flattened, and in many parts its opposite walls are in contact. When moderately distended, its length is thirteen to fifteen inches (33 to 38 centimetres), its greatest diameter, about five inches (12·7 centimetres), and its capacity, one hundred and seventy-five cubic inches (2,868 c. c.), or about five pints. The parts usually noted in anatomical descriptions are the following: a greater and a lesser curvature; a greater and a lesser pouch; a cardiac, or œsophageal opening; a pyloric opening, which leads to the intestinal canal. The great pouch is sometimes called the fundus.

The coats of the stomach are three in number; the peritoneal, muscular and mucous. By some anatomists the fibrous tissue which unites the mucous to the muscular coat is regarded as a distinct covering and is called the fibrous coat.

Peritoneal Coat.—This is simply a layer of peritoneum, similar in structure to the membrane which covers the other abdominal viscera. It is a reflection of the membrane which lines the general abdominal cavity, which, on the viscera, is somewhat thinner than it is on the walls of the cavity. Over the stomach the peritoneum is $\frac{1}{300}$ to $\frac{1}{200}$ of an inch (83 to 125 μ) in thickness. It is a serous membrane and consists of ordinary fibrous tissue with a considerable number of elastic fibres. It is closely adherent to the subjacent muscular coat and is not very abundantly supplied with blood-vessels and nerves. Lymphatics have been demonstrated only in the subserous structure. The surface of the peritoneum is everywhere covered with regularly polygonal cells of pavement endothelium, closely adherent to each other and presenting a perfectly smooth surface which is moistened with a small quantity of liquid. An important office of this membrane is to present a smooth surface covering the abdominal parietes and viscera, so as to allow free movements of the organs over each other and against the walls of the abdomen.

Muscular Coat.—Throughout the alimentary canal, from the cardiac opening of the stomach to the anus, the muscular fibres forming the middle coat are of the non-striated variety. These fibres, called sometimes muscu-