DEMONSTRATION

42. Nearly every one has felt the effects of intemperate eating. When "stomach sick," a sharp-tasting gas and very sour food often come up to the mouth, showing that acid fermentation is going on. Notice how plainly a person feels his own heart beats after a large meal, owing to the pressure of the distended stomach upon the heart.

REVIEW TOPICS

1. Tell how a person knows when and how much to eat or drink.
2. Define an appetite and tell how it can be satisfied naturally.
3. Illustrate an artificial appetite and tell how it can be distinguished from a natural appetite.
4. Tell some of the ways in which men abuse their stomachs by indulging their artificial appetites.
5. Tell some of the effects of too rapid eating; of imperfect mastication; of overeating; of eating between meals.
6. Tell how food sours within the stomach.
7. Tell how drinking at meal times is beneficial, and in what way it can be harmful.
8. Tell how hot or cold food affects the stomach.
9. Give some simple rules for eating.

CHAPTER VIII

INTESTINAL DIGESTION

106. The intestine. — The part of the alimentary canal below the stomach is called the *intestine*. The intestine is a tube of varying size, whose different parts have different names. Next to the stomach is the *small intestine*, which is about one inch in diameter and about twenty feet in length. It opens into the *large intestine*, which is about two inches in diameter and five feet in length.

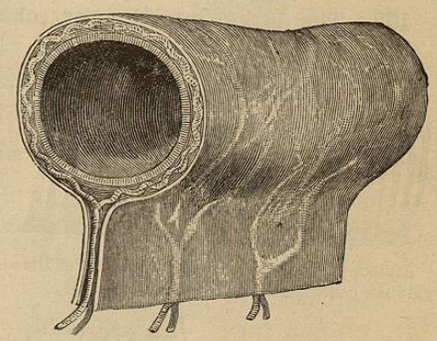


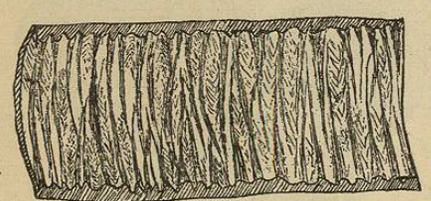
Diagram representing a cross section of the small intestine, showing the three layers, and the way in which the blood tubes pass between the two folds of serous membrane (the peritoneum) which forms the mesentery.

107. The small intestine. — The small intestine is very movable, and is coiled in the abdomen in no definite order. It is held in place by a fanlike fold of peritoneum, called the *mesentery*. The mesentery is about four inches in length along its back edge, which is fastened to the spinal column, and twenty feet at its outer edge, to which the intestine is attached. Its breadth from the spinal column to the intestine is about four inches.

In front of the intestine, and partly enwrapping its folds, is a thin apron of peritoneum, called the *omentum*. It contains much fat, and acts as a cushion and as protection against cold. The small intestine for about ten inches from the stomach is called the *duodenum*. Then for about eight feet it is called the *jejunum*, and the remaining eleven feet is called the *ileum*. There is no very marked difference between any two sections of these divisions.

The intestine ends at about the level of the hip bone, and opens into the side of the large intestine by a slitlike valve, which permits matter to pass into the large intestine, but to a great extent prevents its backward movement.

108. The large intestine, or colon. — The whole large intestine is called the *colon*. Its beginning is a small pouch called the *cæcum*, which is situated on the right side of the abdomen at the level of the hip bone.



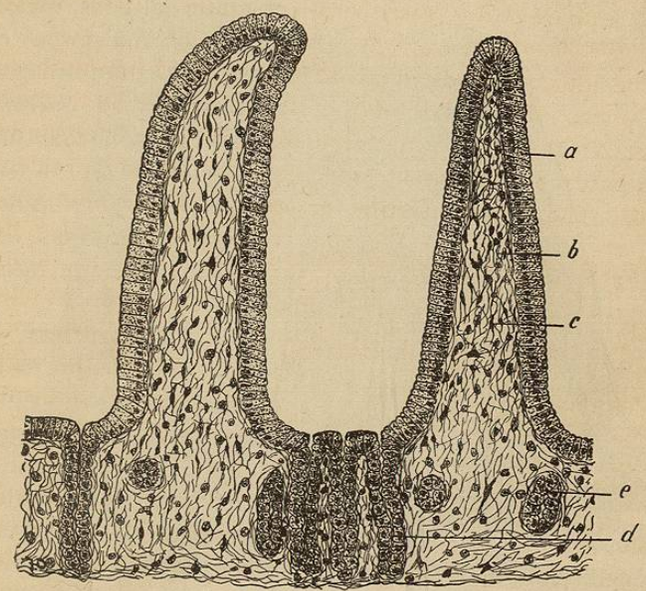
A piece of intestine showing the folds of the valvulæ conniventes upon its inner surface.

From the cæcum there extends a small tube one quarter of an inch in diameter and two inches long, closed at its outer end. This tube is called the *vermiform appendix*. It sometimes becomes inflamed, forming an abscess, and produces the disease called *appendicitis*.

The colon extends upward to the ribs, then crosses the abdomen to the left side, and then extends downward. These parts are called the *ascending*, *transverse*, and *descending* colon. The colon is held in place by a narrow fold of peritoneum. It is not an even tube, but looks as though strings were tied about it at intervals of a few inches.

109. Structure of the intestine. — The whole intestine consists of a tube of muscular tissue, whose walls are

from $\frac{1}{16}$ to $\frac{1}{8}$ of an inch in thickness. It is covered with peritoneum and lined with mucous membrane. Its muscle fibers extend both lengthwise and circularly. In the mucous membrane of the small intestine are folds, each of which



Villi (× 200).

a epithelium upon the surface of the villi.
b connective tissue fibers which support the blood tubes and lacteals.
c connective tissue cells.
d glands which form the intestinal juice.
e intestinal gland cut across.

extends from one half to three fourths the way around the intestine. The folds are called *valvulæ conniventes*. Upon the surface of each fold are fingerlike projections called *villi*, which are from $\frac{1}{50}$ to $\frac{1}{8}$ of an inch in length, and from $\frac{1}{250}$ to $\frac{1}{70}$ of an inch in diameter. Between the bases of the villi minute tubes, $\frac{1}{250}$ of an inch in length and $\frac{1}{600}$

of an inch in diameter, extend into the mucous membrane. Each tube is lined with a layer of epithelial cells, which secrete a fluid called the *intestinal juice*.

110. Villi. — Each villus consists of an outer covering of epithelial cells, inclosing a loose meshwork of fine blood tubes, and also of tubes called *lacteals*, both of which take up the food as it is digested. Neither villi nor valvulæ conniventes are found in the large intestine.

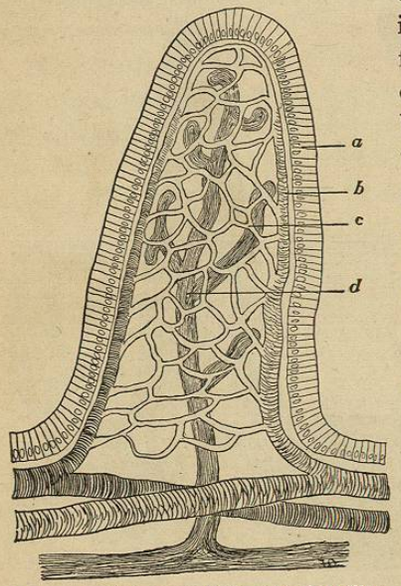


Diagram of the essential parts of a villus.

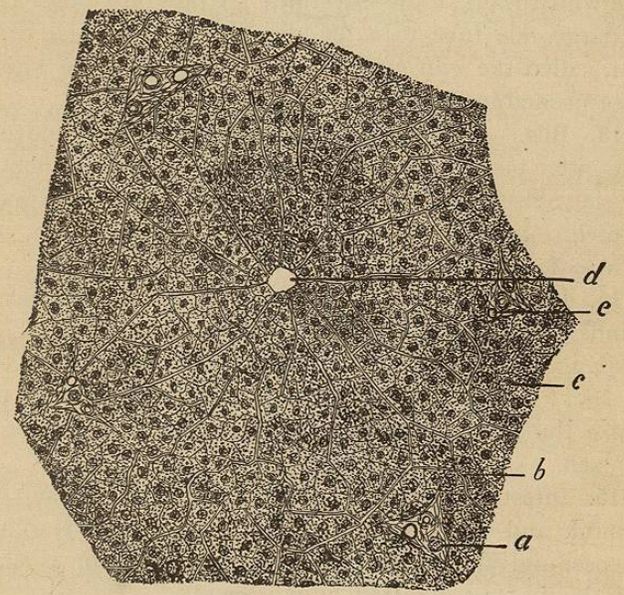
a epithelium which takes up food and transports it to the tubes within.
b an artery. *c* capillaries. *d* a lacteal.

111. The pancreas. — From the duodenum there extends a very short tube, about the size of a small quill. This divides into two tubes, one of which goes to the liver and the other to the pancreas. The *pancreas* is a gland about an inch in diameter and six inches long, lying behind the stomach. In lower animals it is called the *sweetbread*. Its structure resembles that of a salivary gland. It secretes a thin, watery liquid called the *pancreatic juice*, which is poured into the intestine at the rate of one and a half pints a day.

112. The liver. — The liver is a firm, dark-red, wedge-shaped organ, lying under the lowest ribs upon the right

side. It is covered with peritoneum and hung closely to the diaphragm and the spinal column.

The tube leading from the intestine to the liver divides again and again into branches called *bile ducts*, the smallest of which are exceedingly minute, and barely recognizable with a microscope. The walls of the smallest of these ducts are composed of large cells of irregular shape, which crowd one another so that the bile tubes are almost closed. These cells make up the greater part of the liver.



A thin slice of liver (× 200).

a veins bringing blood to the liver. *c* liver cells.
b capillaries between the liver cells. *d* vein to carry blood away from the liver.
e tubes to carry away bile.

Among these tubes there run many fine blood tubes, in such a manner that the cells seem to be arranged around

the capillaries instead of around the bile tubes. Each cell makes bile from the blood and pours it into its bile tube, down which it runs, uniting with streams from other tubes. All the tubes finally unite their streams in the single bile tube which leads to the intestine. A side tube leads from the large bile tube to a bladder on the under side of the liver, called the *gall bladder*, which stores the bile when it is not needed in the intestine.

113. Bile. — Bile is a thick, golden-colored liquid of a very bitter taste. It consists of waste albuminous matter, coloring substances, and mineral matters dissolved in water. Although it is a waste product, it has very important uses in digestion. About a quart is produced daily.

114. Intestinal fluids. — As the food enters the intestine it finds three new substances ready to act upon it. These substances are the *intestinal juice*, the *pancreatic juice*, and the *bile*. All these liquids are *alkaline*, and tend to neutralize the acid in the food as fast as it comes from the stomach.

115. Intestinal juice. — The intestinal juice is small in amount, and contains ferments which change starch to glucose, and albumin to peptone; but its action is slight, and the amount digested by it is small.

116. Pancreatic juice. — The pancreatic juice is a liquid of which five per cent is made of *three ferments* which perform the main part of digestion. As the chyme comes from the stomach, it contains albumin, some already digested, but much only softened and broken up. It also contains fat and starch unchanged.

One of the ferments of the pancreatic juice, *trypsin*, acts upon the undigested albumin, changing it to peptone.

Another ferment, *amylopsin*, changes the starch and

sugar to glucose. It does practically all the work of digesting starch and sugar.

The third ferment, *steapsin*, saponifies some of the fat with the soda and potash of the chyme. About one half an ounce of soap is thus formed daily. It acts as a lubricating and cleansing agent. The ferment also emulsifies the remainder of the fat.

117. Action of the bile. — About a quart of bile is poured into the intestine each day. It has a slight power in emulsifying fat, and in converting starch into glucose, but while its direct action is small, it does a great amount of work in helping and stimulating all the processes in the intestine. It almost doubles the power of the pancreatic juice. It acts as a lubricant to enable the food to slip down the intestine easily. It stimulates the peristalsis of the intestine, and prevents the growth of germs of fermentation. It also enables digested food to pass more readily from the intestine into the blood tubes. When bile is of poor quality, or too little in quantity, digestion is less perfectly performed, and headaches, mental dullness, and all the symptoms called *biliousness* result.

118. Peristalsis. — The intestine shows peristaltic movements like those in the esophagus. A half an inch or so of muscle fiber, running lengthwise of the intestine, contracts, pulling the next lower part of the intestine up over a lump of food. Then the circular fibers contract, squeezing the food down the tube, while the fibers next below repeat the process, as the first ring of contraction relaxes. So the contraction runs down the tube, forcing the intestinal contents before it.

This peristalsis is a slow, gentle movement. By it the intestinal contents are mixed with its juices, and slowly propelled toward the large intestine, where it is propelled still more slowly.

119. Result of intestinal digestion. — By the action of the three digestive fluids, the food is dissolved and reduced to a thin, milky form, called *chyle*. As all food contains many substances wholly indigestible, some solid particles will still remain in the chyle. Digestive action goes on during the whole time that food remains in the intestine, but most of the work is done in the small intestine. As it slowly passes down the tube, the liquid parts are taken up until, when it reaches the large intestine, it has become semi-solid again. The expulsion of the solid waste which finally remains is the last act of digestion. It takes about twelve hours for food to pass the length of the small intestine, and thirty-six hours to traverse the large intestine.

120. What becomes of the ferments. — After the ferments of the gastric, pancreatic, and intestinal juices have done their work of digestion, they are probably digested by the new ferments poured out at the next meal, for they are albumin. Bile is a waste product, yet some of its parts are taken up by the blood and carried to the liver, and again poured into the intestine. Thus nature is as economical as possible with the resources of the body.

121. Perfection of the digestive organs. — The mouth is perfectly adapted to masticating just such food as the stomach can readily digest, while it cannot grind such food as corn or hay. The stomach seems a weak, flabby organ, but nature made it of just the right size and strength to do its own proper work.

The bile is a waste product of the body and yet it is one of the most important agents in digestion. In brief, each part of the digestive system is perfectly adapted to its own work. In lower animals the digestive organs are somewhat modified so as to adapt them to different foods and different modes of eating.

SUMMARY

1. From the stomach the food passes into a long, coiled tube called the *intestine*.
2. In the intestine the food is acted upon by ferments in three fluids: the *intestinal* juice, the *pancreatic* juice, and the *bile*.
3. The intestinal juice has a slight action in changing starch to sugar, and albumin to peptone.
4. The pancreatic juice does the main part in changing starch to sugar and albumin to peptone, and of emulsifying and saponifying fats.
5. The bile greatly increases the power of the pancreatic juice. It also lubricates the intestine, prevents fermentation, and aids the passage of digested food into the blood tubes.
6. The muscles of the intestine slowly force the food down the tube so that it takes about twelve hours for food to traverse the small intestine, and thirty-six to traverse the large intestine.

DEMONSTRATIONS

43. Open the abdomen of a dead animal. Notice the thin, gauze-like omentum containing lumps of fat, and enveloping the intestine. Lift it up, and notice that the upper part of the large intestine seems to be inserted through it as though it were split into two leaves. Notice the difference between the small and large intestine in position, shape, and movability. Notice the beginning of the large intestine and the cæcum. The vermiform appendix can usually be found also. Notice the position, size, and feeling of the liver, and the gall bladder beneath it. By careful search the pancreas can be found behind the stomach, lying crosswise of the body, flattened out upon the backbone. It is covered with peritoneum and fat, and so is obscured, but can be recognized by its nodular appearance. A pig's sweetbread has much the same appearance as a man's pancreas. (See demonstration 35.)

Notice the thin fanlike mesentery, holding the coil of intestine in place. Notice the blood tubes running across it. Open the intestine for a few inches to show the folds of the valvulæ conniventes.

44. The villi are too soft and too small to be seen without a specially prepared specimen. A magnifying power of 50 will show them.

Examine also a specimen of the liver, using at first a power of 100 diameters. Notice the capillaries converging toward central veins. The bile ducts are too fine to be seen.

Next use a power of 400 diameters, and examine the cells carefully. Notice their large size, and that they sometimes have more than one nucleus. Make a sketch of a villus and of the liver cells.

45. Pour some oil into a bottle of water. Shake well, and notice that the two cannot be made to mix. Now add a small pinch of *pancreatine*. Shake once more, and notice that the oil now forms an emulsion with the water.

Explain that the pancreatine contains the ferment of the pancreatic juice, and that it has the same action outside the body that it does inside.

46. Make a little starch paste. While it is warm stir in a small pinch of pancreatine. In a few minutes the paste becomes fluid from the conversion of starch to sugar.

47. Procure some bile. That from a chicken's gall bladder will do. Pour some into a bottle with oil and water, and notice that it forms an emulsion.

REVIEW TOPICS

1. Describe the intestine and its various divisions — the small and the large intestine, the cæcum, the vermiform appendix, the colon, the mesentery, and the omentum.
2. Describe the pancreas.
3. Describe the liver.
4. Describe the bile and its uses.
5. Describe the pancreatic juice and its three ferments, and their uses.
6. Describe the intestinal juice and its use.
7. Describe the peristalsis of the intestine.

CHAPTER IX

ABSORPTION AND ASSIMILATION

122. Absorption of food. — Digested foods which become part of the body are *peptone*, *glucose*, and *emulsified fat*. While they remain in the intestine, they are still outside of the body proper. In order to nourish the body, they must dialyze through the wall of the intestine and become part of the blood. The process of taking any substance into the blood is *absorption*.

The bodies of most cells are semi-fluid and jellylike. The peptone and glucose, dissolved in water, will soak into the soft epithelial cells lining the intestine, while the original albumin and starch or sugar will not. Blood tubes run so near the inner surface of the wall of the intestine, that only a layer of epithelium and the capillary wall, both together thinner than the thinnest paper, separate the blood from the food in the intestine. The food soaks through the epithelial cells and the walls of the blood tube, and is washed away by the blood stream. So there is a steady flow of digested food through the epithelial cells toward the blood tube; while the undigested food remains behind. The cells are alive, however, and to a degree select what they transmit. Common salt is necessary in the process, and bile greatly aids it. Peptone and glucose are thus absorbed from the intestine by every point of its mucous membrane. The millions of villi projecting into the intestine greatly increase the surface for absorption,